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The role of governance in the effect of the internet on financial inclusion in sub-Saharan Africa

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Abstract:

Financial inclusion is a necessary condition for the population to get access to credit. Despite the efforts made by governments and policy makers, the rate of financial inclusion in Sub-Saharan African (SSA) countries remains low. The internet can be one of the options to increase the rate of financial inclusion in SSA. But the use of internet in SSA remains low due to the poor quality of the internet and to its high cost. So, good governance quality can consolidate internet infrastructure in order to promote the internet. This paper analyses the role of governance quality in the relationship between internet and financial inclusion in Sub-Saharan African countries. The study utilises data from the International Monetary Fund (IMF) database for indicators of financial inclusion, World Development Indicators (WDI) for internet users and World Governance Indicators (WGI) for governance indicators over the period 2004 to 2020. Analysing the data using the System Generalized Method of Moments (SGMM), the results show that the internet can be effectively complemented with the quality of governance to improve financial inclusion.Thresholds of governance that are needed for the internet to promote financial inclusion are provided. The established thresholds are as follows: (i) 0.300 “voice and accountability” and “government effectiveness”, respectively; (ii) 0.250 “rule and law”; (iii) 2.500 “economic governance” and (iv) 1.000 “institutional governace” and “general governance”, respectively. Policies aimed at reinforcing the quality of governance in SSA countries could help consolidate internet infrastructure to promote internet usage and in turn improve financial inclusion.

Key words: Internet, financial inclusion, governance quality

JEL Classification: O30 – G20 – H11

1. Introduction

In economic theories, the development of financial services is essential for economic growth(Levine, 2005; Schumpeter, 1934). Moreover, the United Nations (UN) has made financial inclusion a priority for economic development since 2020 (Akpa et al., 2022; Senou et al., 2019). Likewise, the World Bank has placed universal access to finance at the heart of global poverty reduction pillars(Senou et al., 2019; World Bank, 2015). Similarly, financial inclusion (i.e. having a bank account) is the beginning of participation in finance or banking to finance economic activity (Witt, 2015). In sub-Saharan Africa (SSA), about 42.6% of the population aged 15 years and more have an account with 32.8% in a financial institution and 20.9% using mobile money account (World Bank, 2018). This low rate of financial inclusion is due to the weak use of internet in financial institutions and to the weak digitalisation of financial services. Indeed, only 7.6% of the SSA population use the internet to pay bills or to buy something online and 20.8% used a mobile phone or internet to access an account (World Bank, 2018). Other factors such as the rigidity of financial institutions, inadequate services, lack of outreach and openness, the cost of financial services, and bankers' risk aversion to operating in an asymmetry information and underperforming institutions environment explain the low financial inclusion in Africa (Ongo Nkoa & Song, 2020).

According to Niu et al. (2022), the development of technology has created new opportunities to improve financial inclusion. For Shen et al. (2021), the use of digital technology has been an effective way to improve financial inclusion. According to Ongo Nkoa and Song(2020), mobile phones and other methods reduce distances between people and financial services. Therefore, information and communication technologies (ICT), including smartphones and broadband internet, are important for expanding access to safe and affordable financial services such as payments, domestic and international remittances, insurance, credit and savings (Alliance for Financial Inclusion [AFI], 2018; Patwardhan et al., 2018). In addition, many studies have highlighted the different channels through which ICT(mainly a robust telecommunications infrastructure) can contribute to economic growth, such as by improving efficiency, reducing transaction costs, increasing trade, enhancing innovation and development, increasing employment and demand, and developing the financial sector (Chatterjee, 2020; Pradhan et al., 2015, 2018).

Even though mobile penetration in SSA in the last decade has been rapid, the use of the internet is still low. In 2020, while about 83% inhabitants had mobile phones, only 30% of the population was using the internet(World Bank, 2022). Similarly, according to Demirguç-Kunt

and Klapper(2012) and Lashitew et al.(2019), while mobile phone penetration in SSA countries has reached 76%, less than 30% of people have bank accounts. This is because internet cost in African countries remains high. Indeed, the mobile phone sub-basket in sub-Saharan averages about US$11.7/month, while the broadband sub-basket stands at US$44.9/month (MAEP et al., 2019). The high cost of the internet in SSA is due to lack of good ICT infrastructure to provide good internet quality which is also traceable to the absence of high competition in the GSM (Global System for Mobile communication) network market. Good governance can improve economic conditions for investing in technology infrastructure to improve internet access and correspondingly, reduce internet access costs. By reducing transaction costs and freeing up discussions, institutions promote financial inclusion through less restrictive procedures, giving consumers greater access to financial institutions and enabling them to benefit from the financial products offered (Anthony-Orji et al., 2019). Indeed, institutional quality increases households' direct access to banking and microfinance, consolidating incentives for personnel exchange, property rights protection, and innovation(Ongo Nkoa & Song, 2020).

