



Does ICT Diffusion Improve Financial Inclusion in Africa?

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JEMT/2020/v26i1130323

Editor(s):

(1) Dr. Ehlinaz Torun Kayabasi, Kocaeli University Arslanbey Vocational School, Turkey.

Reviewers:

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(2) Francesca Leccis, University of Cagliari, Italy.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/66233>

Original Research Article

Received 25 October 2020

Accepted 30 December 2020

Published 31 December 2020

ABSTRACT

This article examines the effects of Information and Communication Technologies (ICT) diffusion on financial inclusion from a sample of 52 African countries. We specify and estimate a panel data model by Ordinary Least Squares (OLS) over the period 2006-2019, based on the different approaches of financial inclusion. Our results show that, ICT diffusion increases financial inclusion as well as penetration, accessibility and use of financial services in Africa. We suggest policies to promote ICT infrastructure to stimulate financial inclusion by promoting digital finance.

Keywords: Africa; ICT; financial inclusion; OLS.

JEL Classification : O14; O47; R22; E51.

1. INTRODUCTION

Information and Communication Technologies (ICT) remains vital for the development of any country in the world. Digital technologies have been severely cited in academic work. In times of crisis, in the face of a natural disaster or

pandemic, digital connectivity is the thread that keeps people, governments and businesses connected. In the contemporary setting, technology is enabling non-financial institutions such as telecommunication firms to provide financial services, commonly referred to as fintech innovation [1]. One such fintech

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innovation, often touted as a key enabler of financial inclusion, is ICT diffusion [2]. In prior studies, facilitating condition has been found to positively influence intention to use technologies such as mobile payment services, shopping apps and ICTs [3,4]. It was not until the end of the 2000s, coupled with the rise of the New Information and Communication Technologies (NICTs), that a new financial paradigm emerged, namely financial inclusion as a major development issue. For the World Bank [5], financial inclusion is a building block for both poverty reduction and opportunities for economic growth with access to digital financial service critical for joining the new digital economy. It's organized around payments, savings, credit and insurance [6].

The literature on financial inclusion could be divided into three parts, namely: (i) constructing indicators that measure financial inclusion from the micro and macroeconomic perspectives [7] (ii) investigating the effects of financial inclusion on economic, institutional and technological variables [8] (iii) examining of economic, institutional and technological determinants of financial inclusion [9-11]. The theoretical consolidation which allows for distinguishing the nature, consequences and causes of financial inclusion, favored the emergence of two approaches. The pessimistic approach argues low-income population over-indebtedness, reproduction of social exclusion practices and reinforcement of power asymmetries [12,13]. The optimistic approach underlines that financial inclusion makes services accessible at affordable costs, decreases poverty, boosts prosperity, employment, trade and competitiveness [14]. Research at the micro and macroeconomic levels shows that better financial inclusion in addition to relate to numerical economy. Modern ICT can act as a tool to develop a platform which helps us to extend the financial services in remote areas.

The development of ICT infrastructure consolidates financial inclusion by reducing market imperfections and promoting financial functions. ICT adoption in Africa have steadily grown since the turn of the century. Subsequently, studies have sought to investigate several of its benefits, particularly for financial development, economic growth and entrepreneurial activities. Little attention has been paid to Africa, human capital development and economic freedom within studies on ICT and financial inclusion. According Sassi and

Mohamed [15], the development of ICT infrastructure eases monitoring managers and exerting corporate control which are an important function of financial intermediaries among the five functions provided by Levine [16]. Besides, a good ICT infrastructure reduces information asymmetries and price volatility, and increase responsiveness of fishing businesses. The rapid diffusion of ICT plays as one key driver of financial inclusion through the technological innovation channel since it contributes to innovation and to the development of new products and processes. Although the impact of ICT is little investigated a consensus remains in the literature Mushtaq and Bruneau [17] found that ICT diffusion boosts financial inclusion.

Africa is undergoing an unprecedented financial inclusion, amplified by the financial liberalization that favored the emergence of modern finance in the early 2000s, the digital economy and the consolidation of investment [5]. As a reference to the number of people with a bank account, its rate has passed from 25% in 2004 to 40% in 2018. This realization of the high financial inclusion is forcing the World Bank to adopt a new global strategy on financial inclusion and to launch the "Universal Financial Access 2020" initiative, which aims at ensuring that, by 2020, adults who are not currently part of the formal financial system may have access to a transaction account to save money, send and receive payments as a basic means of in managing their financial lives. The remarkable progress has been made in improving access to financial services, with the number of unbanked adults falling to 1.7 billion, representing almost 40 percent of adults in the world (Global Financial Index Database, 2018).

In Africa, ICT is growing rapidly. Two justifications can be put forward. Firstly, the rate of mobile phone subscription per 100 inhabitants rose from 0.006 in 1991 to 83.16% in 2017 [5]. The mobile phone market represented an overall turnover of 48.5 billion euros in 2015, or 6% of the global market. In terms of employment, the sector had more than 3.5 million people with revenues of around 4 to 5% of the GDP of African countries. Between 2005 and 2015, the number of devices used on the continent increased from 130 million to 900 million, with an average of 200 million smartphones. According to Global System for Mobile Association [18] estimates, this figure is expected to reach 500 million by 2020. The association of mobile phone operators, mobile payments currently amount to

\$1 billion a day, via 276 systems deployed in 90 countries. Secondly, the internet penetration rate rose from 0.004 in 1991 to 26.43% in 2017. Its contribution to the African economy is expected to reach 5 to 6% by 2025 (Africa Development Bank, 2019). Africa alone had more than 500 million unique subscribers in 2016, representing a penetration rate of 43%. This rate is projected to exceed 50% in 2020, with approximately 725 million subscribers. The number of Subscriber Identity Module (SIM) card connections was 772 million in 2016 and is expected to exceed one billion by 2020. The increase for Africa as a whole was 344% in ten years. At the same time, the number of connections in the rest of the world increased from 3.2 billion to 6.6 billion, an increase of only 107%. Given its population growth, sub-Saharan Africa is a significant market for the ICT economy. Its weight, already estimated at 7.7% of the GDP, is expected to reach 8.6% in 2020 with tax revenues of around \$13 billion (GSMA, 2019).

