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## ICT in reducing information asymmetry for financial sector competition

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# A G D I Working Paper

WP/18/035

## **ICT in Reducing Information Asymmetry for Financial Sector Competition<sup>1</sup>**

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Research Department

## **ICT in Reducing Information Asymmetry for Financial Sector Competition**

**Simplice A. Asongu & Joseph Nnanna**

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### **Abstract**

In this study, we examine the role of information and communication technology in complementing information sharing bureaus (or private credit bureaus and public credit registries) for financial sector competition. Hitherto unexplored dimensions of financial sector competition are employed, namely: financial sector dynamics of formalization, informalization and non-formalization. The empirical evidence is based on 53 African countries for the period 2004-2011 and the Generalised Method of Moments (GMM) with forward orthogonal deviations. The findings differ across financial sectors in terms of marginal, net and threshold effects. By introducing the concept of financialization, the study unites two streams of research by: improving the macroeconomic literature on measuring financial development and responding to an evolving field of development literature by means of informal finance. Moreover, a practical method by which to disentangle the effects of reducing information asymmetry on various financial sectors is suggested. Policy implications are discussed.

*JEL Classification:* G20; G29; L96; O40; O55

*Keywords:* Information sharing; Banking competition; Africa

## 1. Introduction

Information asymmetry (IA) between lenders and borrowers can substantially constraint access to finance in the banking industry. From a theoretical viewpoint, information sharing bureaus (ISB) are expected to reduce IA. Information and communication technology (ICT) is an instrument by which ISB mitigate IA by stimulating competition within the financial sector. Though, a strand of recent African financial development literature has emphasised the need for ISB in reducing IA for financial access (Triki & Gajigo, 2014), another strand of the literature is articulating the view that ISB may not be stimulating competition in the banking sector for enhanced financial access (Asongu et al., 2016a). According to the narrative, financial institutions with substantial market influence could be using information from ISB to enjoy a ‘quiet life’<sup>2</sup> because of lack of competition within the financial sector.

In addition to the above factors, there are three underlying motivations for positioning an inquiry on the relationship between ICT, reducing IA and financial sector competition in Africa, namely: (i) growing prospects of ICT penetration on the continent; (ii) gaps in the IA literature and (iii) introduction of previously unexplored dimensions of financialization within the framework of financial sector competition.

First, the relevance of ICT is twofold. According to Penard et al. (2012), the continent is experiencing an uneven development in mobiles phones vis-à-vis the internet. As of 2010, the internet (mobile phone) penetration rate was 9.6% (41%). On the other hand, the authors maintain that whereas ICT penetration has reached saturation points in developed economies, there is still much space for its improvement in Africa. In essence, whereas high-end markets in North America, Asia and Europe are experiencing growth-stabilization in ICT, Africa represents substantial business opportunities for ICT development.

Second, a recent stream of literature is consistent with the narrative that, the introduction of ISB about twelve years ago across the continent was primarily motivated by the need to address the policy syndrome of surplus liquidity in financial institutions (Triki & Gajigo, 2014;

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<sup>2</sup> ‘Quiet life’ is the short form of the ‘Quiet Life Hypothesis’ (QLH). According to Coccoresse and Pellicchia (2010) and Asongu and Odhiambo (2018a), the QLH is a supposition that banks with comparatively higher market power would use their advantages to grant less credit to borrowers, but instead exploit such opportunities for high profit margins or a ‘quiet life’.

Asongu et al., 2016b)<sup>3</sup>. The ISB are destined to reduce adverse selection and moral hazard in the financial industry. Notable ISB have included public credit registries (PCR) and private credit bureaus (PCB)<sup>4</sup>. Financial access issues related to IA that the ISB are designed to mitigate include: affordability, eligibility to bank lending and physical access (Batuo & Kupukile, 2010).

