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The role of ICT in reducing information asymmetry for financial access

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A R T I C L E   I N F O

A B S T R A C T

This study assesses the role of ICT in complementing private credit bureaus (PCB) and public credit registries (PCR) in reducing information asymmetry for financial access. The empirical evidence is based on Generalised Method of Moments with 53 African countries for the period 2004–2011. The following findings are established. First on financial access: (i) the marginal effects from interactions between ICT and PCR (PCB) are consistently positive (negative); (ii) net effects from interactions are negative with the higher magnitude from PCR and (iii) only thresholds corresponding to interactions between PCR and internet penetration are within range. Second, findings on financial allocation efficiency reveal positive marginal and net effects exclusively for mobile phones and PCR. Third, allocation efficiency may be constrained by increasing financial deposits. Overall, the complementarity between information offices and ICT in boosting financial access is still very limited. Policy implications are discussed with emphasis on improving the engaged complementarity and fighting surplus liquidity.

1. Introduction

There are at least four reasons for positioning an inquiry on the role of information and communication technology (ICT) in reducing information asymmetry for financial access in Africa, notably: (i) the growing need for investment to finance the continent's growing ambitions; (ii) greater scope for ICT penetration; (iii) substantially documented concerns of surplus liquidity and scarce literature on financial efficiency and (iv) limited financial access owing to information asymmetry.

First, the African business literature has been consistent with the need for alternative investment sources after failed projects of privatisation over the past decades (Rolfe and Woodward, 2004; Bartels et al., 2009; Tuomi, 2011; Darley, 2012).

Second, the growth potential of ICT in Africa is higher compared to other continents. In essence, while high-end markets in Asia, Europe and North America are currently experiencing stabilization in the growth of ICT, business opportunities related to mobile phones and the internet are sill substantial in Africa (Asongu, 2015a). Furthermore, as maintained by Penard et al. (2012), the continent has been witnessing an uneven penetration in the internet, compared to the mobile phone. According to the authors, as of 2010, whereas penetrations of the internet and the mobile phone had reached points of saturation in developed economies, there was still much room for their developments in Africa, notably, with: 9.6% and 41% for internet penetration and mobile phone penetration respectively.

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Third, in response to the concerns about financial inefficiency in African financial institutions (see Saxegaard, 2006; Fouda, 2009; Asongu, 2014a; p.70), the available literature has not focused on the fundamental mission of banking institutions which is to transform mobilised deposits into credit for economic operators (see Ataullah et al., 2004; Al-Obaidan, 2008; Kiyota, 2009; Kablan, 2010). Consistent with Asongu and Tchamyou (2015), available measurements of financial efficiency that have been employed include: profit efficiency (Hauner and Peiris, 2005); cost efficiency (Chen, 2009; Mensah et al., 2012) and Data Envelopment Analysis (DEA) for technical efficiency (see Kablan, 2009).

Fourth, there is an evolving stream of literature maintaining that limited financial access has been due to information asymmetry (Triki and Gajigo, 2014; Asongu et al., 2015). In response to the policy syndrome, over the past decade, information sharing offices (ISO) or public credit registries (PCR) and private credit bureaus (PCB) have been introduced across the continent in an effort to reduce information asymmetry between lenders and borrowers in the banking sector.[1] In essence, the introduction of ISO has been motivated by the idea that lack of financial access is constrained by factors that can be explained by information asymmetry, namely: eligibility to bank lending, physical access and affordability (see Batuo and Kupukile, 2010; Allen et al., 2011). Apart from serving as brokers between lenders and borrowers in financial institutions, ISO improve capital allocation efficiency, mitigate credit constraints and boost market competition (Jappelli and Pagano, 2002). In spite of these appeals, recent evidence suggests that: (i) there is still excess liquidity in African financial institutions (see Fouda, 2009) and (ii) ISO are having a negative effect on financial development on the continent (Asongu et al., 2015). This may not be surprising because the nexus between reducing information asymmetry and bank lending has remained an open debate in the literature: "On the whole, all three models agree on the prediction that information sharing (in one form or another) reduces default rates, whereas the prediction concerning its effect on lending is less clear-cut" (Jappelli and Pagano, 2002; p. 2020).

In the light of the above, the literature on information asymmetry and financial development (which is discussed in Section 2) leaves room for improvement in at least three areas, notably, the need to: (i) position inquiries on scopes where the issue of financial access is very severe; (ii) assess the effect on financial access by engaging the fundamental role of financial institutions in transforming mobilized deposits into credit for economic operators and (iii) examine the role of ICT in boosting 'information sharing' for allocation efficiency.

First, with regard to the scope of study, in spite of the substantially documented concerns of surplus liquidity in the banking sector of Africa, to the best of our knowledge, scholarly focus on addressing the policy syndrome has been limited within the framework of information asymmetry. In other words, the continent with one of the most severe issues of limited access to finance has not been thoroughly engaged or given the scholarly attention it deserves. Furthermore, studies that have focused on Africa have been limited in scope by focusing on a restricted number of countries. To put this point into perspective: Galindo and Miller (2001) have engaged no country on the continent; Love and Mylenko (2003) have focused on four countries while Barth et al. (2009) have engaged nine. Whereas Triki and Gajigo (2014) have positioned their inquiry on 42 nations for the period 2006–2009, the present study focuses on 53 African countries for the period 2004–2011. In the light of the above, the scope of this inquiry is motivated by the scarce literature on Africa, in spite of: recommendations for more scholarly research on the nexus between ISO and financial access (Singh et al., 2009, p. 13) and evolving policy questions about whether the advent of ISO on the continent has been accompanied with increasing financial intermediary efficiency and activity (Triki and Gajigo, 2014)

Second, 'information asymmetry' and 'financial development'-specific literatures have failed to engage the concept of financial development in the light of the fundamental role of banking institutions which is to transform mobilised deposits into credit for economic operators. On the one hand, both general and African-related information asymmetry and information-sharing literatures have engaged for the most part, measurements of constraints in financial access (see Ivashina, 2009; Houston et al., 2010; Tanjung et al., 2010). On the basis that the fundamental role of introducing ISO in Africa has been to enhance financial intermediation efficiency and activity, we measure financial access as the ability of banks to transform deposits into credit. Hence, we measure financial development in terms of financial allocation efficiency (credit/deposit ratio) and financial activity (credit) because ISO have been documented to enhance competition and reduce informational rents, with anticipated results of higher financial activity (lending) and allocation efficiency (Pagano and Jappelli, 1993; p. 2019).