Empirical evidence reveals a mixed relationship between internet and financial inclusion. Thus, Lenka and Barik(2018) in the South Asian Association for Regional Cooperation (SAARC) countries, Okoroafor et al. (2018) in Nigeria using both time series data over 1990 to 2016 and employing the Error Correction Model (ECM) estimation technique and Chatterjee(2020) using a fixed effects panel data model on 41 developed and developing countries, found that internet users have positively and significantly influenced financial inclusion. Indeed, according to Okoroafor et al.(2018), the internet has fundamentally reduced the cost of transactions through mobile and the ATM (Automated Teller Machine) use. However, other studies undertaken by Senou et al.(2019) and Bayar et al.(2021)found an opposite relationship between internet and financial inclusion. Indeed, Senou et al.(2019) found in WAEMU (i.e. the West African Economic and Monetary Union) using the Generalised Method of Moments (GMM) estimation technique that the internet negatively and significantly influences financial inclusion. Similarly, Bayar et al.(2021) found in the EU (i.e. European Union) post-communist countries that there are both positive and negative relationships between internet usage rates and financial institutions and financial markets access. The authors suggested that by increasing internet usage, access to financial institutions can be improved in Bulgaria, Croatia, Czech Republic, Hungary, and Poland and financial markets access can be increased in Latvia and Slovenia.

Considering the mixed relationship between the internet and financial inclusionin the literature (Bayar et al., 2021; Chatterjee, 2020; Lenka & Barik, 2018; Okoroafor et al., 2018; Senou et al., 2019), governance quality can serve as a catalyst to improve the effect of the internet on financial inclusion. Otherwise, good quality of governance can, through the reduction of transaction cost and mismanagement, promote investment in good internet quality infrastructure to reduce corresponding internet cost. Empirical evidence around the world shows that good quality of governance improves financial inclusion (Ali et al., 2016; Anthony-Orji et al., 2019; Aymar & Fabrice-Gilles, 2021; Chinoda & Kwenda, 2019; Chu et al., 2019; Muriu, 2021; Ongo Nkoa & Song, 2020). Otherwise, the emergence of informal credit result from a low institutional quality which benefits not only households but also borrowers (Madestam, 2014). Aymar and Fabrice-Gilles(2021) found in Sub-Saharan Africa that good governance such as quality of regulation improved financial inclusion. Ongo Nkoa and Song(2020) showed in Africa that good institutional quality improves financial inclusion and in turn the penetration, accessibility, and financial servicesuse. Chu et al.(2019) concluded that good institutional quality stimulates financial inclusionfrom a sample of eighty-two (82) countries. Ali et al.(2016) found in fifty-two (52) developing countries that financial inclusion is positively and significantly influenced by governance indicators such as absence of violence, government effectiveness, political stability, and regulatory quality. Anthony-Orji et al.(2019) found in Nigeria that institutional quality is positively associated with financial inclusion. Chinoda and Kwenda(2019) found from a sample of forty-nine (49) countries that institutional quality and governance are positively related to financial inclusion. Muriu(2021) analysed institutions quality role on financial inclusion in 120 countries and found that the rule of law and regulatory quality are positively and significantly associated with financial inclusion. The result implies that an enforcement of the rule of law and regulatory quality leads to higher bank account penetration in SSA economies compared to the rest of the world.

Previous studies have analysed the internet effect on financial inclusion (Bayar et al., 2021; Chatterjee, 2020; Lenka & Barik, 2018; Senou et al., 2019) or the governance effect on financial inclusion (Chinoda & Kwenda, 2019; Chu et al., 2019; Muriu, 2021; Ongo Nkoa & Song, 2020), but the effect of the internet and quality of governance interaction on financial inclusion has not been considered in the extant literature, to the best of knowledge. This study explores the direct and indirect transmission mechanisms through which the internet can affect financial inclusion. While the internet can directly increase financial inclusion through

the reduction of transaction cost, the indirect effect passes through internet interaction with quality of governance because good quality of governance can promote better investment in ICT infrastructure. This represents the present study's contribution to the extant literature. Accordingly, the present study aims to shed light on the theoretical and empirical links between the internet and financial inclusion in SSA. We are providing more in-depth information with which to analyse the effect of the internet on financial inclusion in SSA. By situating the internet in the specific context of financial inclusion, we aim to provide policy makers with insights into how the internet can be used to promote financial inclusion, contingent on good governance. The second section provides a theoretical synthesis of the effect of ICT on financial inclusion. The third section presents the method of analysis and the source of statistical data. The fourth section presents and discusses the results followed by the conclusion and policy implications.