Despite the severe concerns of financial access in African financial institutions, the literature related on IA in the banking industry of the continent is very limited. For instance, Barth et al. (2009) have focused on nine African countries, Love and Mylenko (2003) on four, and Galindo and Miller (2001) on none. More recently, Asongu et al. (2016a, 2016b) have assessed 53 African countries for the period 2004-2011 while Triki and Gajigo (2014) have investigated 42 countries for the period 2006-2009. This inquiry is closest to the last-three studies that have used PCR and PCB as proxies for reducing IA. We steer clear of the stream of literature which has been oriented towards financial access by focusing on financial sector competition. The positioning of the inquiry is also in response to recommendations for more scholarly research on the outcomes of ISB on the continent (Singh et al., 2009, p. 13).

Third, this study introduces previously unexplored concepts of financialization within the framework of financial sector competition because to the best of our knowledge such has not been engaged by both broad (Galindo & Miller, 2001; Ivashina, 2009; Tanjung et al., 2010; Houston et al., 2010) and African-specific IA (Singh et al., 2009; Triki & Gajigo, 2014; Asongu et al., 2016a) literature. A possible reason for this missing dimension could be that ISB data is unavailable before 2004. Furthermore, recent financial development literature on competition within the banking sector has focused for the most part on bank participation and bank concentration (O'Toole, 2014; Asongu, 2015a). By introducing the concept of financialization (which is discussed in-depth in Section 2), the study unites two streams of research by: improving the macroeconomic literature on measuring financial development and responding to an evolving field of development literature by means of informal finance. Moreover, a practicable method by which to disentangle the effects of reducing IA on various financial sectors is suggested by the study. Whereas a substantial bulk of the literature has examined the relationship between reforms in the financial sector and access to finance (Arestis et al., 2002; Batuo & Kupukile, 2010), the role of the informal financial sector has often been neglected (see

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<sup>3</sup> The interested reader can find more insights into concerns about surplus liquidity in Saxegaard (2006) and Fouda (2009).

<sup>4</sup> In this inquiry 'PCR and PCB' and ISB are used interchangeably.

Meagher, 2013; Aryeetey, 2005; Adeusi et al., 2012). The propositions on financial sector competition which this study uses challenge the mainstream narrative in three principal areas, notably, they: (i) provide a definition of the financial system that integrates the missing informal financial sector; (ii) disentangle the existing definition into its formal and semi-formal components and (iii) introduce the notion of financialization within the perspective of financial sector competition.

The rest of the study is organised in the following manner. The theoretical underpinnings, propositions and related literature are provided in Section 2. Section 3 discusses the data and methodology. The empirical results and policy implications are provided in Section 4 while Section 5 concludes with future research directions.

## **2. Theoretical underpinnings, propositions and related literature**

Two principal theoretical perspectives dominate the relationship between reducing IA and financial development (Claus & Grimes, 2003; Asongu et al., 2016b). The first is concerned with the manner in which the risk features of bank assets are transformed whereas the second focuses on channels through which liquidity made available by financial institutions can be enhanced. The two branches of the literature however, accord with the view that the fundamental goal of financial institutions is to transform mobilised deposits into credit for economic operators. The efficiency of resource mobilisation can be boosted by ISB through *inter alia*: reducing the cost of and constraints to credit and increasing competition within the financial sector (see Jappelli & Pagano, 2002). This inquiry is more focused on the latter: how ISB influence competition within the financial sector.

The highlighted perspectives are broadly in accordance with foremost studies on the relevance of reducing IA for financial development, namely: credit rationing models (Jaffee & Russell, 1976; Stiglitz & Weiss, 1981; Williamson, 1986); diversification with financial intermediaries (Diamond, 1984); communication by banks to investors on potential borrowers (Leland & Pyle, 1977) and ex-ante and ex-post information asymmetry (Diamond & Dybvig, 1983). Much recent studies are consistent with theoretical perspective that ISB enhance financial access through competition within the financial sector (see Triki & Gajigo, 2014; Asongu et al., 2016a). In this study, financial sector competition is measured by addressing

setbacks in the definition of the financial system by the International Financial Statistics (IFS, 2008) that has neglected the informal financial sector (Asongu, 2014a).

**Table 1: Summary of propositions**

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

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

Source: Asongu (2015a).