The issue of financial inclusion by ICT diffusion continues to fuel controversy. Despite the current context of intensive use of information in many activities, the contribution of ICTs to Africa's financial inclusion is still in vain. These tools are seen by their critics as an unproductive luxury in light of traditional development priorities in Africa. Considering the current paradigm shift determined by the weight of information and its vector, and which Africa obviously does not escape, there is a lack of interest in the capacity of ICTs to effectively assist in financial inclusion process, in favor of their efficient and effective use for sustainable inclusion.

The relationship between ICT and economic growth has been widely discussed since the 1980s, based on the theories that consider technological progress as fundamentally stimulating economic growth (Aghion and Howitt, 1992; Romer, 1990). In fact, ICT entails technologies that help in facilitating, creating, storing, sending, transmitting, receiving, and manipulating information, which impacts the development and technology of different industries and thus alters economic activities. ICT contributes positively to economic growth, since it provides high-performance tools and software to economic sectors and enhances productivity growth. ICT have the potential to solve the dilemma of this "win-win" situation, that is, producing more output from less energy, and can lead to increased growth, productivity, and employment.

The only important element of the COVID-19 crisis is ICT, which confirm that technology startups have incredible potential to change our lives. Therefore, recent developments surrounding the COVID-19 crisis present challenges and opportunities for financial inclusion going forward. Without claiming to be exhaustive, we can underline the severe setbacks suffered by the real economy, that have weakened borrowers' ability to repay, countering thus non-bank institutions such as microfinance lenders. Fintech startups have been similarly affected, with venture capital and investors forced to withdraw funding. These aspects have increased the transition to digital payments.

The objective of this paper is to determine the effects of ICT diffusion on financial inclusion in Africa. This constitutes an important part of few literatures which seeks to explain financial inclusion in a technological perspective. Indeed, the issue of factors influencing financial inclusion in developing countries focused on economic and institutional factors. This study contributes at the same time to the macroeconomic literature on measuring financial inclusion and responds to Sustainable Development Goals (SDGs) challenges by means of ICT and financial access. In fact, ICT can accelerate SDG1 (End poverty in all its forms everywhere), SDG5 (Achieve gender equality and empower all women and girls), SDG10 (Reduce inequality within and among countries) and SDG16 (Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels).

To this, we consider a sample of fifty-two African countries over the period 2006-2019. The empirical approach is implemented by Ordinary Least Squares and consolidated by fixed effects. The results show that ICT diffusion increases financial inclusion in Africa.

The rest of the paper is organized as follows. Section 2 provides a brief literature review. Section 3 describes the model specification and data. Section 4 reports and analyzes the empirical results. Section 5 concludes.

2. SPECIFIC LITERATURE REVIEW

The literature on the relationship between ICT diffusion and financial inclusion is recent and goes back to its rapid progress in last decade. A lack of consensus remains in the literature. While

theories predict a positive effect of ICT on financial inclusion, empirical studies produced mixed results.

An increasing number of empirical studies have confirmed the positive effect of ICT diffusion on financial inclusion. Andrianaivo and Kpodar [19] using the System Generalized Method of Moment (S-GMM) estimator on a panel of 44 African countries over the period 1988-2007, found that broad adoption of ICTs positively impacts financial inclusion, and as a result generates positive spillovers for financial development and economic growth. Sarma and Pais [20] exhibit effect of ICT and related infrastructure to boost financial inclusion. Mishra and Shailendra [21] found that, mobile technology boosts financial inclusion particularly in far remote areas in countries. Ashenafi and Makina [22] using cross-sectional data of 168 countries, of which 48 African countries over the period 2012-2017, found that technology is fostering both access to and use of financial services. Mushtaq and Bruneau [17] through a panel dataset of 62 countries between 2001-2012, found by using S-GMM estimator's that ICT diffusion boosts financial inclusion, helping in reaching out the poor in a number of ways, by e-banking, mobile- banking and mobile ATMs. It also helps access to timely and cheap information and better connectivity with micro loan officers. Makina [23], found that mobile money facilitated by mobile technology stands out as the most successful innovation in extending financial inclusion in Africa.

Freeman and Soete [24], Aghion and Howitt [13] argue that ICT could impose negative impact on financial inclusion in developing countries. Using GMM and Quantile Regressions in a panel of 162 banks, Asongu et al. [25] assess how the diffusion of information mitigates the negative effect of market power on the quantity and price of loans. Peruta [2] using a macroeconomic approach with cluster analysis in countries where access to formal banking services is low, found that mobile money use doesn't promotes financial inclusion. In order to investigate if mobile money can help firms reduce financial access constraints, Gosavi [26] 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. Bongomin et al. [27] have tested the moderating effect of social networks in the linkage between financial inclusion and mobile money use in rural Uganda,

found a positive and significant moderating effect of social networks in the connection between the use of mobile money and financial inclusion.

Therefore, empirical evidences demonstrate the impact of ICT on financial inclusion is limited to African countries. It is also imperative to place emphasize on to study the role of ICTs in expanding financial inclusion.

3. EMPIRICAL STRATEGY

It's presented in two successive stages. Firstly, the empirical model and secondly, the data.

