Financial Inclusion, ICT and Income Inequality in Africa

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Abstract: *The objective of this paper is to investigate the impact of financial inclusion and information and communication technologies (ICTs) on income inequality. Furthermore, it examines whether ICT amplifies the effect of financial inclusion on income inequality in 47 African countries for the period 2014 to 2015, which surprisingly has received less attention in the literature. The empirical evidence is based on the generalized method of moments (GMM). Two financial inclusion indicators (ATM per 100,000 adults and bank branches per 100,000 adults), three ICT measures (mobile phone, internet users and fixed broadband) and two income inequality variables (Gini index and Palma ratio) are used for this study. The results show that better financial inclusion and more developed ICTs lead to lower income inequality. The results further indicate that ICT amplifies the impact of financial inclusion on income inequality, revealing a complementarity between ICT and financial inclusion in reducing income inequality. Given the complementarity between financial inclusion and ICT, the development of ICT would also lead to an increase in financial inclusion and a reduction in income inequality.*
Keywords: *Financial inclusion, ICT, income inequality, GMM, Africa.*

1. Introduction

The issue of inequality continues to attract the attention of researchers and policymakers, especially in African countries where income inequality is still high. According to the recently published United Nations Development Programme (UNDP) study on income inequality trends, 10 African countries are among the 19 most unequal countries in the world. In this ranking, two African countries occupy the top two places, namely South Africa and Namibia in that order. Because of its negative effects on the populations of African countries [1], Because of its negative effects on the populations of African countries, the problem of income inequality requires a growing interest in

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understanding its determinants. This study takes into account two key variables that have not yet been sufficiently studied to reduce income inequality in African countries, namely financial inclusion and information and communication technologies (ICT).

According to the [2] financial inclusion is defined as the proportion of individuals and businesses that have access to or use financial services. For [3]financial exclusion is a process whereby an individual, group or organisation lacks or is denied access to affordable, appropriate and equitable financial services and products. The consequences of this exclusion are a reduction in their ability to participate fully in social and economic activities and thus an increase in poverty. Beyond the definition of financial inclusion, which is closely related to that of financial exclusion, evidence shows that access to formal financial services remains a major constraint for poor and disadvantaged people. Despite the efforts of African governments as well as international organisations, as many as 2.5 billion adults worldwide suffer from financial exclusion, particularly in African countries, in the sense that they do not have access to savings, credit or other financial services [2, 4]. There is an urgent need for state polycies to find levers to increase financial inclusion and reduce income inequality.

In the literature, financial inclusion has been shown to be one of the main determinants of inequality [5]. Through innovation, ICT has become an important source of financial sector expansion in Africa. Banking technology offers a tremendous opportunity to connect low-income populations at lower cost and bring millions of consumers into the formal financial market through electronic channels [6].

Through innovation, ICTs are a source of capital for the expansion of the financial sector. They contribute to the wider geographical spread of banking services. They have significantly increased the operational proximity of banks to local economies. ATMs, e-banking, mobile phone services and point-of-sale terminals are the most common examples of how ICTs promote the geographical expansion of banking services and reduce inequalities [7].These different lines of reasoning have led to the conjecture that ICT development can amplify the beneficial effect of financial inclusion on income inequality. Do we have empirical evidence to support this conjecture?

To our knowledge, very little empirical work has examined the direct link between financial inclusion and inequality, and further, financial inclusion, ICT and inequality. However, some cross-sectional studies have examined financial inclusion on other phenomena. Among others, we can mention the following books Financial Inclusion and Development [8, 9]; Measuring Financial Inclusion [10–13];the determinant of financial inclusion [14, 15];

Financial inclusion and stability [16–19] ; Financial inclusion and economic growth[20], Mobile banking and financial inclusion [21] Financial inclusion and foreign bank entry [22] Financial inclusion and the role of service [23] Islamic finance and financial inclusion [11], Financial inclusion, poverty and income inequality [24] and more recently financial inclusion, productivity shocks and consumption volatility [25]. This paper empirically assesses the impact of financial inclusion on inequality through ICT. To do so, we will conduct an analysis using the GMM econometric model with data from 47 African countries over the period 2004-2014.

Although the empirical literature on the African region is relatively sparse, this paper adds to that literature by filling an existing gap. It responds to various economic shocks such as the recent financial crises, debt and the recent political, social and military upheavals in several African countries. The rest of the paper is divided as follows. Section 2 highlights the data sources and sample and outlines the empirical methodology and motivation for the empirical models to be estimated. The empirical estimation and results are all summarised in Section 3. Finally, the last section presents conclusions and policy recommendations.

2. Theoretical Background and Literature Review

The literature has extensively studied the relationship between ICT and economic growth. Numerous econometric techniques have been employed, both at the micro and macro level, using cross-country analysis, time series and panel data. However, the results are mixed as regards the impact of ICT on economic growth. More recently, many researchers have examined the effect of financial inclusion on different dimensions of economic development, namely poverty reduction, education and, most importantly, economic growth.

Economic inequality is a complex and multidimensional phenomenon, and to some extent inevitable. Nevertheless, we are convinced that if growing inequality is not effectively monitored and corrected, it could lead to all sorts of political, economic and social disasters. Macroeconomic phenomena (such as growth, nationalisation and privatisation policies, capital accumulation or the evolution of public debt) and microeconomic phenomena (such as individual income and social transfers, household wealth and debt) are mainly responsible for the different types of inequality in the world.

Income inequality varies considerably across countries. With a rate of 37% in Europe and 55% in sub-Saharan Africa [26]Africa remains one of the

continents most affected by this social calamity after Asia. The graph below shows that over the period 1990-2018, the income rate decreased slightly from 2008 onwards in the top decile (richest 10%) in SSA. Over the same period, the income rate of the poorest 50% increased slightly. The relevant remark in this graph shows that in 2018, the top decile captures 55% of income compared to 10% for the bottom 50%.

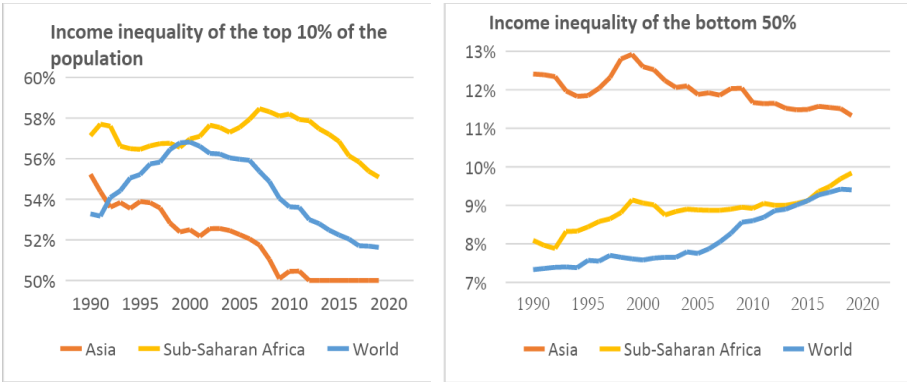

Figure 1. Income inequality in the areas
Source: Author's calculations using data from https://wid.world/fr/donnees/

2.1. Theoretical Foundations

The link between financial development and income inequality originates from the pioneering work of,[27] who established the famous Kuznets curve, arguing for a non-linear relationship between financial development and income inequality. Kuznets' argument confirms that in the early stages of development, income disparities increase due to the rapid rate of urbanisation (with people moving from low-productivity agricultural jobs to high-productivity jobs in industries with higher average incomes). However, in the intermediate stage of development, the relationship is expected to stabilise and then start to deteriorate in the advanced stage due to public redistribution policies.