On the other hand, in the African financial development literature, the conception and definition of financial efficiency has not been tailored towards the fundamental mission of financial institutions which is to transform deposits into credit. Consistent with Asongu and Tchamyou (2015), two mainstream measurements have been used, notably: (i) DEA to assess the efficiency of decision making[2] and (ii) Overall Economic Efficiency (OEE) within the frameworks of technical and scale efficiencies[3] as well as profitability- and cost-related perspectives.[4] We steer clear of this stream of literature by employing

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[1] We use 'PCB and PCR' interchangeably with ISO throughout the study.

[2] We invite the interested reader to refer to Kablan (2009) and Ataullah et al. (2004) who have employed the DEA approach in Africa and Pakistan respectively. These authors are concerned with technical and scale efficiencies.

[3] We also invite the interested reader to consult Al-Obaidan (2008) who employs a composite indicator of banking system efficiency to assess the outcome of globalization on technical efficiency.

[4] This is in line with recent studies on financial efficiency on the continent (see Kablan, 2010; Kiyota, 2009). Consistent with Asongu (2013a), four main indicators on financial efficiency are apparent in the literature. "*They include: the ratio of bank deposits (which measures the extent to which savings can fund private credit), the net interest margin (which is the accounting value of a bank's net interest revenues as a share of its total assets), overhead cost (or the accounting*

a measurement of financial efficiency that is consistent with the discussed policy syndrome of excess liquidity in financial institutions of the continent.

Third, in accordance with the narrative above on the growth potential of internet and mobile phones in Africa, it is reasonable to assess if this ICT has potential to complement ISO in their role of information sharing for better financial intermediation or financial access. The rest of the study is structured as follows. Section 2 discusses the empirical and theoretical literatures. The data and methodology are covered in Section 3. Section 4 presents and discuses the findings while Section 5 concludes with future directions.

2. Empirical and theoretical underpinnings

2.1. Information asymmetry and financial development

In accordance with Asongu et al. (2015), an abundant supply of information asymmetry (hence IA) literature has been oriented towards, the: effect of creditors' right to more information and role of information sharing between creditors. The former has fundamentally focused on the influence of consolidated creditors' rights in among others: bankruptcy (see Djankov et al., 2007; Claessens and Klapper, 2005; Brockman and Unlu, 2009) and risk-taking by financial institutions (Acharya et al., 2011; Houston et al., 2010). The latter perspective has focused on examining how reduced IA: increases access to finance (see Triki and Gajigo, 2014; Brown et al., 2009; Djankov et al., 2007); reduces the cost of credit (Brown et al., 2009); mitigates rate of default (Jappelli and Pagano, 2002); influences syndicated bank loans (Tanjung et al., 2010; Ivashina, 2009); affects corruption in lending (Barth et al., 2009) and impacts antitrust intervention (Coccorese, 2012).

In the light of the above, it is apparent that the engaged literature has focused on developed countries and developing nations in which concerns about surplus liquidity in financial institutions are comparatively less severe. In a nutshell, as documented by Asongu et al. (2015), while the great bulk of the literature has been oriented towards the emerging economies of Latin America and Asia on the one hand and the nations within the Organisation of Economic Cooperation (OECD) on the other hand, the comparative neglect of Africa is a substantial gap in the literature. In what follows, we engage studies highlighted in the introduction to motivate this inquiry.

Love and Mylenko (2000) have combined public and private credit registries with firm-related data from the World Bank Business Environment Survey (WBES) to examine linkages between enhanced financing sharing by perception managers and banks, credit registries and constraints in credit financing. The authors have established that: (i) PCR do not significantly bear on mitigating financing constraints and (ii) PCB are linked with higher financing from banks and lower financing constraints.

Galindo and Miller (2001) have provided a macroeconomic perspective and established that compared to less developed nations with credit bureaus, developed countries with credit registries are endowed with comparatively less restrictions to financial access. In essence, PCR that are well-performing substantially contribute to reduced-sensitivity of firms to investment decisions for the availability of cash flows. The authors further maintain that the performance of credit registries has been clouded by a 50% reduction, especially with respect to how internal funds affect investment decisions.

Barth et al. (2009) have used WEBS from 4000 firms in 56 counties and private credit from 129 countries to examine linkages between information sharing, lender/borrower competition and 'lending corruption' to establish two principal findings. First, firms' and banks' ownership structure, the legal environment and competition by firms substantially influence corruption in lending. Second, information sharing plays a crucial role in the negative relationship between banking competition and corrupt lending.

Triki and Gajigo (2014) have investigated the impact of ISO in access to finance by firms and the nexus between PCR design and financing constraints. Their findings show that: (i) access to finance is comparatively more in economies with PCB, relative to their counterparts with PCR or no credit offices and (ii) there is substantial heterogeneity in financial access as well as the design of ISO with PCR.

Asongu et al. (2015) have assessed information sharing policy thresholds for financial development and established the following. Both PCR and PCB have negative effects on financial depth, with the impact of the former higher in terms of magnitude. Whereas PCB have a negative impact of banking system allocation efficiency, the effect of PCR is not significant. Both PCR and PCB have negative impacts on financial activity, with the latter having a higher magnitude. Both types of credit offices positively affect financial size, with the effect from PCR higher in terms of magnitude.

2.2. Theoretical underpinnings

This section is engaged in two main strands, notably: theoretical underpinnings substantiating the nexus between information sharing and financial allocation efficiency on the one hand and on the other hand, the intuition for the role of ICT in information sharing for financial allocation efficiency.