3.1 Empirical Specification

Following Ashenafi and Makina [22], we use a standard financial inclusion model expressed by the following equation:

$$Financial_inclusion_{it} = \beta_0 + \beta_1 ICTs_{it} + \beta_2 X_{it} + \mu_t + \nu_i + \varepsilon_{it} \quad (1)$$

where $t = 1, \dots, T$, and $i = 1, \dots, N$. T and N denote the time-dimension and the country, respectively. Financial Inclusion represents financial inclusion in country i at period t , is a composite index of three indicators (Penetration, Accessibility, Use) of financial services. The penetration of financial services among the population is captured by the number of bank branches per 1000 inhabitants [28]. The accessibility of financial services takes into account the number of ATMs per 1000 inhabitants [29]. The use of financial service is measured by the number of active mobile phone accounts per 1000 inhabitants [30].

$ICTs_{it}$ represents the Information and Communication Technologies diffusion of country i in period t , measured through: (i) People using the Internet (% of the population) in the past 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, game machine, digital TV, etc; (ii) Cellular mobile subscriptions (per 100 people) are subscriptions to a public mobile telephone service which provide access to the Public Switched Telephone Network (PSTN) using cellular technology. The indicator includes the number of postpaid subscriptions and the number of active prepaid accounts (i.e. which have been used in the past three months). It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private mobile radio, tele-pointing, and radio paging and telemetry services; (iii) Fixed broadband subscription are fixed telephone lines (per 100 people). The use of the Internet and

mobile provides access to employment opportunities in a globalized world and contributes to the empowerment of women [31]. X_{it} represents the vector of exogenous variables that integrates: (i) Human capital is approximated by the number of students enrolled in the secondary. It provides basic skills and the ability to acquire and internalize new technologies related to remuneration, expenses, budgeting, borrowing, savings and the use of other financial services [32]. The expected sign for this variable is positive; (ii) House consumption informs on the level of household consumption. So the accessibility to certain products and notably their payment requires the use of information and communication technologies and decreases financial inclusion [6]; (iii) Infrastructures is approximated by the number of telephone lines per 100 inhabitants. They significantly reduce transaction costs, increase the productivity of industries. In addition, access to financial services also depends on the density of infrastructures and the quality of transport [33]. The expected sign is positive; (iv) Private investment measured by gross capital formation reflects the accumulation of physical capital and shows the contribution of the private sector to domestic production. It contributes to the development of enterprises, facilitates innovation, stimulates demand for financial services and also strives to eliminate disparities in financial inclusion [34]. The expected sign for this variable is positive; (v) Remittances measured by remittances inflows to GDP (%). Naceur et al. [9] found a more nuanced relationship for financial inclusion at the macro level. When remittances are low, they act as a substitute for financial inclusion, but then complement or help to boost financial inclusion when they surpass a certain level; (vi) Trade openness measured by total amount of exports and imports over GDP. According Naceur et al. [9], higher volumes of trade are likely to generate more payments to exporters and importers and create higher demand for financial instruments and more inclusion in the banking sector. Thus, the coefficient of Trade openness is expected to be positive. (vii) Urbanization measured by a percentage of the population living in cities. Urbanization plays a capital role in the economic development. For instance, Urbanization increases human development, economic activities. Ongo and Song [35] confirm that urbanization increase inequalities in Africa. But regarding many published works, we postulate that urbanization increases financial inclusion in Africa and the expected sign is positive.

Therefore, β , μ_i , v_t and ε_{it} represent the coefficient, the country effects, the time effects and a residual term. All variables are listed in Table 1. In order to take into account, the effects of ICTs on disaggregated index, we replace every time the dependent variable by the financial inclusion considered (global, penetration, accessibility and use of financial services).

$$\begin{aligned} \text{Financial_inclusion}_{it} = & \beta_0 + \beta_1 \text{Internet}_{it} + \beta_2 \text{Mobile_phone}_{it} + \beta_3 \text{Fixed_broadband}_{it} + \beta_4 \text{Hum_cap}_{it} \\ & + \beta_5 \text{Urbanization}_{it} + \beta_6 \text{Pri_inv}_{it} + \beta_7 \text{Hou_con}_{it} + \beta_8 \text{Infra}_{it} + \beta_9 \text{Remittances}_{it} \\ & + \beta_{10} \text{Trade}_{it} + \beta_{11} (\text{Internet} * \text{Mobile})_{it} + \beta_{12} (\text{Internet} * \text{Loan})_{it} + u_i + v_t + \varepsilon_{it} \end{aligned} \quad (2)$$

Regressions are made in panel data by the Ordinary Squares (OLS). The choice of this method is justified by the fact that our main variable of interest, (ICT) is divided into three indicators: Internet, the Mobile Phone and the Fixed Phone are time variants. This approach lends itself better to our study, which aims to explain financial inclusion from a technological perspective.

3.2 Methodology

The data are from World Development Indicators (2019) and Global Financial Inclusion Database (2019). We use annual data of 52 African countries (Table 2). The sample spans through the period from 2004 to 2018, the choice being dictated by the availability of data for all the countries under consideration. The data cover the following financial, macroeconomic, and institutional variables.

Descriptive statistics (Table 3) show small variations. It is generally accepted that small fluctuations in data result in unbiased results.

The correlations between the different variables are not high enough to cause serious multicollinearity problems.

According to Fig. 1, there is a net increase in use, penetration and accessibility of financial services. The evolution of these indicators suggests an improvement in the financial inclusion in 2019. Three explanations can be mentioned. Firstly, the various initiatives undertaken to improve people's access to financial products and services through the development of national inclusion strategies, implementation of programs and policies aimed at strengthening the need for financial inclusion, the implementation of the monitoring system

implementing regional financial inclusion strategies and strengthening the regulatory framework for financial institutions activities. Then, the rise in the number of accounts and bank customers, the diversification of the banking services and the dynamism of the microfinance sector. These aspects have increased the geographical proximity of financial services through changes in the distribution networks of financial electronic money services. Finally, the strengthening of banking regulation

from 2009, promoted financial inclusion through the digitalization of financial service offered in this continent with high mobile penetration is the major initiative to improve access to banking services. Therefore, the dynamics of Africa's financial inclusion offers a new perspective that contributes to the African Union's Agenda 2063 for the Transformation of Africa, the Sustainable Development Goal (SDG) 9 and 10 to build resilient infrastructure, encourage innovation and reduce disparities.