<sup>5</sup> Lines 24 and 25 of the International Financial Statistics (October 2008).

<sup>6</sup> Lines 24, 25 and 45 of the International Financial Statistics (2008).

<sup>7</sup> “Accordingly, in undeveloped countries money supply is not equal to liquid liabilities or bank deposits. While in undeveloped countries bank deposits as a ratio of money supply is less than one, in developed countries this ratio is almost equal to 1. This indicator appreciates the degree by which money in circulation is absorbed by the banking system. Here we define ‘financial formalization’ as the propensity of the formal banking system to absorb money in circulation” (Asongu, 2015a, p. 432).

<sup>8</sup> “This indicator measures the rate at which the semi-formal financial sector is evolving at the expense of formal and informal sectors” (Asongu, 2015a, p. 432).

<sup>9</sup> “This proposition appreciates the degree by which the informal financial sector is developing to the detriment of formal and semi-formal sectors” (Asongu, 2015a, p. 432).

<sup>10</sup> “The proposition measures the deterioration of the formal banking sector in the interest of other financial sectors (informal and semi-formal). From common sense, propositions 5 and 8 should be almost perfectly antagonistic, meaning the former (formal financial development at the cost of other financial sectors) and the latter (formal sector deterioration) should almost display a perfectly negative degree of substitution or correlation” (Asongu, 2015a, p. 432).

Table 1 presents propositions that build on shortcomings of the IFS's definition. The propositions which incorporate the missing informal financial sector have been employed in recent African literature on financial sector competition (Asongu, 2015a, 2015b; Asongu & Odhiambo, 2018b; Asongu & Acha-Anyi, 2017; Meniago & Asongu, 2018). While Panel A presents indicators of financial sector that are based on Gross Domestic Product (GDP), those suggested in Panel B are associated with competition for shares in money supply (M2) within the financial sector. Some previously unemployed notions are substantially articulated in the propositions, namely, notions of financial: formalization, informalization, semi-formalization and non-formalization. In essence, the concept of financialization articulates the progress of one financial sector to the detriment of one or more financial sectors. For instance, financial formalization denotes the improvements of money supply shares of the formal financial sector, to the detriment of other financial sectors, namely: the informal and semi-formal sectors.

The literature on reducing IA for financial access has for the most part been focused on developed countries and the emerging economies of Asia and Latin America, whereas the African continent has not been given the scholarly attention it deserves (Asongu et al., 2016a). The broader literature on IA has revolved around two principal themes: the role of IA between creditors on the one hand and the impacts of creditors' rights on strengthened information sharing channels. Accordingly, one stream of studies has focused fundamentally on the importance of stronger creditors' rights in: risk-taking by banks (Houston et al., 2010; Acharya et al., 2011) and bankruptcy (Claessens & Klapper, 2005; Djankov et al., 2007; Brockman & Unlu, 2009). Another stream of literature is oriented towards assessing how reducing IA could: reduce default rates (Jappelli & Pagano, 2002); increase access to finance (Djankov et al., 2007; Brown et al., 2009; Triki & Gajigo, 2014); reduce credit cost (Brown et al., 2009); affect antitrust intervention (Coccoresse, 2012); influence lending linked to corruption (Barth et al., 2009) and affect bank loans that are syndicated (Ivashina, 2009; Tanjung et al., 2010).

From a macroeconomic angle, the issue about reducing IA has been investigated by Galindo and Miller (2001) who have established that, relative to less developed countries, developed nations which are characterised with ISB are associated with fewer financial access restrictions. According to the narrative, high performing PCR substantially contribute towards the reducing sensitivity by enterprises to investment decisions for 'availability of cash flow' which is used to proxy for constraints in access to finance. Love and Mylenko (2000) have used



ISB to assess if reducing IA between banks and perception managers affect financial credit constraints to establish that credit registries are negatively linked to financial credit constraints. The authors have established that while PCR do not considerably reduce constraints in financial access, PCB are linked to higher levels in access to finance. Barth et al. (2009) conclude that: corrupt-oriented lending is mitigated by banking competition and ‘corrupt lending’ is considerably influenced by firm competition, the legal environment and the structure of ownership in firms and banks.