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value of the bank's overhead cost as a share of its total assets) and, cost/income ratio (which assesses overhead costs relative to revenues)" (p.665). While the last-three are linked to the concept of profitability, the notion of efficiency employed within the framework of this paper is the first. The interested reader may also refer to Demirguc-Kunt and Beck, 2009 for additional insights.

In accordance with Claus and Grimes (2003), two main perspectives exist in the literature on the theoretical link between banking institutions and information sharing. Whereas the first lays emphasis on the provision of liquidity by banking institutions, the second is focused on the ability of banking institutions to transform assets' risk characteristics. Both strands in the literature draw on the fundamental mission of financial intermediation of enhancing allocation efficiency through cost reduction and efficient channelling of mobilised resources from lenders to borrowers. Related theories on the role of financial intermediaries have built on imperfect market information literature. In what follows we briefly engage some foremost authors who are consistent on the relevance of information sharing in increasing financial access.

Diamond and Dybvig (1983) have assessed liquidity provision by banks. In their model, ex-ante IA derives from the inability of lenders to classify borrowers in relation to their credit risks, hence, leading to issues of adverse selection. Conversely, ex-post IA arises when only borrowers can observe actual returns from a funded project. This may result in moral hazard if borrowers decide to limit compliance with their financial obligations towards corresponding lenders/banks. The plethora of theoretical contributions in the economics of IA are broadly consistent with the Diamond and Dybvig on the need for information sharing to improve financial allocation efficiency, namely: (i) Leland and Pyle (1977) on the communication of information to investors about potential borrowers by banks; (ii) Diamond (1984) on diversification within financial intermediaries and (iii) Jaffee and Russell (1976), Stiglitz and Weiss (1981) and Williamson, 1986 with models of credit rationing. In essence, above studies are broadly consistent with the perspective that the primary mission of financial intermediaries is to reduce transaction and information costs arising from IA between lenders and borrowers. Therefore, the importance of ISO is consolidated by the need for channels through which information sharing can boost financial access.

ICT has been recently documented to increase information sharing between market participants in various sectors of developing countries. Some advantages have included: reduced marketing cost and increased market participation (Muto and Yamano, 2009; p. 1887) and reduction of information asymmetry (Aminuzzaman et al., 2003). In a nutshell, ICT in the perspectives of mobile phone and internet penetrations reduce information asymmetry (see Andonova, 2006). In the light of the above, the intuition that ICT can complement ISO in the reduction of IA for better financial access is sound.

3. Data and methodology

3.1. Data

The study investigates a panel of 53 African countries for the period 2004–2011, with data from the Financial Development and Structure Database (FDSD) and African Development Indicators (ADI) of the World Bank. The two main financial indicators are from the FDSD. Information on ISO is only available from the year 2004 while the latest year in the FDSD is 2011. First, financial efficiency is proxied with: (i) banking-system-efficiency (with 'banking system credit' on 'banking system deposits') and (ii) financial-system-efficiency (with 'financial system credit' on 'financial system deposits'). Second, financial activity is measured with: (i) banking system activity (with 'private domestic credit by deposit banks') and (ii) financial system activity (with 'private credit by deposit banks and other financial institutions').

In accordance with Triki and Gajigo (2014) and Asongu et al. (2015), IA is measured with PCB and PCR. There are six distinctive features between PCB and PCR, namely: access, status, purpose, coverage, ownership and data sources. For brevity and lack of space, the interested reader can have more insights from the two studies motivating the choice of these variables.

Consistent with the motivation of the inquiry on the growth potential of internet and mobile penetrations in Africa (see Penard et al., 2012; Tchamyou, 2015), ICT is measured with mobile phone and internet penetration rates. Six control indicators from recent financial development literature are employed to account for omission variable bias, notably: the lagged dependent variable, inflation, GDP growth, trade, public investment and foreign aid (Huang, 2005; Osabuohien and Efobi, 2013; Asongu, 2014b). A preliminary assessment shows that accounting for more than six control variables leads to instrument proliferation (or the number of instruments exceeding the number of cross sections). We devote space to discussing expected signs.

First, Do and Levchenko (2004) and Huang and Temple (2005) are supportive of the positive influence of trade openness on levels of domestic financial development. Second, the positive relationship between investment and financial development has been established by Huang (2011). Third, both theoretical (see Huybens and Smith, 1999) and empirical (Boyd et al., 2001) literatures are consistent with the view that chaotic inflation is associated with less active, less efficient and smaller banks. Fourth, the positive relationship between growth and financial development has been substantially documented in the literature (see Saint Paul, 1992; Greenwood and Jovanovic, 1990; Levine, 1997; Asongu, 2015b). In essence, economic growth is linked with reduced financial intermediation cost because of *inter alia*: intensive competition and availability of more funds for productive investments. Furthermore, Jaffee and Levonian (2001) have established that income levels have a positive influence on banking system structure while Asongu (2012) has concluded that higher income countries in Africa are associated with higher levels of financial development. Fifth, whereas development assistance is theoretically expected to boost financial development because it is destined to bridge the saving-investment or finance-investment gap poor countries face (Easterly, 2005), from a practical perspective however, the nexus could also be negative for at least a twofold reason: if foreign aid is substantially spent in donor nations and/or stolen in recipient countries by corrupt officials are deposited in developed countries through tax havens whose politico-economic jurisdictions are controlled by advanced economies.

The definitions and sources of indicators are disclosed in Appendix A. Appendix B provides the summary statistics whereas the correlation matrix is presented in Appendix C. From the summary statistics, the means of the variables are comparable and the corresponding degree of variations is an indication that reasonable estimated linkages would emerge. The purpose of the correlation matrix is to avoid concerns about multicollinearity. After a preliminary assessment, concerns about multi-collinearity are apparent between financial development variables on the one hand and between ICT indicators on the other hand. While the concerns in financial development are not very relevant because they are used exclusively as dependent variables, the underlying issue in ICT is tackled by using the mobile phone and internet variables in distinct specifications.