There are two main conflicting theories on the impact of financial development on inequality. Some believe that financial development is essential for improving growth and reducing inequality. Financial constraints, such as information asymmetry, transaction costs and collateral requirements can severely hamper financial access for the poor. It follows that reducing inequality by improving the efficiency of capital allocation is likely to facilitate

the access of the poor to finance, especially those with profitable investments [28–30]. Therefore, relaxing these financial constraints would, among other things, help the poor, stimulate overall growth and reduce income inequality [31].

In contrast, conflicting theories suggest that financial development largely benefits the rich. According to these theories, the poor depend on remittances and capital from the informal financial sector [31]. The theoretical thesis and antithesis on the pro-poor character of financial development are synthesised by an alternative theoretical perspective that reconciles the opposing views by establishing that the underlying relationship is non-monotonic.

The first theory by [32] postulates an inverted U-shaped relationship. The study established a model of financial development, growth and wage distribution in which the use of financial intermediaries generally improves trade, as it is well known that transactions through these intermediaries lead to larger and more secure profits. Nevertheless, it has been pointed out that transactions between intermediaries generally have a cost, which is often higher in the early stages of development. Due to the constraints of high associated costs and low income, the poor population group may not be able to use the services; and this can only benefit the rich, which will increase income inequality. As the economy approaches the intermediate stage, financial intermediaries are beginning to develop. As a result, the national savings rate will increase, leading to a widening of income disparity, given the low savings capacity of the poor. As the economy moves into the intermediate and then the advanced phase, income inequality will start to narrow, with more and more agents seeing their incomes increase due to easier access to financial intermediaries. The above reasoning, which is similar to that of [27], results in an inverted U-shaped relationship, with income inequality increasing at the beginning of financial development and decreasing at the advanced stage of financial development.

To put this in more perspective, the relationship between the development of inclusive finance and inequality is clearly inverted, indicating that the development of inclusive finance will initially widen income gaps and, when financial development reaches a high level, it will then reduce income and mitigate inequality. However, this relationship between inequality and finance changes over time as an economy develops from the intermediate to the mature stage [33].

In the following years, this school of thought has been challenged by another type of literature establishing a negative linear relationship between financial development and income inequality. The model developed by [34] is

based on the initial assumption that finance can provide entrepreneurial opportunities. However, several imperfections in the financial market, such as high transaction costs and contract compliance, prevent low-income groups from investing and becoming entrepreneurs. This is because they often do not have a credit history and do not have the collateral required by financial institutions. In this context, it stands to reason that access to credit will be limited for the poor even if they are in possession of projects with high profitability and are therefore more likely to work for better employers, earning much less than they should. This suggests that if financial markets were to become accessible, efficient and stable, regardless of their context, entrepreneurs would be able to access capital, resulting in a reduction in income inequality.

The work initiated by [30], is based on the claim that with imperfect credit markets, income inequality prevents an efficient allocation of resources by reducing the ability of poor households to invest in human and physical capital. The model of [30] focuses on the argument that individuals are equal in terms of actual or potential capabilities, but tend to differ in terms of inherited wealth. Due to imperfect information and high transaction costs, the poor tend to face credit constraints and are therefore likely to invest less in human capital than the rich. In the model, the inheritance received by each individual determines whether he or she will invest in human capital (education) to become skilled. As such, the future of a household will therefore be defined by its initial wealth. Wealthy families will therefore tend to invest in human capital and acquire skills, accumulate enough and leave large legacies for the future, while poor families, with few legacies, will remain unskilled and amass little for future generations. Even if it is possible for the poor to finance their human capital, the barriers associated with financial market imperfections prevent them from doing so. Therefore, in the long run, the distribution of income will be determined by the level of investment in human capital, the latter being subordinated to the initial wealth inheritance.

The above debates are reflected in the intensive and extensive margin theories. According to the intensive margin theory, finance affects inequality through an indirect as well as a direct channel. By improving the financial services of agents who already have access to the formal financial system, namely: well-established companies and wealthy individuals [35]. Conversely, the extensive margin theory states that financial development could operate to a large extent by improving access to and use of financial services by agents who, due to financial constraints, were not using financial services [36–38]. In other words, financial development will reduce the intergenerational

persistence of relative income by improving economic opportunities for less privileged groups [39, 40].

This is consistent with the theory of liquidity constraints, which posits that constraints on access to liquidity hinder business opportunities for the poor and thus increase income inequality for economic operators [41–43] .

The positioning of this study is both consistent with intensive and extensive margin theories. On the one hand, it is consistent with the intensive margin theory in the perspective that formal financial access influences inequality both directly and indirectly through ICT. It is important to note that in the empirical specification of this study, ICT dynamics are defined as strictly exogenous variables. Furthermore, in order for the exclusion restriction hypothesis underlying this identification strategy to hold, ICT must influence inequality exclusively through the activated financial access channels.

Within the framework of intensive margin theory, there is an underlying assumption that the interaction between ICTs and banks is exclusively limited to firms with bank accounts and access to finance through formal banking institutions. However, if such interactions also involve the unbanked or previously unbanked population, the extensive margin theory takes hold

On the other hand, the extensive margin theory is consistent with the positioning of this study because ICTs are not exclusively used by those with formal bank accounts. Therefore, ICTs could be a valuable tool with which financially constrained people (especially the unbanked) can access formal financial services. In line with [44], ICT-enabled banking can enable the previously unbanked to access formal financial services if ICT is harnessed in such a way that:

- ICT improves the store of value within the formal banking sector, as the Subscriber Identity Module (SIM) can also act as a smart card (or virtual bank card);
- ICT banking services provide access to bank accounts as they can also be used as an ATM for transactions;
- And ICT banking services enable communications and transactions between banks and thus serve as a Point of Sale (POS).

As a result, the previously unbanked population can benefit from "partially integrated ICT savings" as opposed to basic bank savings. The MPESA system of ICT transfers, used to store and exchange money with the help of conventional banking institutions, is a good example of this economy. In summary, by encouraging partially integrated economies through ICT, the intensive and extensive margin theories underlying this study are feasible.

2.2. Review of the Literature

A recent report of [45]on 'digital dividends', which links the above theories to the digital revolution, argues that internet access is sufficient, but not enough. According to the report, maximising digital dividends requires a better understanding of the interaction between technology and other factors that are essential for economic development, namely: the 'analogue complements'. These factors involve regulations so that businesses can take advantage of the internet to increase their competitiveness and thus innovate better. Improved skills, enabling everyone to take full advantage of digital opportunities, and accountable institutions, so that governments can better respond to the needs and demands of citizens.

Digital technologies can then augment and reinforce these complements and thus accelerate development. The underlying "analogue complements" used in this study are financial access channels. The adoption of such channels is in line with the Global Financial Development Report 2014 which states that new technologies hold promise for the development of FI and that, FI is important for poverty reduction and equality and economic development. Therefore, in this study, we assess whether the complementarity of FI and ICT indicators can reduce income inequality.

Opposing currents in the theoretical literature discussed agree that finance affects inequality (positively or negatively). This investigation 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 its development reduces financing constraints (e.g. transaction costs and information asymmetry), stimulates economic growth and contributes to reducing poverty and income inequality. Therefore, the problem statement of this investigation seems to be justified from a theoretical point of view: ICT impacts on inequality through financial development [46].

Financial inclusion and inclusive development

Inclusive development is instead defined as "development that includes marginalised people, sectors and countries in social, political and economic processes with a view to increasing human well-being, social and environmental sustainability and empowerment" [47]. Inclusive finance is an essential tool for inclusive development, as it provides fair, equitable and affordable access to financial facilities, not only to improve people's lives, but also to promote the participation of all members of a society, especially the poorest, in productive and sustainable economic activities. By enabling people

to compete for and exploit economic opportunities, inclusive finance can therefore be a powerful engine for economic development.