Triki and Gajigo (2014) have recently assessed the role of ISB on financial access, notably: the effect of ISB on firms’ access to finance and how the design of ISB affects constraints in access to finance. They have concluded that: (i) substantial cross-country disparities exist in financial constraints and the design of ISB with PCR and (ii) financial access is higher in nations with PCB, compared to their counterparts with PCR or no ISB. Asongu et al. (2016a) have examined reducing IA policy thresholds by which financial development can be enhanced to establish conflicting findings whereas Asongu et al. (2016b) have investigated the impacts of ISB throughout the conditional distributions of financial development. They have concluded that initial levels of financial development substantially affect the incremental benefits of financial access from the introduction of PCR and PCB.

As documented in the introduction, the present inquiry complements the discussed literature by: engaging the missing dimension of financial sector competition in the IA literature and introducing the role of ICT in the relationship between reducing IA and financial sector competition.

### **3. Data and Methodology**

#### **3.1 Data**

The study assesses a panel of 53 African countries with data from African Development Indicators (ADI) and the Financial Development and Structure Database (FDSD) of the World Bank for the period 2004-2011. It is important to note that data on PCR and PCB are only available from 2004 while the latest date in the FDSD is 2011. The scope of Africa is in accordance with the stylized facts discussed earlier, notably: the scarce literature on the relationship between reducing IA and financial development on the one hand and on the other hand, severe financial access constraints across the continent.

The financial sector competition indicators proposed in Table 1 are computed from the FDSI of the World Bank. Consistent with recent African literature, information sharing proxies used to decrease IA are private credit bureaus (PCB) and public credit registries (PCR) (see Triki & Gajigo, 2014; Asongu et al., 2016b). Three financial sector measurements are used namely: informal financial development (Propositions 3 and 7); formal financial development (Propositions 1 and 5); and non-formal financial development (Propositions 4 and 8). Semi-formal financial development (Propositions 2 and 6) is not employed because of constraints in degrees of freedom.

We employ six control variables to account for concerns in variable omission bias: the lagged dependent variable, public investment, foreign aid, trade, inflation and GDP growth. The choice of these variables for the conditioning information set is in accordance with the financial development literature (see Huang, 2005; Osabuohien & Efobi, 2013; Asongu, 2014b; Asongu et al., 2018). The control variables are limited to six because results from a pilot study or preliminary investigation reveal that controlling for more than six variables leads to instrument proliferation.

Foreign aid is theoretically expected to increase financial development because its purpose is to reduce the saving-investment gap that less developed countries face (Easterly, 2005). From a pragmatic perspective however, development assistance may also negatively affect financial development if *inter alia*: a substantial portion does not reach destination countries or reaches recipient countries but is immediately siphoned by corrupt officials and deposited in tax havens under the jurisdictions of developed countries. The positive nexus between finance and economic prosperity has been substantially documented (see Greenwood & Jovanovic, 1992; Saint-Paul, 1992; Levine, 1997; Jaffee & Levonian 2001). Accordingly, economic growth is positively associated with financial development through, among others: enhanced availability of financial resources for investment purposes and increased competition within the banking sector (see Huang, 2011). Theoretical (Huybens & Smith, 1999) and empirical (Boyd et al., 2001) studies accord with the view that very high inflation is associated with inefficient and less active financial institutions. Trade openness has been documented to be positively linked to financial development (see Do & Levchenko, 2004; Huang & Temple, 2005). It is important to also note that the engaged variables in the conditioning information set may affect the formal and informal financial sectors differently.

Appendix 1, Appendix 2 and Appendix 3 respectively disclose the definition (and sources), summary statistics and correlation matrix of the variables. From the summary statistics, it is apparent from mean values that variables are comparable. Moreover, from related standard deviations, reasonable estimated nexuses can be expected. The objective of the correlation matrix is to control for potential multicollinearity issues. After a preliminary investigation, the issues are apparent between indicators of financial sector competition. Fortunately, such issues are not of serious nature to bias specifications because the financial sector competition indicators are exclusively used in distinct specifications as dependent variables.