2. ICT and financial inclusion: A literature review

This part does a review of the nexus between types of ICT, (notably mobile phone penetration and the internet) and financial inclusion. In general, the influence of ICT on financial inclusion is mixed in the extant literature.

Firstly, we are interested in the relationship between mobile phone penetration and financial inclusion. Some studies have found a positive relationship between mobile phone penetration and financial inclusion. For example, Andrianaivo and Kpodar(2012) have found in African countries a positive and significant relationship between financial inclusion and mobile phone penetration rates. Mushtaq and Bruneau(2019) have concluded from a sample of 61 lower- and middle-income countries, that mobile phone penetration improves financial inclusion.Seng(2017) has shown in Cambodia that mobile phones have a positive effect on both formal and informal borrowing. Lenka and Barik(2018) in the South Asian Association for Regional Cooperation (SAARC) countries have shown a positive relationship between the growth of mobile phones and financial inclusion. Ongo Nkoa and Song(2020) have found in African countries that the number of telephone lines per 100 inhabitants positively and significantly influence financial inclusion. Muriu (2021) has analysed in 120 countries the role of institutions on financial inclusion and found that mobile cellular subscriptions are significantly and positively associated with financial inclusion. Other studies, like those of Senou et al.(2019) and Bayar et al.(2021) have established a controversial association between mobile phone penetration and financial development. Indeed, Senou et al.(2019) found in WAEMU by using random effects model that mobile phone penetration negatively

and significantly influences financial inclusion while by using the GMM estimation technique, the authors found that mobile phone penetration positively influences financial inclusion, though the result is not significant. Bayar et al.(2021) have shown that mobile cellular phone subscriptions positively influence financial institution access in Hungary, Latvia, Lithuania, Poland, and Slovenia and financial market access in Bulgaria, Croatia, and Hungary but negatively related to financial institution access in the Czech Republic and financial market access in the Czech Republic and Poland.

Finally, we are interested in the relationship between the internet and financial inclusion. Some studies have shown that the internet positively influences financial inclusion. Thus, Lenka and Barik(2018) have shown in the South Asian Association for Regional Cooperation (SAARC) countries a positive relationship between the growth of internet and financial inclusion. Okoroafor et al.(2018), have established in Nigeria that internet users have positively and significantly influenced financial inclusion. Indeed, according to the authors, the internet has fundamentally reduced transactions cost through the mobile and ATM use. Chatterjee(2020) has found from a sample of 41 developed and developing countries that internet users positively and significantly influence financial inclusion. However, other studies have found an opposite relationship between the internet and financial inclusion. Indeed, Senou et al. (2019) have established in the WAEMU by using GMM estimation technique, that internet negatively and significantly influences financial inclusion while by using random effects regressions, the authors have shown that internet negatively influences financial inclusion, though the result is not significant. Bayar et al. (2021) have established positive and negative relationships between internet usage rates and financial institutions and financial market access. The authors have suggested that increased internet usage improves access to financial institutions in Bulgaria, Croatia, Czech Republic, Hungary, and Poland and an enhancement of financial markets access in Latvia and Slovenia.

Our study complements the existing literature by exploring the impact of the internet on financial inclusion, using a system GMM model. We analyse the direct and indirect impacts of the internet on financial inclusion in SSA countries. The indirect impact is captured by using an interaction of the internet and governance quality. Similarly, we examined this impact by constructing a financial inclusion index (IFI) using four dimensions of financial inclusion, notably: (i) number of commercial bank branches per 1,000 km2, (ii) number of commercial bank branches per 100,000 adults, (iii) number of ATMs per 1,000 km and, (iv) number of ATMs per 100,000 adults.

3. Methodology

3.1. Construction of IFI

The Financial Inclusion Index (IFI) was designed based on Sarma(2008) and Abdelghaffar et al.(2022). Indeed, it is a composite index that is built using four main indicators of financial inclusion. First, we computed the dimension index for each financial inclusion indicator. We calculate the dimension index for the $i-th$ financial inclusion indicator, d_i, using the following formula:

$$d_i = \frac{A_i - m_i}{M_i - m_i} \quad (1)$$

Where i refers to the financial inclusion indicator number, A_i is the actual value of the financial inclusion indicator i in a certain country; m_i and M_i refers respectively to the minimum and the maximum values of financial inclusion indicator i in the group of selected countries. The value of the dimension (d_i) varies between 0 and 1 (i.e. $0 \le d_i \le 1$). The higher the value of d_i is , the higher the country's achievement in dimension i. The methodology we use to compute index of financial inclusion is consistent with the studies of Arshad(2022) and Abdelghaffar et al.(2022)and follows the methodology used by the United Nations Development Program (UNDP) to compute HDI and other similar indices.

The IFI_i for the i_{th} country is computed by applying the following formula:

$$IFI_i = 1 - \frac{\sqrt{(1-d_1)^2 + (1-d_2)^2 + ... + (1-d_n)^2}}{\sqrt{n}} \quad (2)$$

where n refers to the total number of financial inclusion indicators used in the study.