Inclusive growth is economic growth that creates opportunities in terms of labour, economic activity and assets for all segments of the population [48, 49]. More specifically, "inclusive growth deals with policies that enable people from different groups (gender, ethnicity, religion) and all sectors (agriculture, manufacturing, services) to contribute to and benefit from economic growth" [50].

Access to formal financial services, mainly credit, enables agents to make long-term consumption and investment plans and to participate in productive economic activities. Indeed, recent studies have shown that access to financial products has a direct impact on innovation and productivity, which have been shown to stimulate economic growth [51–54]. There may also be a reverse causal effect in that higher growth, by easing credit constraints, deepening the availability and reducing the cost of financial services, allows more people to be financially included.

Indeed, recent literature [47, 50, 55] argues that there is an urgent need to find and inform policies that simultaneously promote growth and inclusion. Authorities should go "beyond the question of whether growth is 'good for poverty reduction'[30], but rather whether and how the poor can participate in and contribute to growth and how formal and informal institutions can enhance this" [50]. For example through more inclusive financial markets. With better access to forma loans, families can reduce their consumption of durable and non-durable goods and investments, including in education and health . They can also insure themselves against adverse and unexpected events and thus avoid falling further into poverty, which is often the case with such negative events.

The 'credit excluded' who are denied credit by mainstream lenders are exposed to informal lenders who lend money at very high or excessive rates (predatory inclusion), which further increases their vulnerability. The recent global crisis is a major concern, which could exacerbate the problem of financial exclusion, as it has led to a polarisation in financial markets between those who are "hyper-inclusive" and those who are totally excluded and who are in need of financial support [56] and those who are totally excluded and have no access to formal financial services.

More recently [57] examined the relationship without policy variables in light of the Kuznets hypothesis to conclude that financial access and intermediation efficiency reduce inequality and a Kuznets link is apparent between GDP per capita and inequality. [58] The authors empirically examined the relationship between economic development and financial inclusion by

identifying country-specific factors related to financial inclusion. They found that, within a given country, levels of financial inclusion and human development are closely related.

2.3. Information Technology, Financial Inclusion and Inclusive Development

Technology has enabled remote banking, which is the provision of financial services without the use of traditional bank branches using information and communication technology and non-bank retail agents. Communication technologies such as the telephone and/or mobile phone and the penetration of the Internet are key to the adoption of financial innovations. The developing world, particularly Africa, has lagged behind other regions in the development of communications infrastructure. Fortunately, the advent of mobile phones is propelling communications in Africa. As described by [59], mobile phones are multi-functional devices that allow for a variety of communication methods ranging from ubiquitous voice and SMS channels to more sophisticated means such as software applications and web browsers.

An examination of ICT adoption in different regions of the world provides an interesting picture. Table 14 below illustrates how technologies have been adopted over time. These are landline phone subscriptions per 100 people, mobile phone subscriptions per 100 people, ATMs per 100,000 adults and Internet users as a percentage of the population.

Table 1. Adoption of ICT and ATMs

Technology	Fixed Telephone			Mobile Subscriptions			ATMs			Internet Access		
Year	2000	2010	2016	2000	2010	2016	2000	2010	2016	2000	2010	2016
Sub-Saharan Africa	1.38	1.47	1.00	1.72	44.40	74.36	....	3.20	5.82	0.50	7.15	19.99
Latin America & Caribbean	13.98	17.70	16.66	11.66	95.51	108.32	....	29.34	41.12	3.40	34.20	55.81
South Asia	2.68	2.92	1.83	0.33	59.55	84.82	....	4.40	9.64	0.47	7.21	26.47
East Asia & Pacific	9.20	18.47	11.50	5.72	69.92	107.22	....	15.12	37.63	1.90	28.96	48.39
Middle East & North Africa	8.63	16.17	14.66	2.21	82.05	102.84	....	11.85	27.12	0.84	20.62	42.47
Europe and Central Asia	20.73	25.51	19.73	6.65	122.44	128.99	....	42.25	59.99	2.02	35.88	63.67
OECD members	50.73	43.94	37.75	45.24	101.36	118.02	....	89.48	75.25	27.88	67.62	78.59

Note: the reported figures exclude high-income countries in each region.
Source: World Development Indicators (2018).

In terms of fixed phone use, the main laggard was sub-Saharan Africa (SSA), followed by South Asia. However, in all regions, fixed phone subscriptions are declining, while mobile phone subscriptions are increasing. The fixed phone is gradually being replaced by mobile communication. Although SSA has seen the largest increase in mobile subscriptions, from 1.72 subscriptions per 100 inhabitants in 2000 to 74.36 in 2016 (an increase of 4323% over 16 years), it lags behind all other regions except South Asia.

Nevertheless, the number of mobile phone subscriptions has grown exponentially over the past decade in all regions of the world, indicating a strong appetite for mobile communication. In contrast, although ATMs were invented in the 1960s [60] their adoption for the provision of financial services only became significant in the 2000s. ATMs promote financial inclusion because their availability facilitates access to financial services. In terms of ATM access, SSA is the main laggard followed by South Asia. Both regions have the lowest levels of financial inclusion.

The Internet is increasingly becoming an important channel for communicating and providing financial services. Internet users as a percentage of the population are increasing in all regions of the world. SSA is again the biggest laggard, followed by South Asia. In facilitating financial inclusion, mobile phones are having a significant impact by enabling mobile money, i.e. the provision of financial services via a mobile device. The Global Findex 2017 survey estimates that there are around 1.1 billion mobile-owning but unbanked adults in the world. This is about two-thirds of all unbanked adults.

Mobile money is now the main payment platform for the digital economy in developing countries. The GSMA reports that in 2017, there were 690 million registered mobile money accounts worldwide, for which the total transactions processed daily amounted to $1 billion. African countries lead the world, with 66% of the combined population of Kenya, Rwanda, Tanzania and Uganda currently using mobile money. SSA accounts account for the majority of mobile money accounts with a total of 338 million in 2017 (up from 75 million in 2012), accounting for almost half of mobile money adoption to significantly increase its percentage share. Globally, the number of people connected to mobile services exceeded five billion in 2017 and the GSMA estimates that by 2025 there will be five billion internet users. It recognises that mobile internet adoption will soon become the key metric for measuring the reach and value created by the mobile sector. For example, mobile internet users will represent the market for e-commerce, digital solutions and financial technology (FinTech) [60].

Only a few studies have attempted to directly measure the relationship between financial inclusion and technology, but many have investigated the

link between economic growth and technology. Studies by [61, 62], for example, report two-way causal effects between GDP and telecommunications. Similarly, [63] found that a 10% increase in broadband Internet connections could lead to a 1.3% increase in overall economic growth. Furthermore, a study by [64] in Serbia, Bangladesh, Malaysia, Thailand and Pakistan indicates that the contribution of mobile technology to national income is between 4.5% and 6%. To highlight reverse causality, GDP growth has been found to have a positive causal effect on ICT investment and growth. For example, a study of OECD countries for the period 1985-1997 found that a 1% change in GDP led to an 8% increase in telecommunications investment[65].

Since economic growth has empirically also driven financial development, it should also drive inclusion. A study by [66] binvestigated whether mobile phone development promotes economic growth through increased financial inclusion in African countries. Financial inclusion measured private credit as a ratio of GDP and deposits per capita was entered as part of the explanatory variables with per capita income as the dependent variable. The results showed that mobile phone development contributes significantly to economic growth and that the positive effect comes from increased financial inclusion.