### 3.2 Methodology

#### 3.2.1 Specification

The estimation approach adopted by the study is the Generalised Method of Moments (GMM) that employs forward orthogonal deviations. The strategy is the extension of Arellano and Bover (1995) by Roodman (2009a, 2009b) which has been documented to restrict the proliferation of instruments and account for cross-sectional dependence (see Love & Zicchino, 2006; Baltagi, 2008). The two main conditions for the application of the estimation strategy are also satisfied. First,  $N > T$  because the number of time series ( $T=8$ ) is less than the number of cross sections ( $N=53$ ). Second, there is persistence in the dependent or financial sector competition variables because as shown in Appendix 4, their correlations with corresponding lags are higher than the rule of thumb threshold of 0.800 (Tchamyou *et al.*, 2018)

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

$$FSC_{i,t} = \sigma_0 + \sigma_1 FSC_{i,t-\tau} + \sigma_2 ISB_{i,t} + \sigma_3 ICT_{i,t} + \sigma_4 Inter_{i,t} + \sum_{h=1}^5 \delta_j W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$\begin{aligned} FSC_{i,t} - FSC_{i,t-\tau} = & \sigma_0 + \sigma_1 (FSC_{i,t-\tau} - FSC_{i,t-2\tau}) + \sigma_2 (ISB_{i,t} - ISB_{i,t-\tau}) + \sigma_3 (ICT_{i,t} - ICT_{i,t-\tau}) \\ & + \sigma_4 (Inter_{i,t} - Inter_{i,t-\tau}) + \sum_{h=1}^5 \delta_j (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \end{aligned} \quad (2)$$

where,  $FSC_{i,t}$  is the financial sector competition (formal, informal and non-formal finances) of country  $i$  at period  $t$ ;  $\alpha$  is a constant;  $\tau$  represents the coefficient of autoregression;  $ISB$ , Information Sharing Bureaus (PCR or PCB);  $ICT$ , information and communication technology (mobile phone or internet penetration);  $Inter$ , interaction between ISB and ICT;  $W$  is the vector

of five control variables (*inflation, public investment, GDP growth, trade and foreign aid*),  $\eta_i$  is the country-specific effect,  $\xi_t$  is the time-specific constant and  $\varepsilon_{i,t}$  the error term. In the specifications, a *two-step* process is adopted because it accounts for heteroscedasticity. Consistent with Brambor et al. (2006) on the pitfalls surrounding interactive regressions: (i) all constitutive variables are included in the specifications and (ii) the impact of the modifying policy variables (or ICT) are interpreted as conditional marginal impacts.

### 3.2.2 Identification and exclusion restrictions

Consistent with recent literature (see Dewan & Ramaprasad, 2014; Asongu & De Moor, 2017; Tchamyou, 2018a, 2018b; Tchamyou & Asongu, 2017; Boateng et al., 2018), all independent variables are suspected endogenous or predetermined. Therefore, the *gmmstyle* is considered for the predetermined variables whereas only years are treated as strictly exogenous. Moreover, the method for treating the *ivstyle* (years) is ‘iv(years, eq(diff))’ because it is not very likely for the years to become endogenous in first-difference (see Roodman, 2009b).

In order to tackle the concern of simultaneity, lagged regressors are employed as instruments for forward-differenced variables. Accordingly, Helmet transformations are performed for the regressors in order to remove fixed effects that are susceptible of affecting the investigated nexuses (see Asongu & De Moor, 2017). These underlying transformations consist of forward mean-differencing of the variables: instead of subtracting the previous observations for the contemporaneous one, the mean of lead observations are subtracted from the variables (Roodman, 2009b, p. 104). The transformations enable orthogonal or parallel conditions between lagged and forward-differenced values. In order to limit the loss of data, irrespective of lag numbers, the underlying transformations are computed for observations, with the exception of the last observation for each country. “*And because lagged observations do not enter the formula, they are valid as instruments*” (Roodman 2009b, p. 104).