For the development of the financial sector and economic growth of a country, financial inclusion is known as an essentiel measure (Arshad, 2022; Sethy & Goyari, 2018). Many methods are used for the cconstruction of financial inclusion index using its different indicators (Arora & Ratnasiri, 2015; Arshad, 2022; Chakravarty & Pal, 2013; Goel & Sharma, 2017). This study uses indicators such as banking penetration and availability of banking services and usage of the banking system to compute the IFI(Arshad, 2022; Goel & Sharma, 2017; Gupte et al., 2012; Sarma, 2008; Yorulmaz, 2013). Indeed, banking penetration is

measured by the number of accounts per 1,000 people while the availability of banking services is referred to the number of ATMs per 100,000 people, number of bank branches per 1,000 people, bank branches per 1,000 square km and ATMs per 1,000 square km. Similarly, borrowers from commercial banks per 1,000 adults measure the usage dimension of financial inclusion. By following the study of Arshad(2022), we measure financial inclusion using eight dimensions such as: (i) the number of commercial bank branches per 1,000 km2;(ii) the number of commercial bank branches per 100,000 adults; (iii) the number of ATMs per 1,000 km and, (iv) the number of ATMs per 100,000 adults.

The construction of IFI is composed of the four main aforementioned indicators, thus the second formula can be re-written as follows:

$$IFI_i = 1 - \frac{\sqrt{(1-d_1)^2 + (1-d_2)^2 + (1-d_3)^2 + (1-d_4)^2}}{\sqrt{4}} \quad (3)$$

where $d_1,...,d_4$ represents the four dimensions of financial inclusion mentioned above, respectively.

3.2.Dynamic panel data modelling approach

To analyse the internet effect on financial inclusion, we used dynamic panel data models to capture the relationship between internet and financial inclusion. The lagged variable of IFI is included in the model as financial inclusion tends to change slowly over time, and hence the persistence of financial inclusion is captured which makes the model dynamic (Abdelghaffar et al., 2022; Saptoka, 2014). Similarly, the lagged the dependent variable enables the study to correct for autocorrelation. Internet and quality of governance which are the independent variables of interest used in this study are crossed with the internet to analyse the indirect effect of the internet on financial inclusion. In addition, consistent with the extant financial inclusion literature covered, four others variables are incorporated as control variables, notably: growth domestic product per capita (GDPC), human capital (HCAP), trade openness (TRADE) and Gross capital formation (GFCF).

Referring to the studies undertaken by Andrianaivo and Kpodar(2012), Senou et al.(2019), Ongo Nkoa and Song (2020) and Bayar et al.(2021), the estimated regression equation is specified as follows:

$$IFI_{it} = \alpha_0 + \alpha_1 IFI_{it-1} + \alpha_2 INTERNET_{it} + \alpha_3 QG_{it} + \alpha_4 \left(INTERNET_{it} \times QG_{it}\right) + \alpha_5 \ln\left(GDPC_{it}\right) + \alpha_6 HCAP_{it} + \alpha_7 TRADE_{it} + \alpha_8 GFCF_{it} + \mu_{it} \quad (4)$$
$$\text{i} = 1,..., \text{N and t} = 1,..., \text{T}$$

Where IFI_{it} refers to financial inclusion index for country i at time t; IFI_{it-1} is index of financial inclusion for country i at time $t-1$, $INTERNET_{it}$ is the individual using the internet for country i at time t. QG_{it} represents the six governance indicators such as control of corruption, government effectiveness, rule of law, political stability, regulatory quality and voice and accountability bundled into political governance (political stability and voice and accountability), economic governance (regulatory quality and government effectiveness) and institutional governance (rule of law and corruption control) and general governance (PCA of the three dimensions), respectively for country i at time t. $GDPC_{it}$ is the growth domestic product per capita and $HCAP_{it}$ represents the education index. $TRADE_{it}$ is the sum of exports and imports divided by growth domestic product. $GFCF_{it}$ is the gross capital formation. μ_{it} refers to error term and $\alpha_0,..., \alpha_8$ .refer to the coefficients to be estimated.