In another similar study, [9] investigated the link between financial inclusion and development. They used a financial inclusion index constructed using the three dimensions of financial inclusion, namely. Accessibility, availability and use of banking services. Accessibility was measured by the number of bank accounts per 1000 inhabitants. Availability was measured by the number of bank branches and the number of ATMs per 100,000 inhabitants, and use of banking services by the volume of loans and deposits relative to GDP. They found a significant impact of telephone and internet variables on financial inclusion.

Addressing the link between financial inclusion and inclusive growth in a sample of Ghanaian firms,[67] find that access to finance improves firm growth. In a related study in India, [68] finds a positive relationship between financial penetration and per capita growth in several states. [69] finds a positive correlation between access to banking services and educational attainment, but a negative relationship between financial depth and student-teacher ratio. [70] reports in India that financial inclusion increases income, but that the increase is greater for women (8.40%) than for men (3.97%). In contrast, [71] found no gender gap in the welfare effects of financial inclusion in South Africa.

[72] provides evidence of mobile penetration reducing inequality in Africa. Similarly, [44] find that mobile phone diffusion promotes inclusive

development in sub-Saharan Africa. Again, they reveal that institutions reinforce the positive effect of mobile phones on inclusive growth.

[73] study the relationship between inclusive development (inequality and poverty) and mobile banking in 93 developing countries in 2011. They find a positive correlation between mobile banking and inclusive development when a given Human Development Index threshold is reached. [73], using robust simultaneous fixed-effects regressions on data from 49 sub-Saharan African countries, assess the educational quality thresholds through which information provision via mobile phones improves inclusive human development. They find marginal and net positive effects on inclusive development when education quality interacts with mobile phones. They also found that, in primary education, an average of 10 to 27 students per teacher were needed to improve inclusive human development via mobile phones.

[74] used quantile interactive regressions to study the correlations between inclusive development and mobile banking in the conditional distribution of inclusive development. They found that, overall, increasing mobile banking mechanisms to certain thresholds would also increase growth quality and reduce inequality at the top of the distribution of inclusive development. They recommended that encouraging the use of mobile banking applications plays an important role in addressing the challenges of exclusive growth, inequality and poverty in developing countries. [75]supplemented the qualitative and theoretical literature with empirical evidence of the income redistributive effects of mobile phone penetration in 52 African countries. The author used two empirical techniques, namely ordinary least squares and two-stage least squares. The results suggest that mobile phone penetration is pro-poor. A recent special issue on mobile technologies for inclusive development in Africa [76] provides more information on this component.

Using the generalized method of moments and quantile regressions as empirical techniques in a panel of 162 banks, [77] assess how information dissemination 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 dissemination on market power can improve access to finance in Africa.

[78] uses a macroeconomic approach with cluster analysis to determine whether mobile money adoption is high in countries where access to formal banking services is low. In contrast to previous studies, the results do not support the idea that mobile money use promotes financial inclusion.

To determine whether mobile money can help businesses reduce financial access constraints, [79] uses data from the World Bank's 2013 Business Survey Program in Eastern Sub-Saharan Africa. The results show that

firms that use mobile money have the advantage of easily obtaining credit lines or loans. Further analysis reveals that firms using mobile money are productive compared to other firms in the sub-region. [80]tested the moderating effect of social networks on the link between financial inclusion and mobile money use in rural Uganda. The results indicate a positive and significant moderating effect of social networks on the link between mobile money use and financial inclusion in rural Uganda.

Studies in rural Peru also show that mobile coverage increases per capita household consumption and thus reduces extreme and absolute poverty [81]. This is because mobile phones reduce the costs of information seeking and allow villagers to access weather, market and price information, all of which enable optimal production and productivity. There is further evidence of improved economic growth from mobile phones in Indian states [68]. Mobile phones are being used to advance literacy, improve jobs, improve access to health services and improve social networks among people at the bottom of the pyramid in India [82].

[83] compared the contribution of ICT to GDP growth in nine OECD countries over the period 1980-2000. The study found that ICT contributed between 0.2 and 0.5 percentage points per year to GDP growth. However, in the second half of the 1990s, the contribution increased to 0.3 to 0.9 percentage points per year. In summary, there seems to be a consensus in the ICT growth literature that ICT investment has contributed significantly to GDP growth in developed economies, and even more so in the second half of the year.

[84] use a sample of 42 developed and developing countries over the period 1993-2001 to re-examine the relationship between labour productivity and ICT investment. The study suggests that while both ICT and non-ICT capital have a statistically positive impact on productivity growth, the former is stronger than the latter. Moreover, the impact of ICT capital in developed countries is stronger than in developing countries.

[85] used an instrumental variable technique and a seemingly unrelated probit model to assess two main objectives: to investigate and analyze whether mobile phones stimulate pro-poor development by helping households to fight poverty and allocate consumption efficiently. The results show that financial inclusion and mobile phone penetration significantly reduce the probability of a household becoming poor and per capita consumption of non-food and food items.

[86] estimated the economic growth model using time series and comparative data on 62 countries covering the period 2000-2006 and found that the effect of economic growth on ICT varied across income groups. The

author concluded that ICT plays an important role in the growth of high and upper-middle income groups. However, ICT did not contribute to the growth of the lower-middle income group.

3. Data and Methodology

This paper uses panel data for 47 sub-Saharan African countries over the period 2004- 2014 to study the effect of financial inclusion on inequality. The unavailability of data imposes on us the temporal and geographical dimension at the time of this study. This gives us a number of observations equal to N * T = 470, where N is the number of countries (47) and T the number of years (10). The full description of the data is as follows:

3.1. Data

Table 2. Descriptive statistics

Panel A: Summary statistics						
	Variables	Obs	Mean	S.D.	Min	Max
Income inequality	Gini index	516	0,581	0,038	0,441	0,852
	Palma ratio	516	6,245	1,551	2,484	14,435
Financial **Inclusion**	ATMs	420	9,588	13,977	0	65,806
	Branch Bank	501	6,124	8,638	0,132	53,205
ICT	Mobile	513	47,635	37,321	0,208	162,284
	Internet user	510	8,811	11,313	0,031	56,8
	Broadband	427	0,752	1,929	0	14,476
Control variables	Government expenditure	466	15,183	6,13	4,157	39,451
	Education	442	0,929	0,087	0,622	1,121
	Control of corruption	517	-0,574	0,579	-1,538	1,16
	Remittances	476	4,144	6,029	0	41,499
Panel B: List of countries						
Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Dem, Rep, Congo, Rep, Côte d'Ivoire, Djibouti, Egypt, Arab Rep, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tomé and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia.						

Source: Authors based on Stata 15

The dependent variable is income inequality. Our main independent variable is financial inclusion. These variables are taken from the World Bank's

World Development Indicators. In addition to the financial inclusion variable (ATMs and bank branches), we include some control variables, generally considered in the literature as determinants in empirical work on inequality: (i) government expenditure; (ii) level of education; (iii) mobile phone; and (iv) internet use. A detailed description of all variables is presented in Table 3. Inequality has different meanings depending on how it is measured. The main contemporary literary trends on inequality are based on three indicators that will be adopted in our study. [87, 88]These indicators are: (i) the Gini coefficient, which measures the level of wealth inequality within the population. However, the main drawback of this indicator is that it fails to capture the extreme values of the inequality distribution [89]. Therefore, in order to control for the tails of the inequality distribution, the Gini coefficient is complemented by another inequality indicator that are designed to capture the extreme values of the inequality distribution, namely (ii) the Palma ratio which indicates the shares of national income of the richest 10% of households to the poorest 40% [88].

The choice of our financial inclusion variable is justified in the literature. Financial inclusion has the potential to help promote economic development by providing a mechanism for sharing risk, reducing poverty and improving equality.