Table 1. Presentation of the selected variables

Variables	Description	Sources
Use of financial services	Number of active mobile phone accounts per 1000 inhabitants	GFID(2019)
Penetration	Number of bank branches per 1000 inhabitants	GFID(2019)
Accessibility	Number of vending machines per 1000 inhabitants	GFID(2019)
Mobile phone	Mobile phone subscriptions (per 100 people)	WDI (2019)
Internet	Internet subscriptions (per 100 people)	WDI (2019)
Fixed broadband	Fixed broadband (per 100 people)	WDI (2019)
Human capital	Gross secondary school enrolment rate	WDI (2019)
Private investment	Gross capital formation as a percentage of GDP	WDI (2019)
House consumption	Household final consumption as a percentage of GDP	WDI (2019)
Infrastructures	Number of telephone lines per 100 inhabitants	WDI (2019)
Urbanization	Percentage of the population living in cities	WDI (2019)
Trade openness	Total amount of exports and imports over GDP	WDI (2019)
Loans	Total credit given by financial system over GDP	WDI (2019)
Remittances	Remittance inflows to GDP (%)	WDI (2019)

Source: Authors

Table 2. List of countries

Algeria, Angola, Benin, Botswana, Burkina-Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo Democratic Republic, Congo, Djibouti, Gabon, Equatorial Guinea, Cabo-Verde, Cote d'Ivoire, Egypt, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Maurice, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra-Leone, Somalia, Swaziland, South Africa, Tanzania, Tunisia, Togo, Uganda, Zambia, Zimbabwe.

Source: Authors

Table 3. Descriptive statistics

Variables	Observations	Mean	CV	Std. Dev	Minimum	Maximum
Penetration	640	6.830	1.34	9.189	0.132	53.348
Use	728	25.486	3.17	80.795	12.530	679.357
Accessibility	639	11.152	1.41	15.782	2.420	83.189
Internet	707	11.809	1.18	13.976	0.031	64.191
Fixed broadband	714	3.730	1.64	6.121	0.352	32.669
Mobile phone	718	55.380	0.75	41.684	0.210	175.873
Education	728	47.600	0.51	24.345	8.774	102.754
Urbanization	722	43.107	0.41	17.933	9.139	88.976
Private investment	644	22.368	0.39	8.884	2.000	61.469
Remittances	611	3.887	1.34	5.215	0.251	41.499
Trade	673	78.329	0.54	42.436	19.101	376.224
House	647	70.179	0.32	23.078	8.573	228.364
Consumption						
Infrastructures	667	3.863	1.63	6.300	0.032	32.653

Source: Authors. Note : CV: Coefficient of variation

Table 4. Correlation matrix

	Use	Int	Fixed	Mobile	Educ	Urban	Priv_inv	Remitt	Trade	House	Infra
Use	1										
Internet	0.015*	1									
Fixed_bro	0.0546*	0.530*	1								
Mobile_ph	0.0629*	0.759*	0.456*	1							
Educ	0.4170*	0.062	-0.030	-0.011	1						
Urban	-0.0986*	0.420*	0.3525*	0.4963*	0.191*	1					
Priv_inv	0.0258	0.186*	0.1459*	0.2554*	0.0493	0.259*	1				
Remitt	0.2127*	0.0216	-0.0502	0.0111	-0.075	-0.101*	-0.088*	1			
Trade	0.0733	0.200*	0.3713*	0.212*	0.116*	0.403*	0.311*	0.092*	1		
House_con	-0.0899*	-0.0323	0.0405	0.058	-0.26*	-0.012	-0.125*	0.250*	0.078	1	
Infra	0.148*	0.116*	-0.005	-0.027	0.742*	0.052	0.125*	-0.058	0.004	-0.208*	1
Penetration	1	Internet	Fixed_bro	Mobile_ph	Educ	Urban	Priv_inv	Remitt	Trade	House	Infra
Internet	0.074*	1									
Fixed_bro	0.106*	0.530*	1								
Mobile_ph	0.021*	0.759*	0.456*	1							
Educ	0.645*	0.062	-0.030	-0.011	1						
Urban	0.030	0.420*	0.352*	0.496*	0.191*	1					
Priv_inv	0.021	0.186*	0.145*	0.255*	0.049	0.259*	1				
Remitt	-0.111*	0.021	-0.050	0.011	-0.075	-0.101*	-0.088*	1			
Trade	0.1376*	0.200*	0.3713*	0.2127*	0.11*	0.403*	0.3110*	0.092*	1		
House_con	-0.215*	-0.032	0.040	0.058	-0.26*	-0.012	-0.125*	0.250*	0.078	1	
Infra	0.738*	0.116*	-0.005	-0.027	0.742*	0.052	0.125*	-0.058	0.004	-0.208*	1
Accessibility	1	Internet	Fixed_bro	Mobile_ph	Educ	Urban	Priv_inv	Remitt	Trade	House	Infra
Internet	0.080*	1									
Fixed_bro	-0.008	0.530*	1								
Mobile_ph	0.039*	0.759*	0.456*	1							
Educ	0.7595*	0.0622	-0.0306	-0.011	1						
Urban	-0.024	0.420*	0.3525*	0.4963*	0.191*	1					
Priv_inv	-0.0494	0.186*	0.145*	0.255*	0.049	0.259*	1				
Remitt	-0.043	0.021	-0.050	0.011	-0.075	-0.101*	-0.088*	1			
Trade	0.030	0.200*	0.371*	0.212*	0.116*	0.403*	0.311*	0.092*	1		
House_con	-0.183*	-0.032	0.040	0.058	-0.26*	-0.012	-0.125*	0.250*	0.078	1	
Infra	0.666*	0.116*	-0.005	-0.027	0.742*	0.052	0.125*	-0.058	0.047	-0.207*	1