We further argue that the instruments that exhibit strict exogeneity can influence the dependent variable exclusively through explaining variables. The statistical importance of the exclusion restriction is established with the Difference in Hansen Test (DHT) for instrument exogeneity. Accordingly, the alternative hypothesis of the test should be rejected for the instruments to elucidate the dependent variable exclusively via the endogenous explaining variables.

In the standard instrumental variable (IV) procedure, a rejection of the alternative hypothesis of the Sargan Overidentifying Restrictions (OIR) test indicates that the instruments explain the dependent variable exclusively via investigated mechanisms or explaining variables. While this information criterion has been used in the IV literature (see Beck et al., 2003; Asongu & Nwachukwu, 2016), in the GMM approach (with forward orthogonal deviations), the DHT is used to assess if years exhibit strict exogeneity: by explaining financial sector competition exclusively via the proposed endogenous explaining variables or proposed channels. Hence, when reporting the findings, the validity of the exclusion restriction is confirmed when the alternative hypothesis of DHT related to IV (year, eq(diff)) is rejected.

## 4. Empirical results

### 4.1 Presentation of results

Table 2, Table 3 and Table 4 respectively present findings corresponding to formal, informal and non-formal financial developments. Each table is displayed in two categories: the left-hand-side (LHS) shows results related to GDP-based indicators while the right-hand-side (RHS) presents findings linked to money supply (M2)-oriented measurements of financialization. Four post-estimation diagnostic tests are used to assess the validity of models (Asongu & De Moor, 2017)<sup>11</sup>.

The findings are discussed in three levels, namely, with respect to: marginal impacts, net impacts and thresholds. The net impacts with ICT are computed with the unconditional and marginal effects from ISB. For instance, in the second column of Table 2, the marginal effect (from the interaction) is 0.003 while the unconditional impact of PCR is -0.420. The corresponding net effect of PCR with mobile phones is -0.310 ( $[36.659 \times 0.003] + -0.420$ )<sup>12</sup>. Given that the marginal effect is positive, the corresponding ICT positive threshold at which the negative unconditional effect changes from negative to positive is 140 ( $0.420/0.003$ ). The

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<sup>11</sup> “First, the null hypothesis of the second-order Arellano and Bond autocorrelation test (AR(2)) in difference for the absence of autocorrelation in the residuals should not be rejected. Second the Sargan and Hansen overidentification restrictions (OIR) tests should not be significant because their null hypotheses are the positions that instruments are valid or not correlated with the error terms. In essence, while the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross-sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fischer test for the joint validity of estimated coefficients is also provided” (Asongu & De Moor, 2017, p.200).

<sup>12</sup> 36.659 is the mean value of mobile phones.

positive threshold is feasible because it is within the mobile phone range (minimum to maximum) disclosed by the summary statistics (0.241 to 171.51).

The following findings can be established in Table 2 on linkages between ICT, formal finance and information asymmetry. First, it is not possible to derive valid inferences from the RHS of Table 2 because at the 1% significance level, post-estimation autocorrelation is still apparent in the residuals. Second, the marginal effect from the interaction between PCR and mobile phones is positive; the corresponding net effect is negative while the positive threshold is within range. Third, whereas the marginal effects from the interactions between ICT and PCB is negative, the net effects of PCB with ICT is positive, while the corresponding negative thresholds are not within the ranges disclosed by the summary statistics. Fourth, the significant control variables have expected signs.

In Table 3 on linkages between ICT, informal finance and information asymmetry, autocorrelation is apparent in the RHS and three specifications of the LHS. The following findings can be established. First, the marginal impact from the interaction between PCR and internet is positive; the corresponding net effect is negative while the positive threshold of 41 is within the internet penetration range (0.031 to 51.00). Second, most of the control variables are significant with expected signs.