[31]. An inclusive financial system not only generates lower socio-economic inequality [31, 90] but also a more prosperous economy and higher economic growth [91, 92]. Through income-generating activity, financial inclusion enables disadvantaged people to access micro-credit and develop themselves out of poverty.

[93] Similarly, women from disadvantaged groups who have participated in financial inclusion programmes have improved their living conditions [70]. [31] also find that banking industries are associated with a statistically significant reduction in income inequality.

[13] find that policy measures to increase financial inclusion have the side benefit of also contributing to financial stability and [94] shows that financial inclusion contributes to reducing income inequality in low-income countries.

The Financial Inclusion variable and the ICT variable each have an impact on reducing income inequality. In our work, we will cross-reference the ICT and financial inclusion variables to see their effect on income inequality. We believe that financial inclusion amplifies the impact of ICT. The development of banking forms allows disadvantaged people to have access to financial services that remain a luxury for the rich.

Table 3. Correlation Matrix

	Income inequality		Financial inclusion		ICT			Control variables			
	Gini	Palma ratio	ATMs	Branch Bank	Mobile	Internet	Broadband	Govexp	Educ	CC	Remit
Gini	1,000	0,943	0,172	-0,157	-0,084	-0,145	-0,295	0,017	0,079	0,241	-0,007
Palma ratio		1,000	0,193	-0,139	-0,041	-0,135	-0,266	0,163	0,106	0,346	0,122
ATMs			1,000	0,780	0,646	0,701	0,664	0,353	0,236	0,675	-0,138
Branch Bank				1,000	0,536	0,743	0,719	0,399	0,237	0,574	-0,062
Mobile					1,000	0,780	0,611	0,179	0,262	0,417	-0,102
Internet						1,000	0,725	0,208	0,266	0,412	-0,031
Broadband							1,000	0,189	0,245	0,406	-0,110
Govex								1,000	0,117	0,364	0,250
Educ									1,000	0,426	0,044
CC										1,000	0,038
Remit											1,000

Source: Author based on Stata 15

Table 4. Definition and sources of variables

Variables	Definitions	Sources
Gini index	"The Gini index is a measure of income distribution of a country's residents.	PIAG
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.	PIAG
BranchBank	Number of commercial bank branches per 100,000 adults.	World Bank (FDSD)
ATMs	Number of ATMs per 100,000 adults.	World Bank (FDSD)
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 expenditure	General government final consumption expenditure	World Bank (WDI)
Education	School enrolment, secondary (gross)	World Bank (WDI)
Remittances	Remittances inflows to GDP (%)	World Bank (WDI)
Control corruption	Control for 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, 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. GFDD: Global Financial Development Database.GCIP: Global Consumption and Income Project.

3.2. Methodology

To study the relationship between financial inclusion, ICT and income inequality, we analyse the direct impact of financial inclusion and ICT on income inequality. To conduct our analysis, the empirical model is based on Lartey (2013); Adams and Klobodu (2016) and Zghidi et al. (2018). Following these studies, we estimate the following equation:

$$IneRev_{it} = \beta_0 + \beta_1 IneRev_{it-1} + \beta_2 FinI_{it} + \beta_3 X_{it} + \mu_i + v_t + \varepsilon_{it}$$

Where $IneRev_{it}$ is equal to the income inequality indicators, $FinI_{it}$ is the financial inclusion variables, X_{it} represents a conditioning information vector that controls for other factors associated with economic growth, μ_i is an unobserved observer country-specific effect, v_t is a time-specific effect and ε_{it} is the error term.

In addition to the direct impact of financial inclusion and ICT on income inequality described in equation (1), several factors can amplify or mitigate the effects of financial inclusion on income inequality. As mentioned above, this paper examines the role of ICT in the relationship between financial inclusion and income inequality. To this end, we analyze financial inclusion with the ICT variable and test the significance of the interacting coefficient. The specification of the equation is as follows:

$$IneRev_{it} = \beta_0 + \beta_1 IneRev_{it-1} + \beta_2 FinI_{it} + \beta_3 (ICT_{it} FinI_{it}) + \beta_4 ICT_{it} + \beta_3 X_{it} + \mu_i + v_t + \varepsilon_{it}$$

Where ICT_{it} is information and communication technology, $(ICT_{it} FinI_{it})$ is the interaction term between ICT and financial inclusion. To test the hypothesis explained above, we are interested in and provide information on the marginal effect of financial inclusion on income inequality as a function of the level of ICT development. A positive interaction coefficient term would imply that the marginal impact of financial inclusion on income inequality is magnified with the level of ICT development. On the other hand, a negative interaction term would indicate that ICT mitigates the beneficial effect of financial inclusion on income inequality.

We apply the system-based generalized method of moments (GMM) proposed by [95–97]. GMMs are used for several advantages. First, the GMM estimator has been widely used to solve the endogeneity problem that arises in the estimation of data [96, 97]. Second, the GMM estimator also takes into

account biases that arise due to country-specific effects. Third, GMM also avoids problems of simultaneity or reverse causality. The GMM method has two variants, namely one-step and two-step estimators. However, the two-step estimator has proven to be more efficient than the one-step estimator because it uses optimal weighting matrices [98]. Therefore, this paper applies the two-stage GMM system to study the effect of remittances on inequality through financial inclusion. The consistency of the GMM estimator depends on two factors: the validity of the assumption that the error term has no serial correlation (AR (2)) and the validity of the instruments (Hansen test).

4. Empirical Results and Discussion

The results obtained with the previous regression models are presented in the tables below. They include successively the basic model, the basic model and its control variables and finally the model of the cross variable between inequality and financial inclusion.

Table 5. Basic Model

	Dependent variable : Measured by the GINI index					
PANEL A	BranchBank			ATMs		
	(A)	(B)	(C)	(D)	(E)	(F)
BranchBank	-0.000407***	-5.40e-05***	-0.000250***			
	(7.77e-06)	(6.90e-06)	(3.51e-06)			
ATMs				-0.000118***	-5.46e-05***	-8.32e-05***
				(6.35e-06)	(6.94e-06)	(3.95e-07)
Mobile Phone	-1.08e-05***			-2.13e-05***		
	(2.69e-06)			(2.76e-06)		
Net User		-0.000198***			-0.000175***	
		(2.01e-06)			(1.01e-05)	
Broad band			-0.000281***			-0.000683***
			(9.42e-06)			(1.32e-06)
L.gini	0.876***	0.895***	0.905***	0.882***	0.875***	
	(0.000967)	(0.000459)	(0.000739)	(0.00175)	(0.000957)	

Constant	0.0740***	0.0620***	0.0561***	0.0699***	0.0738***	0.0546***
	(0.000581)	(0.000280)	(0.000469)	(0.000889)	(0.000503)	(9.72e-05)
Comments	455	452	396	390	386	346
Number of i	47	47	46	46	46	45
ar1p	0.105	0.108	0.177	0.109	0.112	0.182
ar2p	0.454	0.436	0.464	0.445	0.437	0.461
j	36	45	42	36	36	42
hansenp	0.192	0.364	0.396	0.189	0.227	0.255
F	453337	1.020e+07	5.727e+06	122768	354949	1.750e+07