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; standard deviations robust to heteroscedasticity in parentheses

Source: Authors

Africa still appears at the bottom of the world rankings in terms of ICT development and the exploitation of their potential. As shown in Fig. 2. Africa has seen significant advances in ICT in favor of the democratization of computer equipment and Internet in the 1990s. As an illustration, the Internet penetration rate increased from 0.004% in 1991 to 26.43% in 2017 as a result of the modernization of technological infrastructures which contribute to digitalization and the digital economy. The internet penetration rate is strongly growing and was estimated at 26.43 % in 2017 in Africa, less than 22 % for sub-Saharan Africa, while the world average exceeds 45%. The plausible explanation stems from the fact that more than half of Internet connections go through the mobile phone rather than a computer. In addition, the spread of smartphones has only accelerated recently with the emergence of a second-hand product market and the appearance of more financially and technologically accessible devices, often made in China. With an average annual growth rate of more than 6% according to the GSM Association (2017), mobile telephone is experiencing stronger growth although disparities remain in Africa. For example, in Niger and the Central African Republic, the penetration rate of mobile telephone does not reach 25%. In Eritrea it is estimated at 9%. In Mauritius, Seychelles, Botswana and South Africa, the rates are close to 70%. In recent times, advancement in internet technology has continued to drive the digital revolution in financial transactions across the world through the use of mobile phones, personal computers, mobile applications, debit/credit cards and other facilities. The adoption of internet technology has also brought innovations that seem to be encouraging efficiency and financial inclusion in developing countries.

Africa is experiencing unprecedented rapid financial inclusion, so the rate is estimated at 60% by 2050, given its investment and reforms aimed at digital economy, qualitative and quantitative improvement of infrastructure. However, the sustainability, inclusiveness and digitalization of these processes amplify the digital transition through the adoption and dissemination of ICT, implicitly inducing the problem of financial inclusion in Africa. Thus, Africa continues to respond favorably to global calls through actions on sustainable, interest and dedication to promoting financial inclusion. It is not surprising that financial inclusion is found in seven of the seventeen Sustainable

Development Goals (SDGs), to the extent that it's part the prism of integrity, accessibility and use in Africa. It's there for important to understand the scale of innovations, and take into account physical and institutional integration, involving investment strengthening, governance, uncertainty eradication, poverty and inequality in a context of population explosion.

For Kenya and Malaysia, payments are directly made in an account. These countries face economic and development challenges, and the growth rate of GDP remains insufficient for reducing vulnerability for a large segment of the population, particularly women, youth, and the disabled. The financial reforms market has been successful in recent years. Mobile operators are now subject to clear rules for providing mobile money services. In addition, the process of ensuring access to financial services and timely and adequate credit where needed by vulnerable groups such as weaker sections and low income groups at an affordable cost.

4. RESULTS

This section reports and discusses the empirical results from the basic model and the robustness analyses.

4.1 Results from the Basic Specification

The results of the effect of ICT on financial inclusion are reported and discussed in this section. The results of the OLS estimators are presented in Table 5 by considering Internet, mobile phone and Fixed broadband as ICT proxy. The results are presented for the linear specifications. With regard to the OLS, the coefficient of determination (R-squared) varies between 0.709 and 0.734 0.687 for the models with Internet, mobile phone and Fixed broadband, indicating a good quality of adjustment of our models.

Overall, the results show positive and statistically significant effects of Internet and Mobile Phone variables on Penetration, Accessibility and Use of financial services (Table 5). For Peruta [2], this result reflects the importance and persistence of ICT under aegis of innovations, making it easy to spread financial services. The internet and mobile phones are increasing the popularization of financial services. They help to improve economic and human wellbeing on the plethora of fronts, including enhancement of corporate performance, reduction of income disparities

between the rich and the poor, facilitation of improved health outcomes and availment of financial access. In addition, ICT diffusion is important because of higher levels of economic inclusion and saturation in the penetration of information technology. The others plausible explanations lie in the need to eradicate physical, bureaucratic, and financial barriers to expand financial inclusion as challenge since this also requires addressing the underlying structural causes. Thus, measures to improve contestability of financial systems and underlying information and regulatory environment are also likely to speed up the introduction and adoption of new products, processes, and technology that may help further lessen these barriers in Africa. ICT diffusion 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. These aspects densify financial inclusion through financial education, the penetration of financial services, the accessibility and use of financial services and instruments that help make financial decisions, strengthen the behaviors of target groups that can lead to better budget planning, increased savings, more thoughtful spending and borrowing. However, these behaviors promote the emergence of economic activities and indirectly contribute to urbanization through the modernization of cities. Recent technological advances like innovation, mobile money and the creation of new banking services are enhancing conditions for financial access in Africa. These results are consistent with those of Bongomin et al. [27].

can be put forward. Firstly, in accordance with Gérineau and Jacolin [32], human capital as the ability to acquire and internalize new technologies consolidates the penetration, accessibility and use of financial services. Then, a better educated population, combined with effective trade openness and basic infrastructure, contribute to increasing accessibility to a range of banking services by households and businesses at a reasonable cost. Thus, education strengthens access to financial services by expanding knowledge about money and the role of banks. It creates financial literacy, with basic information about money and the benefits of a relationship with a formal banking institution, allowing consumers to understand financial messages transmitted through social networks or other popular channels. These results are tenable, as a means of providing sustainable access to financial services, as well as a diversity of financial service providers to provide clients with a wide variety of efficient solutions. These results are in line with those obtained by Ouma et al. (2017). Finally, Infrastructure underpins penetration, accessibility, and use, reducing the risks and costs of providing financial services to low-income individuals and micro and small enterprises. In addition, payment systems facilitate business transactions, government payments, remittances, and innovative retail payments and bring safety and efficiency to a financial system. In fact, Human capital, Trade and notably infrastructures, favours building innovations in the fintech sector, from the block chain to artificial intelligence, reconfiguring the entire financial services value chain, although balance is needed between the use of financial technologies, risk management, and stability and the protection of low-income consumers.