3.2. Methodology

The study adopts an empirical strategy that is based on *two-step* Generalised Method Moments (GMM) with forward orthogonal deviations instead of differencing. This estimation approach is an extension of Arellano and Bover (1995) by Roodman (2009a, b). The estimation strategy has two main advantages, notably: it restricts instrument proliferation or over-identification and controls for cross-sectional dependence (Love and Zicchino, 2006; Baltagi, 2008). The two basic requirements for the adoption of a GMM approach are satisfied because: (i) the number of cross-sections is higher than the number of time series in the cross-sections or N(53) > T(8) and (ii) the dependent variables are persistent as apparent in Appendix D where the coefficients of correlation between the dependent variables and their lagged values are higher than the rule of thumb threshold of 0.800.

The following equations in levels (1) and first difference (2) summarize the estimation procedure.

$$FD_{i,t} = \sigma_0 + \sigma_1 FD_{i,t-\tau} + \sigma_2 ISO_{i,t} + \sigma_3 ICT_{i,t} + \sigma_4 Inter_{i,t} + \sum_{h=1}^{5} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \tag{1}$$

$$FD_{i,t} - FD_{i,t-\tau} = \sigma_0 + \sigma_1(FD_{i,t-\tau} - FD_{i,t-2\tau}) + \sigma_2(ISO_{i,t} - ISO_{i,t-\tau}) + \sigma_3(ICT_{i,t} - ICT_{i,t-\tau})$$

$$+\sigma_4(Inter_{i,t} - Inter_{i,t-\tau}) + \sum_{h=1}^{5} \delta_h(W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + \varepsilon_{i,t-\tau} \tag{2}$$

where $FD_{i,t}$ is the financial development (efficiency and activity) of country i at period t; α is a constant; τ represents tau; *ISO*, is an information sharing office (PCR or PCB); *ICT*, information and communication technology (mobile phone or internet); *Inter*, interaction between ISO and ICT; *W* is the vector of five control variables (*inflation, public investment, GDP growth, trade* and *foreign aid*), η_i is the country-specific effect, ξ_t is the time-specific constant and $\varepsilon_{i,t}$ the error term.

A *two-step* specification is preferred to the *one-step* procedure because it is consistent with heteroscedasticity. We are also consistent with Brambor et al. (2006) in integrating all constitutive terms into the specifications.

4. Empirical results

4.1. Presentation of results

The empirical exercise is engaged at three levels. We first begin by examining the role of ICT on ISO in financial activity. Then the focus is oriented towards financial allocation efficiency. Last, we elicit the financial allocation efficiency findings by assessing linkages with liquid liabilities or financial system deposits. Specifications are valid if post-estimation diagnostic tests are acceptable. To this end, four main information criteria are employed to assess the validity of estimated models. First, the absence of autocorrelation in the residuals is ascertained by a failure to reject the null hypothesis of the second-order Arellano and Bond autocorrelation test in difference (AR(2)). Second, null hypotheses corresponding to the Hansen and Sargan over-identification restrictions (OIR) tests should also not be rejected for the instruments to be valid. In essence, the Sargan (Hansen) test which is based on homoscedasticity (heteroscedasticity) is not robust (robust) but not weakened (weakened) by instruments. In order to avoid instrument proliferation, the specifications are tailored such that the number of cross sections is higher than the corresponding number of instruments. Third, the Difference in Hansen Test (DHT) for the exogeneity of instruments is also employed to further assess the validity of the Hansen OIR. Fourth, the joint validity of estimated coefficients is examined with the Fisher test.

Tables 1–3 respectively present findings corresponding to financial activity, financial efficiency and liquid liabilities. Three main findings are articulated, namely: the marginal effects, net impacts of ICT and thresholds at which the marginal effects of ICT can completely change the sign of the unconditional ISO impact. Moreover, for an ICT threshold to have economic meaning, it must be within the range provided by the summary statistics. For instance, in the first specification of Table 1: (i) the marginal effect of mobile phones on PCR for banking system activity is 0.0009; (ii) the corresponding net effect is $-0.129([36.659 \times 0.0009] \pm 0.162)$[5] and (iii) the threshold at which the positive marginal effects changes the unconditional

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[5] 36.659 is the mean value of mobile phone penetration.

Table 1
Financial activity, mobile phones and information asymmetry.