	Dependent variable : Measured by the Palma Ratio					
PANEL B	BranchBank			ATMs		
	(G)	(H)	(I)	(J)	(K)	(L)
BranchBank	-0.0100***	-0.00722***	-0.00279***			
	(0.000255)	(0.000347)	(0.000189)			
ATMs				-0.00514***	-0.00349***	-0.00265***
				(0.000166)	(0.000358)	(5.30e-05)
Mobile Phone	-0.000477***			-0.000445***		
	(9.09e-05)			(6.01e-05)		
Net User		-0.000593**			-0.00290***	
		(0.000270)			(0.000420)	
Broad band			-0.0146***			-0.0147***
			(0.000608)			(0.000281)
L.palmaratio	0.932***	0.933***	0.935***	0.942***	0.935***	0.935***
	(0.00165)	(0.00176)	(0.00118)	(0.00132)	(0.00125)	(0.000639)
Constant	0.472***	0.424***	0.394***	0.400***	0.432***	0.400***
	(0.0151)	(0.0164)	(0.00740)	(0.00848)	(0.00447)	(0.00332)
Comments	455	452	396	390	386	346
Number of i	47	47	46	46	46	45
ar1p	0.0951	0.0943	0.168	0.105	0.103	0.184
ar2p	0.309	0.306	0.302	0.311	0.315	0.305

j	36	36	36	36	36	36
hansenp	0.217	0.386	0.316	0.233	0.240	0.257
F	150964	254980	752702	383620	698137	5.895e+06

Note:***, **, *: Significance levels at 1%, 5% and 10% respectively. Standard errors reported in parenthesis. The significance of bold values is twofold. 1) The significance of estimated coefficients and Wald statistics. 2) The failure to reject the null hypothesis of: a) no autocorrelation in the AR (1) & AR (2) tests and; b) the validity of the instruments in the Hansen OIR tests.

Source: Author based on Stata 15.

Table 5 above presents the empirical results of the impact of the FI on inequalities via ICT without the control variables. This table shows us that the Fisher test is significant hence the model is overall good. The number of instruments being lower than the number of countries and the probability of Hassen's test being higher than 10%, there is no proliferation of instruments and finally, there is no autocorrelation because the Arelano and Bond conditions are respected, i.e. the probability of AR >10%. All conditions being met, the results table shows that all inclusion variables are significant and negative, hence there is a negative relationship of FI on inequalities via the ICT channel. What about the general model when controlling for the control variables?

4.1. Basic Model and Control Variables

Table 6. Income inequality and its control variables

Dependent variable: GINI inequality

PANEL A	BranchBank			ATMs		
	(A)	(B)	(C)	(D)	(E)	(F)
BranchBank	-0.000419***	-0.000313***	-0.000297***			
	(7.23e-05)	(2.03e-05)	(2.75e-05)			
ATMs				-9.86e-05***	-0.000139***	-5.76e-05*
				(3.26e-05)	(1.67e-05)	(3.37e-05)
MobilFon	-0.000100***			-9.95e-05***		
	(1.28e-05)			(1.75e-05)		
useNet		-4.97e-05***			-0.000325***	
		(7.68e-06)			(1.69e-05)	
broadband			-0.00207***			-0.00144***
			(0.000122)			(0.000304)
GoVConsum	-1.93e-05	-0.000823***	-0.000594***	-0.000456***	3.00e-05	-0.000543***
	(2.89e-05)	(5.08e-05)	(0.000132)	(9.75e-05)	(6.86e-05)	(0.000152)
School	0.0274***	-0.0559***	0.0910***	0.0517***	0.00551**	-0.119***
	(0.00642)	(0.00226)	(0.00359)	(0.00666)	(0.00204)	(0.0123)

remittances	7.91e-05	0.000372***	0.000214***	0.000365***	4.44e-05	0.000518***
	(8.22e-05)	(6.68e-05)	(6.43e-05)	(0.000116)	(5.38e-05)	(0.000153)
cc	0.0111***	0.0107***	0.0121***	0.0108***	0.0100***	0.0124***
	(0.00144)	(0.000634)	(0.000808)	(0.00143)	(0.000180)	(0.00122)
L.gini	0.831***	0.878***	0.811***	0.852***	0.862***	0.882***
	(0.00880)	(0.00208)	(0.00338)	(0.00494)	(0.00179)	(0.0110)
Constant	0.0852***	0.142***	0.0411***	0.0535***	0.0830***	0.193***
	(0.00906)	(0.00232)	(0.00483)	(0.00391)	(0.00129)	(0.0166)
Comments	328	323	298	276	272	253
Number of i	42	42	41	41	41	40
ar1p	0.189	0.194	0.282	0.201	0.204	0.260
ar2p	0.273	0.233	0.357	0.326	0.279	0.138
j	42	41	40	40	40	32
hansenp	0.755	0.264	0.826	0.517	0.236	0.513
F	45326	962133	913898	60483	557628	24447

PANEL B	Dependent variable: Inequality of the Palma ratio					
	BranchBank			ATMs		
	(G)	(H)	(I)	(J)	(K)	(L.)
BranchBank	-0.0197***	-0.00661***	-0.0129***			
	(0.00401)	(0.00137)	(0.00209)			
ATMs				-0.00892***	-0.00900***	-0.00370***
				(0.00138)	(0.000489)	(0.00115)
Mobile Phone	-0.00324***			-0.00280***		
	(0.000541)			(0.000341)		
Net User		-0.00565***			-0.00272***	
		(0.000599)			(0.000431)	
Broad band			-0.00962*			-0.0149*
			(0.00484)			(0.00858)
GoVConsum	0.0288***	-0.0115***	0.00202	0.0108***	-0.00718***	0.00292
	(0.00325)	(0.00160)	(0.00351)	(0.00297)	(0.00133)	(0.00264)
School	1.581***	2.093***	-0.00589	3.438***	0.0958	-0.259
	(0.507)	(0.180)	(0.346)	(0.523)	(0.0661)	(0.198)
remittances	0.0159**	0.0265***	0.0176***	0.0319***	0.0198***	0.00622**
	(0.00720)	(0.00419)	(0.00391)	(0.00684)	(0.00281)	(0.00303)
CC	0.497***	0.171***	0.229***	0.448***	0.323***	0.110***
	(0.0699)	(0.0346)	(0.0365)	(0.0582)	(0.00855)	(0.0294)
L.palmaratio	0.841***	0.893***	0.896***	0.871***	0.919***	0.940***
	(0.0193)	(0.00614)	(0.00835)	(0.00481)	(0.00287)	(0.00988)
Constant	-0.509	-1.094***	0.708**	-2.326***	0.681***	0.599***
	(0.404)	(0.178)	(0.347)	(0.485)	(0.0764)	(0.213)
Comments	328	323	298	276	272	253
Number of i	42	42	41	41	41	40
ar1p	0.0784	0.102	0.103	0.113	0.106	0.140
ar2p	0.344	0.316	0.335	0.259	0.306	0.305
j	36	40	36	40	40	28
hansenp	0.788	0.790	0.817	0.609	0.448	0.356
F	3069	18168	9443	363327	634340	2995

Note: ***, **, *: Significance levels at 1%, 5% and 10% respectively. Standard errors reported in parenthesis. The significance of bold values is twofold. 1) The significance of estimated coefficients and Wald statistics. 2) The failure to reject the null hypothesis of: a) no autocorrelation in the AR (1) & AR (2) tests and; b) the validity of the instruments in the Hansen OIR tests.

Source: Author based on Stata 15.

Table 6 above shows Panel A for the GINI Index and Panel B for the PALMA Ratio.

The results of panel A (the GINI inequality) show that the bank branch variable BRCH, is significant and negative at 1% in model 1 ,2 and 3 respectively. This result corresponds to the expected one. The variable ATMs, is significant and negative at 1% in model 4 and 5 respectively. At 10% in model 6. This result corresponds to the expected one and is in the same direction as the one found by [99].

[100] who found that ATMs have a positive effect on growth and finally the sign of the variable IF is positive and significant and its sign corresponds to that expected. This result is in line with the work of [101] who believes that there is a positive link between economic growth and FI in particular, in the penetration of banking services. And in the same vein, in October 2013, the World Bank Group formulated the global goal of universal access to financial services for all.