Therefore, Human capital, Trade and infrastructures have positive and significant effects on ICT components. Three explanations

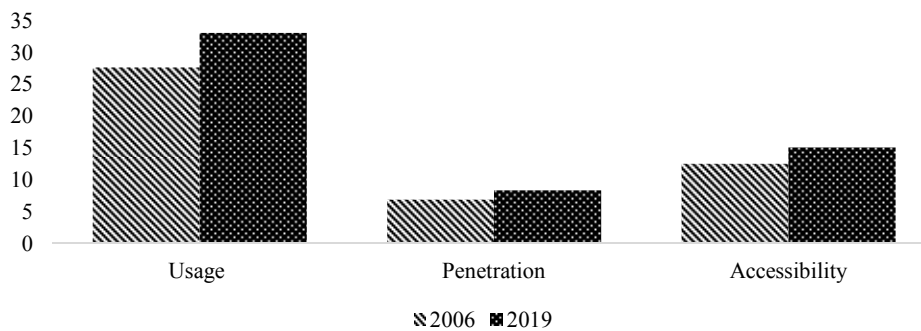


Fig. 1. Evolution of financial inclusion indices in Africa

Source: Authors, from GFID (2019)

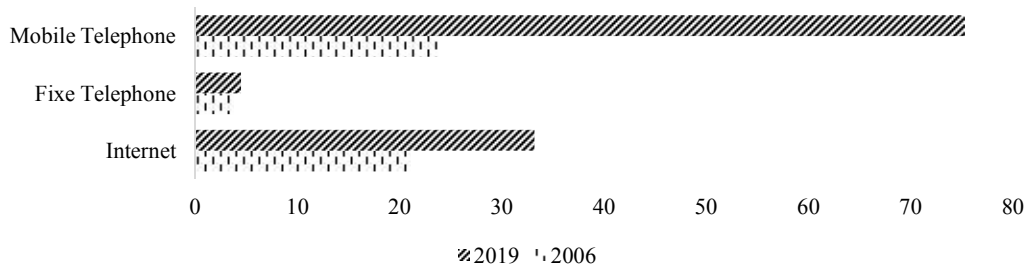


Fig. 2. ICT diffusion in Africa
Source: Authors, from WDI (2018)

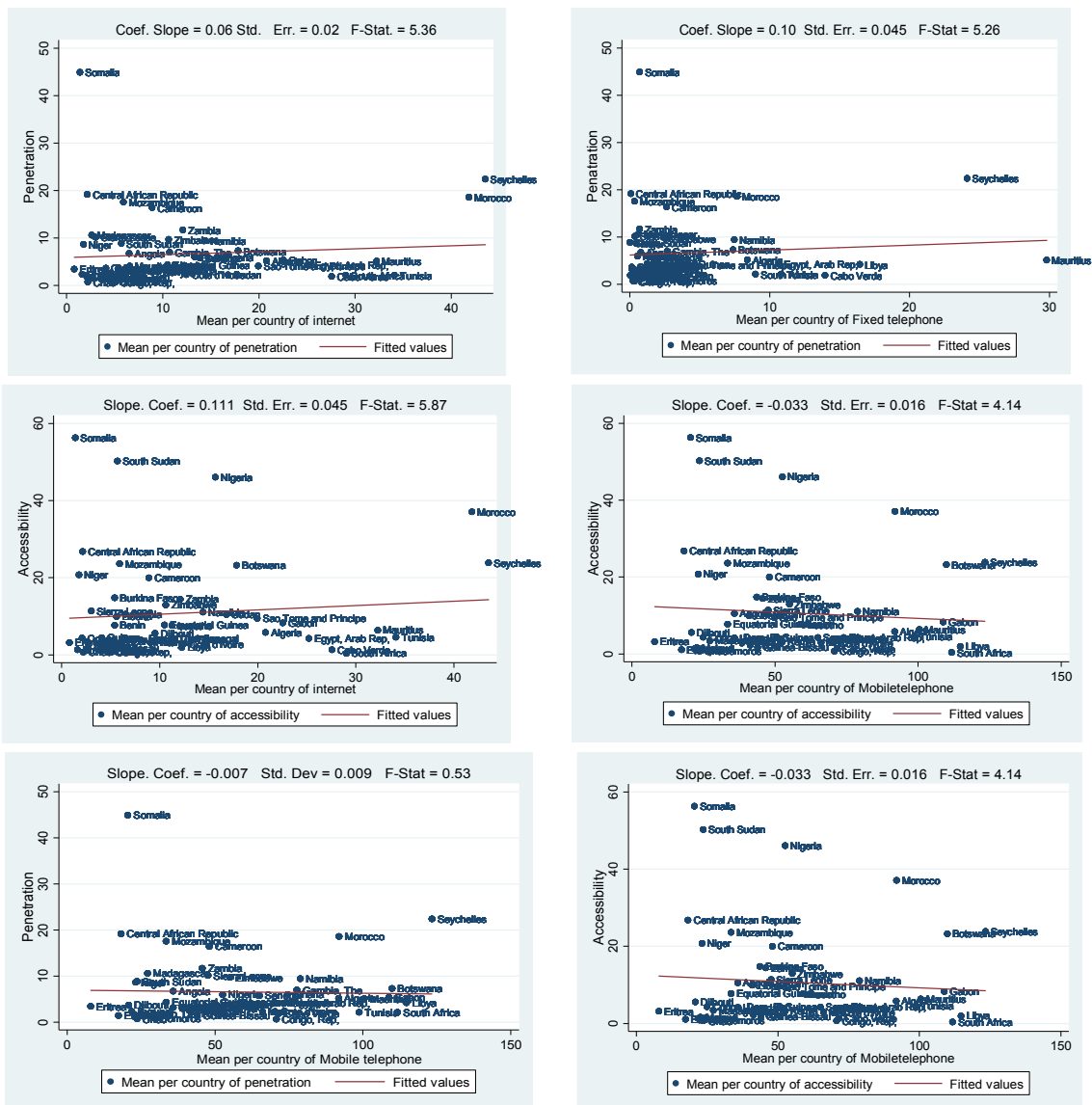


Fig. 3. Correlation between ICT and financial inclusion in Africa
Source: Authors, from GFID (2018) and WDI (2018)