In Equation (4), α_2 and α_3 respectively measure the direct impact of the internet and quality of governance while α_4 examines the simultaneous change in both the internet and quality of governance on financial inclusion. Partially differentiating Equation (4) with respect to the internet produces Equation (5) which is the unconditional effect of the internet on financial inclusion and the corresponding conditional effect from the interaction between the internet and governance quality:

$$\frac{\partial IFI_{it}}{\partial INTERNET_{it}} = \alpha_2 + \alpha_4 QG_{it} \quad (5)$$

Still considering Equation (5), the corresponding governance quality threshold is derived by taking the absolute value of the ratio of the unconditional to the conditional effect as follows:

$$\text{QG threshold} = \left|\frac{\text{unconditional impact}}{\text{Conditional impact}}\right| = \left|\frac{\alpha_2}{\alpha_4}\right| \quad (6)$$

Empirically, we estimated dynamic panel data models using the GMM technique proposed by Arellano and Bond(1991) and Arellano Bover(1995) and extended by Blundell and Bond (1998) who suggest a GMM estimator that uses lagged levels ofendogenous variables as instruments for equations in difference forms (Abdelghaffar et al., 2022; Tsionas, 2019).

The use of the GMM technique has several advantages. Indeed, firstly, it is widely used in finance due to the existence of endogeneity in financial decisions (Abdelghaffar et al., 2022; Ahmed et al., 2021). So, GMM allows to control for the potential endogeneity bias by the reduction of the correlation between endogenous variables and the error term (Abdelghaffar et al., 2022; Asongu et al., 2020; Asongu & Nwachukwu, 2016; Kim et al., 2018). Secondly, it is the most appropriate when the cross-sectional data (N) are larger than the time dimension (T) (Abdelghaffar et al., 2022; Asongu et al., 2020; Asongu & Nwachukwu, 2016). Thirdly, this technique allows for the removal of any bias created by unobserved country-specific effects(Asongu et al., 2020; Asongu & Nwachukwu, 2016). Consequently, the system GMM provides unbiased results due to the hypothesis that there is no existence of second-order autocorrelation in addition to the absence of correlation between the instruments and the error terms (Ababio et al., 2021; Abdelghaffar et al., 2022).

3.3. Data and variable selection

The study is based on an annual dataset of 42 sub-Saharan African countries covering the period from 2004 to 2019. Data used in this model are extracted from many sources such as the International Monetary Fund (IMF), Financial Access Survey (FAS), World Governance Indicators (WGI), World Development Indicators (WDI) and UNDP database. Data on financial inclusion such as number of commercial bank branches per 1,000 km2, number of commercial bank branches per 100,000 adults, number of ATMs per 1,000 km andnumber of ATMs per 100,000 adults, used to compute the index of financial inclusion are obtained from the IMF FAS database. The choice of this variable is based on the studies of Akpa et al. (2022), Arshad (2022) and Abdelghaffar et al.(2022). Data on governance quality such as control of corruption, government effectiveness, rule of law, political stability, regulatory quality and voice and accountability are provided from the World Governance Indicators of the World Bank (World Bank, 2022). The choice of this variable is based on the studies by Asongu and Odhiambo(2020) and Asongu et al.(2018). The expected sign is positive, meaning that governance quality increases financial inclusion. Data on ICT were measured as the individual using the internet (% of population) and sourced from the World Development Indicators (WDI) of the World Bank. Moreover, the choice of the indicator is informed by Okoroafor et al.(2018), Chatterjee(2020) and Bayar et al.(2021). The expected sign is positive, meaning that internet increases financial inclusion. Economic growth per capita is measured by growth domestic product per capita and are provided from WDI(World Bank, 2022). Its choice is informed by Lashitew et al.(2019), Senou et al.(2019) and Liu et

al.(2021). The education index is measured by the combined primary, secondary and tertiary gross enrolment ratio and its choice is based on the studies of Lenka and Barik(2018), Chatterjee (2020), Huang et al.(2022) and Akpa et al.(2022). The variable is provided from the UNDP database and the expected sign is positive. Data on trade openness are measured by the sum of exports and imports divided by growth domestic product and are sourced from WDI. The choice of this variable is informed by Chatterjee(2020) and Sikayena et al.(2022) and the expected sign is positive. Physical capital is measured by gross capital formation (formerly gross domestic investment) and are provided from WDI. The choice of the variable is motivated by studies from Sikayena et al.(2022) and Jayasuriya & Wodon, (2003) and the expected is positive.

4. Results and discussion

4.1.Empirical results

The outcomes of the estimate of the role of governance quality in the relationship between internet and financial inclusion are reported in this section in Table 1. The findings have been presented in three main groups corresponding to the three main governance dimensions, notably political governance (political stability and voice and accountability), economic governance (government effectiveness and regulatory quality) and institutional governance (corruption control and the rule of law), respectively. Each governance dimension is composed of two indicators of governance. Two main criteria are used to analyse the post-estimation validity of the GMM outcomes. Based on these criteria, the results also showed an absence of Arellano and Bond second-order autocorrelation. The Sargan/Hansen test of over-instrumentation confirmed that the instrumental variables used are valid and correct the endogeneity of the lagged index of financial inclusion. The table shows that the lag of the dependent variable positively and significantly affects the dependent variable at 1% level. This outcome was expected because financial inclusion is very persistent, therefore, the current level of financial inclusion is affected by the previous level of financial inclusion. This is why action must be taken to increase financial inclusion early on, as actions taken to increase financial inclusion today will help raise future financial inclusion.