Given the high correlation between informal finance and non-formal finance, we complement the findings in Table 3 with those of Table 4 on nexuses between ICT, non-formal finance and information asymmetry. The following findings can be established. First, like with previous tables, valid inferences cannot be established from the RHS because at the 1% significance level, post-estimation autocorrelation is still apparent in the residuals. Second, the marginal effect from the interaction between ISB and ICT is positive; the net effects are negative while the corresponding positive thresholds are within range. Third, most of the significant control variables have expected signs.

**Table 2: Formal finance, ICT and Information Asymmetry**

	Dependent variable : Formal Financial Development							
	Formal Financial Development (Prop.1)				Financial Development Formalization (Prop.5)			
	Mobile Phones		Internet		Mobile Phones		Internet	
	PCR	PCB	PCR	PCB	PCR	PCB	PCR	PCB
Constant	-1.987 (0.123)	<b>-2.335***</b> (0.008)	<b>-2.825***</b> (0.000)	0.899 (0.493)	<b>-0.074***</b> (0.003)	<b>-0.055***</b> (0.000)	<b>-0.049**</b> (0.016)	<b>-0.054***</b> (0.006)
Prop.1 (-1)	<b>1.060***</b> (0.000)	<b>0.980***</b> (0.000)	<b>1.003***</b> (0.000)	<b>1.005***</b> (0.000)	---	---	---	---
Prop. 5 (-1)	---	---	---	---	<b>1.078***</b> (0.000)	<b>1.048***</b> (0.000)	<b>1.047***</b> (0.000)	<b>1.057***</b> (0.000)
Public Credit Registries (PCR)	<b>-0.420***</b> (0.000)	---	-0.043 (0.303)	---	-0.0002 (0.571)	---	<b>0.0005**</b> (0.026)	---
Private Credit Bureaus (PCB)	---	<b>0.129***</b> (0.000)	---	<b>0.125***</b> (0.000)	---	<b>-0.0002**</b> (0.016)	---	<b>-0.0004***</b> (0.000)
Mobile Phones	<b>-0.044***</b> (0.000)	-0.006 (0.619)	---	---	-0.00006 (0.323)	-0.00003 (0.612)	---	---
Internet	---	---	-0.034 (0.302)	-0.013 (0.494)	---	---	-0.0003 (0.209)	<b>-0.0006***</b> (0.000)
PCR ×Mobile Phones	<b>0.003***</b> (0.002)	---	---	---	0.000003 (0.491)	---	---	---
PCB ×Mobile Phones	---	<b>-0.001***</b> (0.000)	---	---	---	0.000001 (0.149)	---	---
PCR ×Internet	---	---	-0.002 (0.182)	---	---	---	-0.00001 (0.192)	---
PCB ×Internet	---	---	---	<b>-0.010***</b> (0.000)	---	---	---	<b>0.00003***</b> (0.000)
GDP growth	<b>0.043**</b> (0.014)	<b>0.046***</b> (0.004)	0.012 (0.369)	<b>0.033***</b> (0.007)	<b>0.0008***</b> (0.000)	<b>0.0007***</b> (0.000)	<b>0.0008***</b> (0.000)	<b>0.0007***</b> (0.000)
Inflation	<b>-0.086***</b> (0.000)	<b>-0.091***</b> (0.000)	<b>-0.089***</b> (0.000)	<b>-0.076***</b> (0.000)	0.00004 (0.853)	0.0001 (0.582)	-0.0001 (0.543)	0.0003 (0.140)
Public Investment	<b>-0.134***</b> (0.000)	<b>-0.169***</b> (0.000)	<b>-0.173***</b> (0.000)	<b>-0.199***</b> (0.000)	<b>0.0009***</b> (0.001)	<b>0.0006**</b> (0.021)	<b>0.0009***</b> (0.000)	<b>0.0008**</b> (0.025)