Table 5. Effects of ICT diffusion on financial inclusion in Africa

	Estimation technique: Ordinary Least Squares														
	Penetration			Accessibility					Use						
Internet	0.0548*** (0.016)					0.109*** (0.036)					0.360* (0.276)				
Fixed_broadl		0.029 (0.035)					0.096 (0.071)					0.674 (0.557)			
Mobile phone			0.0150** (0.005)					0.034*** (0.012)					0.050** (0.096)		
Human_cap	0.083*** (0.013)	0.072*** (0.013)	0.072*** (0.013)	0.075*** (0.013)	0.069*** (0.013)	0.196*** (0.031)	0.178** (0.079)	0.177*** (0.029)	0.192*** (0.030)	0.164*** (0.030)	1.97*** (0.232)	1.96*** (0.231)	1.88*** (0.222)	1.94*** (0.228)	1.97*** (0.230)
Urbanization	-0.040*** (0.015)	-0.025 (0.015)	-0.0387** (0.016)	-0.025* (0.015)	-0.020 (0.014)	-0.097*** (0.037)	-0.071 (0.061)	-0.095** (0.037)	-0.089** (0.036)	-0.0408 (0.036)	-0.71** (0.260)	-0.65** (0.244)	-0.61** (0.265)	-0.658** (0.254)	-0.67** (0.249)
Private_inv	0.029 (0.027)	0.035 (0.027)	0.030 (0.027)	0.037 (0.027)	0.038 (0.027)	-0.176*** (0.063)	-0.165* (0.088)	-0.18*** (0.063)	-0.159** (0.062)	-0.160** (0.063)	-1.51** (0.478)	-1.48** (0.478)	-1.46** (0.478)	-1.44*** (0.474)	-1.46** (0.473)
Remittances	-0.085* (0.051)	-0.065 (0.052)	-0.076 (0.051)	-0.069 (0.051)	-0.067 (0.051)	0.078 (0.111)	0.112 (0.139)	0.095 (0.111)	0.086 (0.110)	0.120 (0.113)	-0.053 (0.862)	0.071 (0.863)	-0.0354 (0.860)	-0.028 (0.856)	0.0964 (0.859)
Trade	0.003 (0.005)	0.002 (0.005)	0.0029 (0.0048)	0.001 (0.004)	-7.520 (0.00472)	0.026** (0.011)	0.023* (0.0122)	0.023** (0.010)	0.021** (0.010)	0.015 (0.010)	0.082 (0.086)	0.061 (0.090)	0.049 (0.081)	0.0549 (0.079)	0.0517 (0.078)
House_cons	-0.012 (0.013)	-0.010 (0.013)	-0.013 (0.013)	-0.0140 (0.013)	-0.012 (0.013)	-0.015 (0.028)	-0.007 (0.033)	-0.0152 (0.028)	-0.0174 (0.028)	-0.018 (0.029)	-0.62** (0.216)	-0.54** (0.220)	-0.62** (0.215)	-0.64*** (0.215)	-0.66** (0.217)
Infrastructures	0.467*** (0.046)	0.527*** (0.043)	0.523*** (0.041)	0.504*** (0.048)	0.532*** (0.042)	0.856*** (0.100)	0.965*** (0.139)	0.960*** (0.090)	0.871*** (0.098)	0.991*** (0.090)	3.24** (0.789)	3.01** (0.735)	2.83** (0.721)	3.11*** (0.771)	3.24** (0.780)
Internet*Loan					0.024** (0.009)				0.081*** (0.002)					0.022* (0.002)	
Internet*Mobile					0.034** (0.013)					0.0115* (0.001)					0.036** (0.002)
Constant	1.130 (1.320)	1.136 (1.360)	1.191 (1.317)	1.391 (1.323)	1.342 (1.349)	1.072 (2.905)	0.728 (2.582)	1.107 (2.881)	1.327 (2.867)	1.854 (2.924)	3.994* (2.214)	3.460 (2.250)	4.111* (2.295)	4.234* (2.188)	4.427** (2.193)
Observations	276	276	278	279	279	237	237	239	240	240	237	237	239	240	240
R-squared	0.734	0.725	0.731	0.726	0.724	0.718	0.709	0.716	0.716	0.707	0.718	0.709	0.716	0.718	0.709
Countries	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
Fixed effects	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; standard deviations robust to heteroscedasticity in parentheses