Table 1. Estimation results

	Dependent variable: Financial inclusion					
	Political governance		Economic governance		Institutional governance	
	Political stability	Voice and accountability	Regulation quality	Government effectiveness	Rule of law	Corruption control
Financial inclusion (IFI) (-1)	0.941*** (0.000)	0.964*** (0.000)	0.928*** (0.000)	0.935*** (0.000)	0.937*** (0.000)	0.997*** (0.000)
Internet (INTERNET)	-0.0003*** (0.000)	-0.0003*** (0.000)	4.17e-06 (0.979)	-0.0003** (0.021)	-0.0002*** (0.007)	-0.0005*** (0.000)
Political stability (PS)	0.015 (0.318)					
Voice and accountability (VA)		0.003 (0.820)				
Regulation quality (RQ)			0.006 (0.721)			
Government effectiveness (GE)				0.012 (0.514)		
Rule of law (RL)					0.006 (0.666)	
Corruption control (CC)						0.016*** (0.003)
INTERNET×PS	-0.0001 (0.843)					
INTERNET×VA		0.001** (0.042)				
INTERNET×RQ			0.001*** (0.001)			
INTERNET×GE				0.001*** (0.005)		
INTERNET×RL					0.0008** (0.019)	
INTERNET×CC						-0.0004 (0.171)
Log economic growth	-0.007** (0.028)	-0.002 (0.366)	-0.009*** (0.002)	-0.001 (0.770)	-0.003 (0.106)	0.001 (0.123)
Education	0.046 (0.164)	0.052 (0.147)	0.153*** (0.000)	0.017 (0.460)	0.080*** (0.004)	0.004 (0.753)
Trade openness	0.008 (0.636	0.013 (0.400)	0.053*** (0.000)	0.002 (0.817)	0.020* (0.090)	-0.016* (0.068)
Physical capital	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)
Constant	0.005 (0.884)	-0.053* (0.092)	-0.077*** (0.005)	-0.026 (0.469)	-0.052 (0.110)	-0.014 (0.181)
Internet net effects	na	-0.0009	na	-0.001	-0.0008	na
Gov. thresholds	na	0.300	na	0.300	0.250	na
AR(1)	-3.18*** (0.001)	-2.88*** (0.004)	-2.70*** (0.007)	-3.06*** (0.002)	-3.08*** (0.002)	-3.37*** (0.001)
AR(2)	-1.38 (0.166)	-1.10 (0.272)	-0.93 (0.352)	-1.38 (0.168)	-0.92 (0.359)	-0.10 (0.916)
Sargan	2.37 (0.997)	1.42 (1.000)	0.62 (1.000)	0.62 (1.000)	1.56 (1.000)	4.19 (0.964
Hansen	9.24 (0.600)	9.19 (0.604)	7.65 (0.745)	6.75 (0.749)	8.77 (0.643)	11.87 (0.373)
Fisher	991.53*** (0.000)	1137.26*** (0.000)	907.90*** (0.000)	855.04*** (0.000)	1674.59*** (0.000)	3463*** (0.000)
Number of instruments	20	20	20	19	20	20
Number of groups	42	42	42	42	42	42
Observations	426	426	426	435	426	426

Source: Authors' computation.*,**,***: significance levels of 10%, 5% and 1% respectively.Gov: governance. na: not applicable because at least one estimated coefficient needed for the computation of net effect and/or threshold is not statistically significant. The mean values of 'voice & accountability', government effectiveness and rule of law are respectively, -0.648, -0.760 and -0.748.

The outcome shows that the internet negatively and significantly affect on financial inclusion at the 1% level. Otherwise, an increase in internet users by one person decreases financial inclusion in SSA countries. The outcome is not amazing because access to the internet in SSA countries on average is low. These findings are consistent with Senou et al.(2019) who have found in WAEMU that the internet negatively and significantly influences financial inclusion and Bayar et al.(2021) who have established in the EU post-communist countries that the internet negatively and significantly influences financial inclusion in Estonia, Latvia, Lithuania, and Slovenia. But the findings are also in contrast to Lenka and Barik(2018), Okoroafor et al.(2018), and Chatterjee(2020) who have posited that the internet improves financial inclusion. Moreover, from the outcome, the interaction between the internet and governance indicators showed that only the interactions with regulatory quality, rule of law, voice and accountability and government effectiveness are significant and positive. Indeed, a simultaneous increase in both the internet and governance indicators such as voice and accountability, regulatory quality, and government effectiveness increases financial inclusion, respectively. Similarly, a simultaneous increase both in the internet and rule of law increases financial inclusion. In short, our findings support the argument that the quality of governance can serve as a catalyst to reduce the gap between the internet and financial inclusion in SSA countries. The findings are similar to those of Aymar and Fabrice-Gilles(2021), Ongo Nkoa and Song(2020), Chinoda and Kwenda(2019) and Ali et al.(2016) who found that quality of governance improves financial inclusion.