BRCH, and ATMs, have negative effects on inequality at 1%. When we interpret the coefficient of financial inclusion measures, the results mean that a one unit increase in the number of bank branches, and ATMs leads to a decrease of 7.23e-05 units; 2.03e-05 units; and 2.75e-05 units of inequality in Africa respectively.

With regard to the ICT variables, the MobilFon variable is significant and negative at the 1% level in models 2 and 4 respectively. This result corresponds to the expected one. The useNet variable is significant and negative at the 1% level in models 2 and 5 respectively. This result corresponds to the expected sign. The broadband variable is significant and negative at the 1% level in models 3 and 6 respectively. This result corresponds to the expected one. We find that in general ICT is negatively related to FI. This result is in line with the work of [87] who examined the role of ICT in income inequality through financial development dynamics in 48 African countries over the period 1996-2014 with the GMM method. The three main inequality dependent variables are used, namely: the Gini index, the Palma ratio and the Atkinson index. The results of this extension show that ICT reduces inequality through the development of the formal financial sector and the formalisation of the financial sector.

[57] extended [102] by re-examining the link between financial inequality and a group of African countries in the light of the Kuznets hypothesis to conclude that, with the exception of the financial stability mechanism, financial activity (or access to credit) and financial allocation efficiency reduce income inequality and confirm Kuznets' hypothesis on the link between income levels and inequality of income .

The GoVConsum variable is significant and negative at the 1% level in models 2, 4 and 6 respectively. This result corresponds to the expected one. This result is in line with the one found [99]. Econometric analysis shows that the development of the financial intermediation sector as measured by the ratio of credit to the private sector, GDP growth, macroeconomic policies, government spending and institutional development can play a key role in reducing inequality .

The School variable is significant and negative at the 1% level in models 2 and 6 respectively. And significant and positive at 1% in models 1, 3, and 4. At 5% in model 5. This result corresponds to the research of [103]. Using samples from 50 countries, including OECD, East Asia, Latin America and Africa, he found that public education spending mitigated income inequality as represented by the Gini coefficients. The results are quite robust across countries.

The remittances variable is significant and positive at the 1% level in models 2, 3, 4 and 6 respectively. This result corresponds to the expected signs. [104] the two variables explain the increase or decrease in inequality due to the immigration cost process. When costs are low, both types of households are not constrained. This is because migration and remittances reduce the income range at origin, regardless of the initial income gap. The opposite result is not necessarily true. For high migration costs, poor households are significantly more constrained, so that inequality increases. [104] Both the high and low costs of migration explain the increase or decrease in inequality due to the cost of migration process. When costs are low, both types of household are not constrained. This is because migration and remittances reduce the income range at origin, regardless of the initial income gap. The opposite result is not necessarily true. For high migration costs, poor households are significantly more constrained, so that inequality increases.

The CC variable is significant and positive at 1%. This result is contrary to the expected sign. This result is consistent with [105] who found, for example, that a one standard deviation increase in corruption increased the Gini inequality coefficient by about 11 points.

In Panel B (Palma's inequality), we find that the bank branch variable, BRCH, is significant and negative at the 1% level in model 1, 2 and 3

respectively. This result corresponds to the expected one. The variable ATMs, is significant and negative at the 1% level in models 4, 5 and 6 respectively. The sign of this result corresponds to the expected one which shows that the financial FI reduces the inequalities of the Palma ratio. And it is in line with the study [106] found that financial inclusion reduces inequality in the MENA region. The results of the study suggest that policymakers in the MENA region face two dilemmas: move towards reforms to promote financial inclusion, innovation and financial access, or focus on further improvements in financial stability.

Based on the SARMA index, the results of a study conducted on 37 Asian countries clearly show a strong and significant correlation between financial inclusion and the reduction of poverty and income inequality (Park C-Y et al, 2015). This and other studies [107, 108], support a positive link between access to finance and reduced inequality and poverty. They also shed new light on the channels through which access to finance for low-income people promotes social and economic development.

[109] who have highlighted the importance of the financial system in allocating resources to high return investments, thereby promoting economic growth and reducing inequalities.

With regard to the ICT variables (Mobile Phone, Net User and Broad band) the results show that the Mobile Phone variable is negative and significant at the 1% level in models 1 and 4. Its sign corresponds to that expected. The Net User variable is negative and significant at 1% in models 2 and 5. And finally the Broad band variable is negative and significant at 10% in models 3 and 6. Its sign corresponds to that expected. If we increase the mobile phone by one unit in model 1 and 4, it decreases the inequalities by 0.000541 and 0.00341 units respectively. In model 2 and 5 the use of internet decreases inequalities by 0.000599 and 0.000431 respectively. Finally, the Broad Band decreases inequalities by 0.00484 and 0.0858 respectively in models 3 and 6. This result is in line with the work of [72] which provides evidence of mobile penetration reducing inequality in Africa. Similarly, [110] find that mobile phone diffusion promotes inclusive development in sub-Saharan Africa. Again, they reveal that institutions reinforce the positive effect of mobile phones on inclusive growth. Studies in rural Peru have also shown that mobile coverage increases household consumption per capita and thus reduces extreme and absolute poverty [80]. ICTs improve access to relevant and up-to-date information, which is essential for development activities, mainly because they increase users' low-cost access to development inputs, increase their capacities and limit existing barriers [111]; the positive development externalities highlighted are more rewarding for the poor than for the richer

factions of the population in Africa ([72] The GoVConsum variable is negative and significant at the 1% level in models 2 and 6 . And in models 1 and 4, it is positive and significant at 1%. Its sign corresponds to that expected.

The School variable is significant and positive at the 1% level in models 1, 2 and 4 respectively. This result is contrary to the expected sign. It reveals that increasing education by one unit will increase inequality by 0.507, 0.180, and 0.52 units respectively. This result is in line with the work of Hendel and al. (2005) who showed that in situations where there are government programmes that aim to make borrowing easier or lowering school fees more affordable, the talented become educated and leave the pool of the uneducated, leading to a fall in the wages of unskilled workers and an increase in the skill premium, which results in higher levels of income inequality.

The remittances variable is significant and positive at 1% in model 2, 3, 4, and 5 respectively. At 5% in models 1 and 6. This result corresponds to the expected signs. This can be explained by the fact that remittances seem to reduce economic inequalities in communities with a long tradition of migration, but increase inequalities within communities at the beginning of the migration process. This is consistent with various theoretical arguments about the role of migration networks and/or the dynamics of intergenerational wealth transmission. It seems that the impact of remittances on income inequality depends on who migrates, i.e. the quintile that migrants occupy in the income distribution in their country of origin [112].

The CC variable is positive and significant at the 1% level in models 1, 2, 3, 4, 5 and 6. This result is contrary to the expected sign. This result is in line with e most researchers who agree that there is indeed a very significant relationship between income inequality and corruption. Some results from quantitative analyses suggest that countries with higher corruption also have higher inequality [113]. Some authors also suggest that controlling inequality could be a plausible method to reduce corruption. However, the relationship is probably not so simple: corruption is probably both a cause and a consequence of inequality [114]. For example, [105] found a significant correlation between income inequality and corruption in a selection of 37 countries. The authors argue that corruption increases inequality; in fact, a one standard deviation increase in corruption increases the Gini coefficient of income inequality by 11 points.

The overall finding of this analysis is that regardless of income inequality (GINI Index or Palma Ratio), FI (BranchBank, ATMs) and ICT (Mobile Phone, Net User, and Broad band) reduce this inequality in Africa.

4.2. Cross-variable Model

Table 7.