	Dependent Variable Financial Activity							
	Banking System Activity				Financial System Activity			
	Mobile Phones		Internet		Mobile Phones		Internet	
	PCR	PCB	PCR	PCB	PCR	PCB	PCR	PCB
Constant	−4.008***	−1.086	−1.856	−1.392**	−1.583	0.383	0.364	−0.974
	(0.000)	(0.145)	(0.129)	(0.028)	(0.227)	(0.722)	(0.780)	(0.150)
Banking System Activity (-1)	1.135***	1.089***	1.154***	1.046***	–	–	–	–
	(0.000)	(0.000)	(0.000)	(0.000)				
Financial System Activity (-1)	–	–	–	–	1.114***	1.122***	1.182***	1.061***
					(0.000)	(0.000)	(0.000)	(0.000)
Public Credit Registries (PCR)	−0.162***	–	-0.158***	–	−0.175***	–	-0.132***	–
	(0.005)		(0.001)		(0.003)		(0.000)	
Private Credit Bureaus (PCB)	–	0.014	–	0.028**	–	0.017	–	0.051***
		(0.287)		(0.018)		(0.251)		(0.000)
Mobile Phones	−0.043***	−0.019**	–	–	−0.029**	−0.021**	–	–
	(0.001)	(0.021)			(0.022)	(0.043)		
Internet	–	–	−0.198***	−0.015	–	–	-0.259***	−0.010
			(0.000)	(0.293)			(0.000)	(0.348)
PCR*Mobile Phones	0.0009**	–	–	–	0.001***	–	–	–
	(0.046)				(0.007)			
PCB*Mobile Phones	–	−0.0005***	–	–	–	−0.001***	–	–
		(0.000)				(0.000)		
PCR*Internet	–	–	0.003**	–	–	–	0.003***	–
			(0.011)				(0.000)	
PCB*Internet	–	–	–	−0.006***	–	–	–	−0.008***
				(0.000)				(0.000)
GDP growth	0.071**	0.048**	0.055***	0.024	0.029	0.049*	0.017	−0.010
	(0.020)	(0.022)	(0.009)	(0.211)	(0.459)	(0.057)	(0.560)	(0.600)
Inflation	−0.020	-0.021*	−0.012	-0.017***	−0.021	−0.027	−0.024	-0.030**
	(0.201)	(0.059)	(0.389)	(0.000)	(0.284)	(0.130)	(0.372)	(0.017)
Public Investment	0.147***	0.066***	0.081***	0.024	0.153***	0.092***	0.126***	0.025
	(0.000)	(0.005)	(0.007)	(0.181)	(0.000)	(0.000)	(0.000)	(0.215)
Foreign Aid	0.010	0.001	0.047	0.064***	−0.013	-0.052*	−0.055*	0.081***
	(0.637)	(0.959)	(0.145)	(0.003)	(0.597)	(0.057)	(0.070)	(0.001)
Trade	0.017	0.014***	0.014	0.020***	−0.002	−0.006	−0.032**	0.009
	(0.159)	(0.003)	(0.322)	(0.004)	(0.812)	(0.446)	(0.024)	(0.218)
Net Effect of Mobile Phones	−0.129	−0.004	–	–	−0.138	−0.019	–	–
Net Effect of Internet	–	–	−0.137	−0.012	–	–	−0.111	na
Thresholds (-/ +)	180	−28	52.66	−4.66	175	−17	44	na
AR(1)	(0.021)	(0.008)	(0.034)	(0.003)	(0.091)	(0.025)	(0.185)	(0.003)
AR(2)	(0.298)	(0.201)	(0.402)	(0.196)	(0.115)	(0.119)	(0.164)	(0.088)
Sargan OIR	(0.028)	(0.009)	(0.042)	(0.000)	(0.006)	(0.010)	(0.204)	(0.000)
Hansen OIR	(0.432)	(0.388)	(0.266)	(0.205)	(0.402)	(0.335)	(0.570)	(0.206)
DHT for instruments								
(a)Instruments in levels								
H excluding group	(0.167)	(0.070)	(0.224)	(0.089)	(0.049)	(0.036)	(0.381)	(0.123)
Dif(null, H = exogenous)	(0.675)	(0.806)	(0.368)	(0.468)	(0.879)	(0.859)	(0.627)	(0.401)
(b) IV (years, eq(diff))								
H excluding group	(0.330)	(0.220)	(0.498)	(0.499)	(0.234)	(0.133)	(0.419)	(0.410)
Dif(null, H = exogenous)	(0.618)	(0.814)	(0.102)	(0.058)	(0.805)	(0.958)	(0.740)	(0.096)
Fisher	2657.72***	43729.6***	28165.3***	45640.8***	8277.50***	225087***	62262***	146109***
Instruments	41	41	41	41	41	41	41	41
Countries	45	45	45	45	45	45	45	45
Observations	259	259	255	255	261	261	257	257

DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) and AR(2) tests and; b) the validity of the instruments in the Sargan OIR test. GDP: Gross Domestic Product.

* significance levels of 10%.
** significance level of 5%.
*** significance level of 1% respectively.

negative effect of PCR (-0.162) from negative to positive is 180 (0.162/0.0009). Unfortunately, the positive threshold is not within the mobile phone range (0.214–171.51) disclosed by the summary statistics.

The following findings can be established for Table 1. First, marginal effects from interactions between ICT and PCR (PCB) are consistently positive (negative). Second, net effects from interactions between ICT and ISO are negative with a higher magnitude from interactions with PCR. Third, only thresholds corresponding to interactions between PCR and internet

Table 2
Banking efficiency, mobile phones and information asymmetry.

	Dependent Variable: Financial Efficiency							
	Banking System Efficiency				Financial System Efficiency			
	Mobile Phones		Internet		Mobile Phones		Internet	
	PCR	PCB	PCR	PCB	PCR	PCB	PCR	PCB
Constant	31.170*** (0.000)	28.316*** (0.000)	16.790*** (0.000)	25.551*** (0.000)	8.360*** (0.008)	−2.190 (0.363)	13.057*** (0.000)	0.606 (0.838)
Banking System Efficiency (-1)	0.719*** (0.000)	0.774*** (0.000)	0.798*** (0.000)	0.785*** (0.000)	–	–	–	–
Financial System Efficiency (-1)	–	–	–	–	0.854*** (0.000)	0.972*** (0.000)	0.793*** (0.000)	0.948*** (0.000)
Public Credit Registries (PCR)	−0.104 (0.543)	–	−0.055 (0.808)	–	−0.109 (0.286)	–	−0.236** (0.023)	–
Private Credit Bureaus (PCB)	–	−0.054 (0.655)	–	-0.203*** (0.004)	–	-0.078*** (0.003)	–	-0.165*** (0.000)
Mobile Phones	-0.081** (0.011)	−0.002 (0.956)	–	–	−0.021 (0.175)	-0.036* (0.053)	–	–
Internet	–	–	−0.129 (0.159)	−0.091 (0.399)	–	–	0.083 (0.186)	−0.011 (0.857)
PCR*Mobile Phones	0.003** (0.048)	–	–	–	0.001 (0.119)	–	–	–
PCB*Mobile Phones	–	−0.0001 (0.911)	–	–	–	0.0004 (0.130)	–	–
PCR*Internet	–	–	0.007 (0.344)	–	–	–	0.010*** (0.008)	–
PCB*Internet	–	–	–	0.007 (0.191)	–	–	–	0.008*** (0.000)
GDP growth	0.536*** (0.000)	0.390*** (0.004)	0.499*** (0.000)	0.605*** (0.000)	0.636*** (0.000)	0.650*** (0.000)	0.489*** (0.000)	0.609*** (0.000)
Inflation	0.0005*** (0.000)	0.0006*** (0.000)	0.0006*** (0.000)	0.0006*** (0.000)	0.041 (0.459)	−0.042 (0.303)	0.019 (0.773)	−0.038 (0.483)
Public Investment	-0.311*** (0.000)	-0.375*** (0.000)	-0.290** (0.019)	-0.479*** (0.000)	−0.031 (0.653)	0.095 (0.213)	−0.021 (0.791)	0.053 (0.483)
Foreign Aid	-0.350*** (0.000)	-0.375*** (0.006)	-0.336*** (0.003)	-0.491*** (0.000)	-0.138** (0.015)	−0.093 (0.0113)	−0.111 (0.146)	0.032 (0.349)
Trade	−0.00004 (0.999)	−0.039 (0.317)	0.058* (0.097)	0.007 (0.791)	0.046 (0.169)	0.044 (0.148)	0.022 (0.478)	0.035 (0.349)
Net Effect of Mobile Phones	0.005	na	–	–	na	na	–	–
Net Effect of Internet	–	–	na	na	–	–	na	na
Thresholds (-/ +)	34.66	na	na	na	na	na	na	na
AR(1)	(0.003)	(0.002)	(0.002)	(0.003)	(0.137)	(0.093)	(0.156)	(0.102)
AR(2)	(0.135)	(0.153)	(0.087)	(0.125)	(0.020)	(0.023)	(0.021)	(0.018)
Sargan OIR	(0.221)	(0.033)	(0.266)	(0.325)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	(0.474)	(0.344)	(0.749)	(0.219)	(0.215)	(0.251)	(0.278)	(0.311)
DHT for instruments								
(a)Instruments in levels								
H excluding group	(0.768)	(0.530)	(0.581)	(0.570)	(0.409)	(0.262)	(0.397)	(0.312)
Dif(null, H = exogenous)	(0.280)	(0.265)	(0.712)	(0.135)	(0.184)	(0.313)	(0.260)	(0.355)
(b) IV (years, eq(diff))								
H excluding group	(0.713)	(0.364)	(0.554)	(0.455)	(0.245)	(0.137)	(0.557)	(0.168)
Dif(null, H = exogenous)	(0.140)	(0.347)	(0.877)	(0.085)	(0.282)	(0.735)	(0.083)	(0.790)
Fisher	6887.33***	6566.06***	7684.16***	1873.05***	1351.21***	59825.5***	558.27***	68898.6***
Instruments	41	41	41	41	41	41	41	41
Countries	45	45	45	45	45	45	45	45
Observations	266	266	262	262	259	259	255	255

DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) and AR(2) tests and; b) the validity of the instruments in the Sargan OIR test. GDP: Gross Domestic Product.

    * significance levels of 10%.
   ** significance levels of 5%.
   *** significance levels of 1% respectively.

penetration are within range, notably: 52. 66 and 44 respectively for 'banking system activity' and 'financial system activity'. Fourth, the significant control variables have expected signs.

In Table 2 on financial efficiency regressions, the following can be established. First, on the interaction between mobile phones and PCR, the: marginal effect is positive (0.003), net effect is positive (0.005) and positive threshold (34.66) is within range (0.214–171.51). Second, the control variables are significant with the expected signs. Given that the findings on financial allocation efficiency are less significant compared to those on financial activity, we attempt to elicit this insignificance

Table 3
Liquid liabilities, mobile phones and information asymmetry.

| | Dependent Variable: Financial System Deposits (Liquid Liabilities) | | | |
| | Mobile Phones | | Internet | |
	PCR	PCB	PCR	PCB
Constant	−2.415	−4.324**	−1.386*	−1.838
	(0.126)	(0.014)	(0.072)	(0.140)
Liquid Liabilities (-1)	1.093***	1.016***	1.075***	1.061***
	(0.000)	(0.000)	(0.000)	(0.000)
Public Credit Registries (PCR)	-0.348***	–	-0.113***	–
	(0.000)		(0.008)	
Private Credit Bureaus (PCB)	–	0.082***	–	0.084***
		(0.000)		(0.000)
Mobile Phones	-0.023*	0.011	–	–
	(0.060)	(0.269)		
Internet	–	–	-0.104***	-0.090***
			(0.000)	(0.000)
PCR*Mobile Phones	0.001***	–	–	–
	(0.002)			
PCB*Mobile Phones	–	-0.0009***	–	–
		(0.000)		
PCR*Internet	–	–	−0.0003	–
			(0.819)	
PCB*Internet	–	–	–	-0.005***
				(0.000)
GDP growth	-0.059**	-0.081***	-0.099***	-0.102***
	(0.011)	(0.000)	(0.000)	(0.000)
Inflation	−0.017	0.0006	-0.018**	-0.019*
	(0.324)	(0.935)	(0.023)	(0.078)
Public Investment	0.107***	0.008	0.0009	−0.018
	(0.000)	(0.721)	(0.968)	(0.372)
Foreign Aid	0.029	0.101**	0.034	0.084*
	(0.346)	(0.011)	(0.211)	(0.057)
Trade	0.026	0.045***	0.029***	0.026**
	(0.100)	(0.003)	(0.000)	(0.021)
Net Effect of Mobile Phones	−0.311	0.049	–	–
Net Effect of Internet	–	–	na	0.049
Thresholds (-/ +)	348	−91.11	na	−16.80
AR(1)	(0.002)	(0.001)	(0.002)	(0.001)
AR(2)	(0.544)	(0.388)	(0.650)	(0.344)
Sargan OIR	(0.038)	(0.004)	(0.056)	(0.056)
Hansen OIR	(0.541)	(0.558)	(0.415)	(0.185)
DHT for instruments				
(a)Instruments in levels				
H excluding group	(0.414)	(0.091)	(0.119)	(0.029)
Dif(null, H = exogenous)	(0.565)	(0.917)	(0.733)	(0.668)
(b) IV (years, eq(diff))				
H excluding group	(0.739)	(0.414)	(0.459)	(0.368)
Dif(null, H = exogenous)	(0.180)	(0.724)	(0.330)	(0.099)
Fisher	2098.91***	9750.14***	42993.22***	57432.6***
Instruments	41	41	41	41
Countries	45	45	45	45
Observations	259	259	255	255

DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) and AR(2) tests and; b) the validity of the instruments in the Sargan OIR test. GDP: Gross Domestic Product.