In order to assess the overall effect of governance quality in modulating the effect of the internet on financial inclusion, net effects and thresholds are computed. The corresponding net effects and thresholds entail both the unconditional and the conditional effects of the internet on financial inclusion. For instance, in the thirth column of Table 1, in the regressions pertaining to voice and accountability, the net effect of voice and accountability in moderating the effect the internet on financial inclusion is –0.0009 ([-0.0003]+ [0.001× –0.648]). In the computation, –0.648 is the mean value of voice and accountability; the unconditional effect of the internet is -0.0003, whereas the conditional impact from the interaction between the internet and voice and accountability is 0.001. This approach to establishing an overall incidence based on net effects is consistent with contemporary interactive regressions

literature (Tchamyou & Asongu, 2017; Asongu & Odhiambo, 2019b; Asongu & Odhiambo, 2020). Consistent with Asongu and Odhiambo (2019b), we compute the corresponding governance quality thresholds which are: (i) 0.300 (i.e. 0.0003/0.001) of "voice and accountability" and "government effectiveness", respectively and (ii) 0.250 for the "rule and law". The attendant thresholds are obtained by dividing the unconditional effect with the conditional incidence as established in Equation (6).

4.2.**Robustness check**

To assess if the outcomes in Table 1 withstand further empirical scrutiny, the six governance indicators are grouped into four additional governance dimensions, namely: political governance (political stability and voice and accountability), economic governance (government effectiveness and regulatory quality), institutional governance (rule of law and control of corruption), and general governance (political, economic, and institutional governances). Similarly, as in Table 1, we also compute the governance thresholds.

Table 2. Robustness check

	Dependent variable: Financial inclusion			
	Political governance	Economic governance	Institutional governance	General governance
Financial inclusion (IFI) (-1)	0.997***	0.873***	0.955***	0.932***
	(0.000)	(0.000)	(0.000)	(0.000)
Internet (INTERNET)	-0.0002	-0.001***	-0.001***	-0.001***
	(0.860)	(0.007)	(0.000)	(0.000)
Political governance (PG)	-0.009			
	(0.680)			
Economic governance (EG)		0.134		
		(0.107)		
Institutional governance (IG)			-0.008	
			(0.213)	
General governance (GG)				-0.002
				(0.776)
INTERNET×PG	-0.0001			
	(0.886)			
INTERNET×EG		0.0004**		
		(0.028)		
INTERNET×IG			0.001***	
			(0.000)	
INTERNET×GG				0.001***
				(0.000)
Log economic growth	0.005	-0.003	-0.001	-0.003
	(0.292)	(0.219)	(0.766)	(0.381)
Education	-0.105	0.063**	0.088***	0.099**
	(0.800)	(0.014)	(0.004)	(0.016)
Trade openness	-0.004	0.018*	0.023*	0.028
	(0.900)	(0.070)	(0.062)	(0.125)
Physical capital	0.001**	0.002***	0.002***	0.002***
	(0.015)	(0.000)	(0.000)	(0.000)
Constant	-0.011	-0.044*	-0.086***	-0.083**
	(0.952)	(0.061)	(0.002)	(0.024)

Internet net effects	nsa	nsa	nsa	nsa
Governance thresholds	na	2.500	1.000	1.000
AR(1)	-3.22*** (0.000)	-3.11*** (0.002)	-2.57*** (0.010)	-2.27** (0.023)
AR(2)	-0.42 (0.673)	-1.05 (0.293)	-1.09 (0.274)	-1.14 (0.253)
Sargan	1.40 (0.999)	0.84 (1.000)	1.23 (1.000)	0.68 (1.000)
Hansen	8.25 (0.604)	7.33 (0.694)	11.00 (0.443)	10.65 (0.473)
Fisher	1960.14*** (0.000)	968.94*** (0.000)	935.53*** (0.000)	643.32*** (0.000)
Number of instruments	19	19	20	20
Number of groups	42	42	42	42
Observations	426	435	426	426

Source: Authors' computation. *,**,***: significance levels of 10%, 5% and 1% respectively. na: not applicable because at least one estimated coefficient needed for the computation of threshold is not statistically significant. nsa: not specifically applicable because the mean values of the composite governance indicators are close to zero.