Dependent variable : Gini index						
	BranchBank			ATMs		
PANEL A	(A)	(B)	(C)	(D)	(E)	(F)
BranchBank	-0.000196***	0.00136***	-0.000900***			
	(3.88e-05)	(3.58e-05)	(4.61e-05)			
ATMs				-0.000806***	-0.000437***	-0.000141***
				(0.000135)	(1.77e-05)	(5.15e-05)
Mobile	0.000138***			-5.39e-05**		
	(1.44e-05)			(2.15e-05)		
Internet		0.000162***			-0.000539***	
		(9.64e-06)			(2.60e-05)	
Broadband			-0.00455***			-0.00404***
			(0.000310)			(0.000547)
FI*Mobile	4.73e-06***			7.41e-06***		
	(7.08e-07)			(7.63e-07)		
FI*Internet user		3.93e-05***			9.92e-06***	
		(9.01e-07)			(2.91e-07)	
FI*Broadband			0.000119***			4.71e-05***
			(6.25e-06)			(9.02e-06)
Government consumption	-0.000263**	-0.000278***	-0.000892***	-0.000393***	-0.000203***	-0.000654***
	(0.000112)	(4.00e-05)	(9.75e-05)	(0.000121)	(6.88e-05)	(0.000161)
Education	-0.124***	-0.0453***	0.110***	0.0725***	0.0184***	-0.0623**
	(0.00988)	(0.00188)	(0.00701)	(0.0101)	(0.00569)	(0.0280)
Remittances	2.96e-06	8.72e-05	0.000483***	0.000160	1.66e-05	0.000362**
	(0.000124)	(5.89e-05)	(9.81e-05)	(0.000132)	(0.000115)	(0.000165)
Control corruption	0.00120	0.00519***	0.0143***	0.0101***	0.0132***	0.0123***
	(0.00137)	(0.000459)	(0.000701)	(0.00140)	(0.000269)	(0.00134)
Lgini	0.877***	0.867***	0.818***	0.820***	0.863***	0.875***
	(0.0155)	(0.00282)	(0.00432)	(0.00552)	(0.00234)	(0.0104)
Constant	0.185***	0.120***	0.0275***	0.0474***	0.0789***	0.149***
	(0.00727)	(0.00284)	(0.00758)	(0.00585)	(0.00481)	(0.0295)

Comments	328	323	298	276	272	253
Number of countries	42	42	41	41	41	40
AR(1)	0.191	0.198	0.287	0.193	0.199	0.267
AR(2)	0.215	0.224	0.365	0.194	0.338	0.203
Instruments	32	41	40	40	40	32
Hansen OIR	0.335	0.372	0.558	0.607	0.228	0.467
Fisher	47595***	101913***	355834***	116505***	191435***	43546***

Dependent variable: Palma Ratio Index						
PANEL B	Branch Bank			ATMs		
	(G)	(H)	(I)	(J)	(K)	(L)
Branch Bank	-0.0498***	-0.0266***	-0.0242***			
	(0.00814)	(0.00468)	(0.00281)			
ATMs				-0.0423***	-0.0314***	-0.00457***
				(0.00632)	(0.00381)	(0.00144)
Mobile	-0.00487***			-0.00242***		
	(0.000550)			(0.000731)		
Internet		-0.00456**			-0.00764***	
		(0.00194)			(0.00240)	
Broadband			-0.0756***			-0.0392***
			(0.0121)			(0.0140)
FI*Mobile	0.000249***			0.000302***		
	(4.46e-05)			(4.86e-05)		
FI*Internet user		0.000451***			0.000822***	
		(0.000119)			(0.000111)	
FI*Broadband			0.00288***			0.000492***
			(0.000279)			(0.000159)
Government consumption	0.0180***	-0.00693	-0.00624	0.00139	-0.0371***	0.00112
	(0.00516)	(0.00434)	(0.00376)	(0.00817)	(0.00482)	(0.00309)
Education	1.205***	1.424***	-0.287	-0.809	0.322	-0.345
	(0.424)	(0.436)	(0.369)	(0.556)	(0.701)	(0.220)
Remittances	0.0224***	0.0462***	0.0265***	0.0383***	0.0974***	0.00691**
	(0.00826)	(0.00647)	(0.00454)	(0.00841)	(0.00966)	(0.00304)
Control corruption	0.561***	0.0979**	0.343***	0.328***		0.149***
	(0.0665)	(0.0438)	(0.0360)	(0.0676)		(0.0305)
Lpalmaratio	0.858***	0.903***	0.898***	0.902***	0.979***	0.938***
	(0.0193)	(0.00767)	(0.00826)	(0.0230)	(0.0141)	(0.0110)
Constant	0.0700	-0.670*	1.182***	1.580***	0.232	0.759***
	(0.399)	(0.334)	(0.372)	(0.518)	(0.612)	(0.234)

Comments	328	323	298	276	249	253
Number of country	42	42	41	41	40	40
AR(1)	0.0863	0.104	0.0974	0.109	0.103	0.132
AR(2)	0.367	0.279	0.356	0.215	0.199	0.304
Instruments	36	40	36	30	30	28
Hansen OIR	0.928	0.717	0.803	0.619	0.852	0.413
Fisher	1502***	37425***	19290***	2815***	3550***	2327***

Note: ***,**,*: Significance levels at 1%, 5% and 10% respectively. Standard errors reported in parenthesis. The significance of bold values is twofold. 1) The significance of estimated coefficients and Wald statistics. 2) The failure to reject the null hypothesis of: a) no autocorrelation in the AR (1) & AR (2) tests and; b) the validity of the instruments in the Hansen OIR tests.

Source: Author based on Stata 15

The various analyses in Table 8 above show that access to formal financial services reduces income inequality (GINI and Palma). In this sense, the poor can now finance their projects, avoid shocks and ensure good health. Accompanied by the mobile phone as a catalyst for access to financial services, Donovan (2012) presents the benefits and potential impact of mobile money in promoting FI in developing countries. It notes that mobile money has the potential to contribute to FI in developing countries and recommends appropriate regulation for the sector to deliver on its promise. The results in Table 8 of the interaction between FI and ICT have positive and significant signs. ICTs enhance the beneficial effect of FI on inequality, and a strengthening of ICTs could therefore improve FI by curbing the expansion of income inequality.

The results of the interaction between ICT and FI turn out to be highly significant for the reduction of inequalities in our sample. On average, the estimated coefficients of the interaction terms are positive and statistically significant at the 1% level, implying that mobile phones can contribute to the reduction of inequality. The significant positive interaction between FI and ICT shown in the table below suggests that ICT enhances the reduction of inequality brought about by FI. These results corroborate with the work of Abor et al. 2018 who find that mobile phone penetration and financial inclusion significantly reduce the probability of a household becoming poor and increase its per capita consumption of food and non-food items. Our results show that the social benefits of mobile phones and financial inclusion are not more pronounced in female-headed households. This information serves as a useful guide to government and other stakeholders seeking ways to improve livelihoods.

6. Conclusion and Future Research Directions

The objective of this section was to analyze the role of FI on income inequality via the ICT channel. The literature shows in theory that FI remains a better lever for growth and poverty reduction. Empirical work shows us that FI acts positively on growth and ICT is a channel of diffusion of financial services where banking fails to serve the populations. The originality of our paper lies in the fact that no work has ever been done in Africa highlighting ICT as a catalyst for FI in reducing income inequality. And beyond the selected measures, we introduced the insurance variable (LINSUR). The GMM analysis shows that FI reduces income inequality through the ICT channel. In the framework of this study, the results of the interactions obtained show that ICTs improve the reduction of the two inequalities (Income Inequality and Palma Inequality) of income present in our study.

The future focus of our work could be on each individual country. For the political specificities of the different countries or economic zones would affect the different inequalities more or less.

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