* significance levels of 10%.
** significance levels of 5%.
*** significance levels of 1% respectively.

by further assessing the role of ICT in ISO for financial system deposits. This is to verify if the unsatisfactory findings from financial efficiency may be the result of ICT also reducing information asymmetry to increase financial system deposits (liquid liabilities). To this end, results from Table 3 broadly confirm this intuition because: the marginal effect of mobile phone penetration on PCR is positive whereas the net effects of ICT on PCB are positive. It follows that financial allocation efficiency may also be constrained by the increasing financial system deposits. In other words, the interaction between ICT and ISO for allocation efficiency may be constrained by increasing financial system deposits. Most of the control variables in Tables 2 and 3 are significant with the expected signs because the three dependent variables are by conception and definition

conflicting because the dependent variable in Table 2 (allocation efficiency) is the ability of the dependent variable in Table 3 (financial deposit) to be transformed into the dependent variable in Table 1 (financial credit).

4.2. Further discussion of results and implications

Established results are further discussed in two main strands, namely, implications for: theory and practice.

4.2.1. Implications for theory

Given that findings related to financial efficiency are not overwhelmingly significant; implications for theory are fundamentally related to the negative net impacts of interactions on financial activity. This implies that the net effect of the interaction between ICT and ISO on the allocation of credit is negative, for the most part. Hence, it is reasonable to infer that the 'quiet of life hypothesis' (QLH) may be enjoyed by banking institutions (Coccorese and Pellecchia, 2010). In essence, the QLH postulates that banks with substantial advantages would dedicate less effort towards pursuing objectives of financial access. Instead, they would prefer to instrument the underlying advantages to increasing their gains and enjoying a 'quiet life' instead of increasing financial access to borrowers.

In the light of consistent negative net effects, we can be tempted to infer that African financial institutions are taking advantage of the burgeoning ICT and ISO to improve their profit margins instead of increasing financial access. Hence, we may also infer that the ISO are not fulfilling their theoretical mission of helping financial institutions to increase credit allocation. This is specifically because, ISO should reduce information rents linked to the high credit cost and ICT is instrumental in the provision and diffusion of information. Given that ISO are fundamentally relevant in checking the abuse of market power by big banks and that 'quality of life' is related to banks with market power for the most part, it is also reasonable to infer that the advent of ISO and ICT have not been accompanied with increased market competition in the banking industry. In summary, the nexus between ISO and ICT may not be garnering anticipated financial access externalities because the interaction is yet to counteract the weight of powerful banks by, amongst others, sharing information to: boost competition, reduce rents in the information market and increase the contestability of credit markets (see Pagano and Jappelli, 1993; p. 2019). As an implication, it would be worthwhile for policy to tailor the nexus between ISO and ICT towards improving competition in the financial environment and limiting the domination of powerful banks.

It is important to extend the above discourse with possible inherent issues of: (i) moral hazard from bank customers and (ii) the nexus between ISO and ICT as a disciplinary mechanism for borrowers. This interpretation is relevant in the perspective that the sharing of information by ISO with help of ICT is not resulting in a net positive effect in terms of the allocation of credit because of fundamental moral hazard concerns on the part of borrowers. In essence, even if ISO and ICT contribute to completely mitigating information rents that banks previously enjoyed, banks may still be very unwilling to increase financial access if they are not convinced that a higher repayment probability would result from information provided by the association between ICT and ISO. This line of interpretation is fundamentally because ISO play an essential mission as a 'discipline instrument' on the part of borrowers by reducing moral hazard and providing them with performance incentives. Hence, as a policy implication, measures underlying the association between ISO and ICT for better financial access should be tailored with the hypothesis that, information provided as a result of the association between ICT and ISO may not be effective at increasing borrowers' discipline and reducing moral hazard, because of *inter alia*: rampant corrupt lending; recourse to informal financial mechanisms by borrowers and borrowers unafraid of losing their reputation.

4.2.2. Implications for practice

The fundamental practical implication of this study is that the nexus between ISO and ICT is yet not sufficient to fight the substantially documented concerns of surplus liquidity in African financial institutions. The existing complementarity between ISO and ICT would benefit from enhance information synchronisation and more qualified personal through *inter alia*: 'knowledge economy' (KE)-driven economic policies; regular training of ISO staff; reliable high-speed access to the internet and instrumentation of mobile banking services. These improvements would help in consolidating the fight against the voluntary and involuntary holding of excess liquidity. First, the discussed instruments could be used to reduce involuntary holding of cash via, *inter alia*: reduction of the inability of banks to lend when interest rates are regulated; ease investment in bond markets by banks; augment competition in lending between banks and enlarge opportunities so that financial institutions invest in regional stock markets. Second, underlying instruments can also be used to limit voluntary holding of excess cash by, *inter alia*: easing constraints banks face when updating their status' at the level of central banks in order to prevent them from keeping reserves above statutory thresholds; facilitating contingency-related interbank lending and overcoming concerns about transportation that may constraint financial institutions in remote geographic areas to keep excess cash.

5. Conclusion and future directions

This study has assessed the role of information and communication technology (ICT) in complementing private credit bureaus (PCB) and public credit registries (PCR) in reducing information asymmetry for financial access and allocation efficiency. The empirical evidence is based on GMM with 53 African countries for the period 2004–2011. The following findings have been established. First on financial access: (i) the marginal effects from the interaction between ICT and PCR

(PCB) are consistently positive (negative); (ii) net effects from interactions between ICT and credit offices are negative with a higher magnitude from interactions with PCR and (iii) only thresholds corresponding to interactions between PCR and internet penetration are within range. Second, findings on financial allocation efficiency reveal positive marginal and net effects exclusively for mobile phones and PCR. Third, allocation efficiency may be constrained by increasing financial system deposits. Overall, the complementarity between information sharing offices and ICT in boosting financial access is still very limited. Policy implications have been discussed in the light of improving the complementary role of ICT in the mission of ISO and fighting surplus liquidity.