Source: Authors

Table 6. Effects of ICT diffusion on financial education in Africa

	Estimation technique: Fixed effects								
	Penetration			Accessibility			Use		
Internet	0.072***			0.126***			0.419**		
	(0.017)			(0.032)			(0.192)		
Fixed broadband		0.093			-0.0707			0.155	
		(0.069)			(0.196)			(1.401)	
Mobile phone			0.116*			0.0161***			3.902***
			(0.069)			(0.055)			(0.598)
Human_cap	0.139***	0.141***	0.135***	0.236***	0.242***	0.237***	1.533***	0.879***	1.553***
	(0.015)	(0.015)	(0.015)	(0.026)	(0.027)	(0.026)	(0.176)	(0.199)	(0.177)
Urbanization	-0.024	-0.057	-0.017	0.116	0.283***	0.134	-1.860***	-1.746***	-1.263**
	(0.024)	(0.025)	(0.025)	(0.084)	(0.078)	(0.089)	(0.599)	(0.557)	(0.542)
Private_inv	0.048*	0.054**	0.044	-0.049	-0.0480	-0.069	-0.0742	-0.244	-0.101
	(0.026)	(0.027)	(0.027)	(0.042)	(0.044)	(0.043)	(0.286)	(0.270)	(0.289)
Remittances	-0.033	0.001	-0.041	0.058	0.0671	-0.014	0.165	0.337	0.257
	(0.062)	(0.063)	(0.063)	(0.111)	(0.115)	(0.114)	(0.773)	(0.724)	(0.778)
Trade	0.019*	0.017**	3.510*	0.017*	0.01**	0.018*	0.136*	0.107	0.133
	(0.006)	(0.067)	(0.005)	(0.011)	(0.012)	(0.010)	(0.074)	(0.066)	(0.082)
House_consumption	-0.021	-0.019	-0.019	-0.016	-0.0071	-0.005	-0.278*	-0.178	-0.284*
	(0.014)	(0.014)	(0.014)	(0.027)	(0.028)	(0.027)	(0.164)	(0.160)	(0.167)
Infrastructures	0.219***	0.245***	0.257***	0.751***	0.790***	0.778***	3.966***	4.461***	3.810***
	(0.050)	(0.052)	(0.050)	(0.082)	(0.086)	(0.082)	(0.536)	(0.516)	(0.561)
Constant	-1.524	-2.263	-1.694	-9.105**	-1.61***	-9.701**	50.57*	60.68**	29.65
	(1.635)	(1.685)	(1.645)	(4.341)	(4.263)	(4.482)	(29.99)	(29.19)	(28.68)
Observations	276	276	278	237	237	239	289	279	289
Countries	52	52	52	52	52	52	52	52	52
R ²	0.101	0.193	0.127	0.105	0.155	0.105	0.112	0.118	0.123

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01; standard deviations robust to heteroscedasticity in parentheses

Source: Authors

Contrary, private investment, household consumption, urbanization and remittances decrease penetration, accessibility and use of financial services in Africa. In fact, the relative openness markets to people ejects who were previously excluded and restraints penetration, accessibility and use of financial services. For example, private investment reduces financial inclusion through the lack of banking for young people, the low density of bank branches outside major urban centers, the lack of transportation and telecommunications infrastructure, and the relative isolation of rural populations. Similarly, anarchic urbanization and the extent of illicit financial flows hamper infrastructure and contribute to reduce penetration, accessibility and use of financial services. They ensure that more than half of Africa's poor are unbanked and have limited or no access to financial services, such as savings, loans, credit, insurance, and payment. This hinders their ability to cope with unexpected expenditures, take advantage of economic and educational opportunities, participate in business transactions, and send and receive remittances. Furthermore, an increase in private investment, household consumption, urbanization and remittances is associated to a decrease in financial inclusion. These results are similar to those obtained by Naceur et al. [9], Ongo and Song [35].

Previous estimates are quite interesting since they provide useful information on how ICT diffusion affects environmental quality in Africa. However, estimates do not indicate the importance and significance of the channels from Internet to financial inclusion. In order to test the channels, we resort to causal mediation analysis. Therefore, we find that, the level of loans and mobile phone are interactive variables by which the internet influences penetration, accessibility and use of financial services in Africa.

5. DISCUSSION

To test our results, we estimate the above Model 2 by fixed effects. Overall, the results reinforce the positive effects of the Internet and mobile phone on the penetration, accessibility and use of financial services. The adoption of Internet and Mobile phone have a positive and significant effect on financial inclusion in Africa. Two explanations can be put forward. First, the adoption of ICT is not subject to regulation that tends to become a source of modernization of activities, mobility and health coverage that promote urban transition. Secondly, ICT as a

lever to modernize African cities is part of the logic of key infrastructures that make it possible to smooth information flows and speed up certain procedures by simplifying the lives of users. The results are consistent with those obtained in the basic model and empirical literature.

6. CONCLUSION

ICT diffusion offers Africa an unprecedented opportunity to develop its economy, create jobs and transform the living conditions of its people. This paper highlights the effects of ICT diffusion on financial inclusion by using Ordinary Least Squares (OLS) from a sample of 52 African countries over the period 2006 to 2019. In doing so, the paper brings some new contributions to the existing literature through an analysis based on disaggregated indices of financial inclusion. Our results shown that ICT diffusion (mobile and internet) increase penetration, accessibility and use of financial services in Africa. When we control for another estimation technique, notably Fixed effects, our results remain statistically significant and relatively stable overall.

Therefore, some non-exhaustive suggestions for economic policies can be made with the aim of increasing financial inclusion in Africa: (i) the promotion of a financial culture through the use of innovative technologies and the participation of non-traditional institutions oriented towards new technologies, in order to reduce information asymmetries and institutional inefficiencies, densify financial inclusion with a view to diversifying financial institutions; (ii) Modernizing infrastructures and rationalizing public spending in order to consolidate their impact on financial inclusion; (iii) Consolidate digitalization strategies of economies to help countries accelerate their efforts, increase access to high-speed internet and lay the groundwork for a dynamic digital economy, while adapting to changes that will become the norm, fostering innovation and entrepreneurship.

In fact, African countries must support responsible financial inclusion by promoting financial capability and strengthening financial consumer protection frameworks, which will help countries to develop secure and efficient payment, remittances, securities settlement, and credit reporting systems. Also, African countries must improve the institutional environment through the establishment of economic, political, and legal rules that delimit and support transactional activity, by promoting a financial

culture through the use of innovative technologies and the participation of no traditional institutions that use new technologies, in order to reduce information asymmetry and institutional inefficiency and deepen financial inclusion with a view to diversifying financial institutions.

ACKNOWLEDGEMENTS

The authors would like to thank 2 anonymous referees for insightful comments. The usual disclaimer applies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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