Consistent with Asongu and Odhiambo(2020), we use the Kaiser(1974) and Jolliffe(2022) criterion to select the main components in the principal component analysis. Based on this criterion, we retain only principal components with an eigenvalue greater than the mean (Asongu & Odhiambo, 2019a, 2020). In this study, this criterion has been adopted to retain the composite governance indicators. The use of the approach of clustering governance variables for robustness using principal component analysis is supported by extant studies (Asongu & Odhiambo, 2018, 2020; Tchamyou, 2017). The results show that internet interaction with economic governance, institutional governance and general governance positively and significantly influence financial inclusion. On other hand, an increase in institutional governance and general governance increase financial inclusion. Similarly, an increase in economic governance increases financial inclusion in SSA. The corresponding positive thresholds are: (i) 2.500 of "economic governance" and (ii) 1.000 of "institutional governace" and "general governance", respectively.

5. Concluding implications and future research directions

Financial inclusion is a necessary condition for the population to get access to credit. Despite the efforts made by governments and policy makers, the rate of financial inclusion in Sub-Saharan African (SSA) countries remains low. The internet can be one of the options to increase the rate of financial inclusion in SSA. But the use of internet in SSA remains low due to the poor quality of the internet and to its high cost. So, good governance quality can consolidate internet infrastructure in order to promote the internet. This paper analyses the role of governance quality in the relationship between internet and financial inclusion in Sub-

Saharan African countries. The study utilises data from the International Monetary Fund (IMF) database for indicators of financial inclusion, World Development Indicators (WDI) for internet users and World Governance Indicators (WGI) for governance indicators over the period 2004 to 2020. Analysing the data using the System Generalized Method of Moments (SGMM), the results show that the internet can be effectively complemented with the quality of governance to improve financial inclusion.Thresholds of governance that are needed for the internet to promote financial inclusion are provided. The established thresholds are as follows: (i) 0.300 "voice and accountability" and "government effectiveness", respectively; (ii) 0.250 "rule and law"; (iii) 2.500 "economic governance" and (iv) 1.000 "institutional governace" and "general governance", respectively.

Our research findings suggest some policy implications that are worthwhile to increase financial inclusion in SSA countries. Policies aimed at reinforcing the quality of governance in SSA countries could help consolidate internet infrastructure to promote internet usage and in turn improve financial inclusion. The ICT, notably the internet, is very important in the economic sector, especially in the development of financial services. Thus, SSA countries must reinforce policies aimed at improving the quality of governance, especially beyond the established govenrance thresholds in order to engender a positive nexus between internet penetration and financial inclusion. The investment in internet infrastructures through good quality of governance will thus improve the quality of the internet and in turn reduce internet costs. Indeed, poor quality internet represents an impediment to the development of financial services in SSA countries. Quality internet services can improve the quality of financial services and reduce the distance between customers and financial institutions. Policies aimed at reinforcing the quality of governance in SSA countries should also be tailored to consolidate and enhance internet infrastructure in order to reduce internet costs and in turn improve financial inclusion.

The findings in this study, evidently provide space for future research, especially within the remit of considering how established nexuses influence the achievement of other United Nations' sustainable development goals (SDGs). In engaging this future lines of inquiry, emphasis should be placed on how country-specific economic development fundamentals influence the corresponding nexuses.

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Appendix

Table A1. List of countries

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cabo-Verde, Chad, Central African Republic, Comoros, Congo, Democratic Republic of Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Madagascar, Mali, Mauritius, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe

Table A2. Description of financial inclusion variables

Variable	Method of calculation (in each reporting country
Number of commercial bank branches per 1,000 km2	1,000*reported number of commercial bank branches/ km2
Number of commercial bank branches per 100,000 adults	100,000*reported number of commercial bank branches/ adult population
Number of ATMs per 1,000 km2	1,000*Number of ATMs/km2
Number of ATMs per 100,000 adults	100,000*Number of ATMs/adult population

Table A3. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Index of financial inclusion	558	0.074	0.108	0.001	0.612
Political stability	714	-0.604	0.906	-2.880	1.200
Voice and accountability	714	-0.648	0.720	-2.19	0.979
Regulation quality	714	-0.708	0.597	-2.645	1.127
Government effectiveness	714	-0.760	0.597	-1.849	1.057
Rule of law	714	-0.748	0.648	-2.606	1.029
Corruption control	714	-0.652	0.620	-1.816	1.160
Political governance	714	9.17e-11	1.281	-3.440	2.746
Economic governance	714	2.52e-10	1.282	-2.604	4.307
Institutional governance	714	7.87e-10	1.316	-2.153	3.579
General governance	714	1.13e-10	1.627	-2.691	4.389
Internet	686	12.693	14.753	0.155	70.000
Economic growth per capita	714	2199.452	2976.927	128.337	22942.610
Education index	671	0.429	0.116	0.137	0.736
Trade openness	714	0.680	0.389	0.000	3.480
Physical capital	676	22.639	9.118	2.000	81.021

Source: Authors' computation