Future research could focus on examining the complementarity of ISO and ICT throughout the conditional distribution of financial access variables. The policy relevance of this approach is that dynamics of the engaged complementarity may be contingent on initial levels of financial access.

Appendix A. : Summary Statistics (2004–2011).

	Variables	Mean	S.D	Min	Max	Observations
Financial Access	Financial System Depth (Fdgdp).	28.262	21.066	2.926	92.325	377
	Banking System Efficiency (BcBd)	68.118	27.725	14.804	171.85	402
	Financial System Efficiency (FcFd)	68.118	27.725	14.804	171.85	402
	Banking System Activity (Pcrb)	72.722	35.884	22.200	252.88	377
	Financial System Activity (Pcrbof)	21.571	24.154	0.010	149.77	379
ICT	Mobile Phone Penetration	36.659	32.848	0.214	171.51	420
	Internet Penetration	6.822	8.852	0.031	51.00	414
Information Asymmetry	Public Credit registries (PCR)	2.155	5.812	0	49.8	381
	Private Credit Bureaus (PCB)	4.223	13.734	0	64.8	380
Control Variables	Economic Prosperity (GDPg)	4.996	4.556	−17.66	37.998	404
	Inflation	7.801	4.720	0	43.011	357
	Public Investment	74.778	1241.70	−8.974	24411	387
	Development Assistance	10.396	12.958	0.027	147.05	411
	Trade Openness (Trade)	80.861	32.935	24.968	186.15	392

S.D: Standard Deviation. Min: Minimum. Max: Maximum. Fdgdp: Financial deposits(liquid liabilities). BcBd: Bank credit on Bank deposits. FcFd: Financial credit on Financial deposits. Pcrb: Private domestic credit from deposit banks. Pcrbof: Private domestic credit from deposit banks and other financial institutions. GDPg: GDP growth.

Appendix B. : Correlation Analysis (Uniform sample size: 291).

Financial Access													
Deposits	Financial Efficiency		Financial Activity		Info Asymmetry		ICT		Other variables				
Fdgdp	BcBd	FcFd	Prcb	Pcrbof	PCR	PCB	Mobile	Internet	GDPg	Inflation	PubIvt	NODA	Trade
1.000	0.114	0.199	0.879	0.750	0.386	0.281	0.469	0.727	−0.100	−0.059	0.055	−0.281	0.130	Fdgdp
	1.000	0.859	0.490	0.495	0.154	0.303	0.117	0.140	−0.016	−0.144	−0.169	−0.133	−0.176	Bcbd
		1.000	0.583	0.743	0.067	0.510	0.224	0.149	−0.056	−0.097	−0.149	−0.179	−0.189	FcFd
			1.000	0.922	0.448	0.439	0.523	0.707	−0.092	−0.089	−0.055	−0.343	0.093	Pcrb
				1.000	0.293	0.556	0.495	0.558	−0.088	−0.073	−0.057	−0.324	0.019	Pcrbof
					1.000	−0.140	0.360	0.428	−0.026	−0.081	0.068	−0.154	0.207	PCR
						1.000	0.399	0.157	−0.101	−0.035	−0.047	−0.329	0.084	PCB
							1.000	0.629	−0.192	−0.136	0.088	−0.496	0.195	Mobile
								1.000	−0.082	−0.025	−0.024	−0.373	0.117	Internet

Fdgdp: Financial system deposits. BcBd: Bank credit on bank deposits. FcFd: Financial credit on Financial deposits. Pcrb: Private domestic credit from deposit banks. Pcrbof: Private domestic credit from deposit banks and other financial institutions. Info: Information. PCR: Public Credit Registries. PCB: Private Credit Bureaus. ICT: Information and Communication Technology. Mobile: Mobile Phone Penetration. Internet: Internet Penetration. GDPg: GDP growth. Popg: Population growth. PubIvt: Public Investment. NODA: Net Official Development Assistance. Info: Information.

Appendix C. : Variable Definitions.

Variables	Signs	Variable Definitions	Sources
Financial System Deposits	Fdgdp	Liquid Liabilities (% of GDP)	World Bank (FDSD)
Banking System Efficiency	BcBd	Bank credit on Bank deposits.	World Bank (FDSD)
Financial System Efficiency	FcFd	Financial credit on Financial deposits	World Bank (FDSD)
Banking System Activity	Prcb	Private domestic credit from deposit banks (% of GDP)	World Bank (FDSD)
Financial System Activity	Prcbof	Private domestic credit from financial institutions (% of GDP).	World Bank (FDSD)
Information Asymmetry	PCR	Public credit registry coverage (% of adults)	World Bank (WDI)
	PCB	Private credit bureau coverage (% of adults)	World Bank (WDI)
Information and Communication	Mobile	Mobile phone subscriptions (per 100 people)	World Bank (WDI)
Technology	Internet	Internet penetration (per 100 people)	World Bank (WDI)
Economic Prosperity	GDPg	GDP Growth (annual%)	World Bank (WDI)
Inflation	Infl	Consumer Price Index (annual%)	World Bank (WDI)
Public Investment	Publvt	Gross Public Investment (% of GDP)	World Bank (WDI)
Development Assistance	NODA	Total Net Official Development Assistance (% of GDP)	World Bank (WDI)
Trade openness	Trade	Imports plus Exports in commodities (% of GDP)	World Bank (WDI)

WDI: World Bank Development Indicators. FDSD: Financial Development and Structure Database.

Appendix D. : Persistence of the dependent variables.

	Deposits	Financial Efficiency		Financial Activity	
	Fdgdp	BcBd	FcFd	Pcrd	Pcrdof
Fdgdp(-1)	0.990				
BcBd(-1)		0.9438			
FcFd(-1)			0.9815		
Pcrd (-1)				0.9919	
Pcrdof(-1)					0.9945

BcBd: Bank credit on bank deposits. FcFd: Financial credit on Financial deposits. Pcrb: Private domestic credit from deposit banks. Pcrbof: Private domestic credit from deposit banks and other financial institutions. Fdgdp(-1): Lagged value of Financial system deposits.

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