Foreign Aid	<b>0.108***</b> (0.007)	<b>0.178***</b> (0.000)	<b>0.058*</b> (0.060)	<b>0.036</b> (0.402)	<b>0.001***</b> (0.000)	<b>0.001***</b> (0.000)	<b>0.001***</b> (0.000)	<b>0.0008**</b> (0.011)
Trade	<b>0.066***</b> (0.000)	<b>0.057***</b> (0.000)	<b>0.052***</b> (0.000)	<b>0.027**</b> (0.020)	-0.00003 (0.736)	0.00005 (0.581)	-0.00005 (0.477)	-0.00002 (0.845)
Net Effect with Mobile Phones	-0.310	0.092	---	---	na	na	---	---
Net Effect with the Internet	---	---	na	0.056	---	---	na	-0.0001
Thresholds of ICT (-/+)	140(+)	129(-)	na	12.50(-)	na	na	na	13.33(-)
AR(1)	(0.001)	(0.003)	(0.001)	(0.002)	<b>(0.130)</b>	<b>(0.159)</b>	<b>(0.188)</b>	<b>(0.170)</b>
AR(2)	<b>(0.496)</b>	<b>(0.452)</b>	<b>(0.540)</b>	<b>(0.377)</b>	(0.031)	(0.038)	(0.032)	(0.028)
Sargan OIR	<b>(0.621)</b>	(0.001)	<b>(0.444)</b>	(0.035)	(0.001)	(0.002)	(0.001)	(0.020)
Hansen OIR	<b>(0.317)</b>	<b>(0.209)</b>	<b>(0.245)</b>	<b>(0.281)</b>	<b>(0.193)</b>	<b>(0.245)</b>	<b>(0.338)</b>	<b>(0.240)</b>
DHT for instruments								
(a) Instruments in levels								
H excluding group	<b>(0.137)</b>	<b>(0.115)</b>	<b>(0.347)</b>	<b>(0.622)</b>	<b>(0.636)</b>	<b>(0.475)</b>	<b>(0.473)</b>	<b>(0.831)</b>
Dif(null, H=exogenous)	<b>(0.561)</b>	<b>(0.421)</b>	<b>(0.249)</b>	<b>(0.170)</b>	<b>(0.100)</b>	<b>(0.190)</b>	<b>(0.287)</b>	(0.088)
(b) IV (years, eq(diff))								
H excluding group	<b>(0.414)</b>	<b>(0.425)</b>	<b>(0.335)</b>	<b>(0.760)</b>	(0.081)	<b>(0.201)</b>	<b>(0.111)</b>	<b>(0.158)</b>
Dif(null, H=exogenous)	<b>(0.229)</b>	<b>(0.091)</b>	<b>(0.208)</b>	(0.027)	<b>(0.837)</b>	<b>(0.471)</b>	<b>(0.996)</b>	<b>(0.605)</b>
Fisher	<b>70429.9***</b>	<b>172883***</b>	<b>90986.6***</b>	<b>23620.9***</b>	<b>2942.32***</b>	<b>844152***</b>	<b>2002.14***</b>	<b>1.2e+06***</b>
Instruments	41	41	41	41	41	41	41	41
Countries	45	45	45	45	45	45	45	45
Observations	257	258	255	256	257	258	255	256

\*, \*\*, \*\*\*: significance levels of 10%, 5% and 1% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, 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 and Hansen OIR tests. GDP: Gross Domestic Product.

**Table 3: Informal finance, ICT and Information Asymmetry**

	Dependent variable : Informal Financial Development							
	Informal Financial Development (Prop.3)				Financial Development Informalization (Prop.7)			
	Mobile Phones		Internet		Mobile Phones		Internet	
	PCR	PCB	PCR	PCB	PCR	PCB	PCR	PCB
Constant	<b>-1.319***</b> (0.000)	<b>-1.127***</b> (0.000)	-0.198 (0.687)	<b>-2.627***</b> (0.000)	<b>-0.030***</b> (0.003)	0.0002 (0.984)	<b>-0.024**</b> (0.031)	<b>-0.021**</b> (0.046)
Prop.3 (-1)	<b>1.056***</b> (0.000)	<b>1.090***</b> (0.000)	<b>1.083***</b> (0.000)	<b>1.082***</b> (0.000)	---	---	---	---
Prop.7 (-1)	---	---	---	---	<b>0.998***</b> (0.000)	<b>1.027***</b> (0.000)	<b>1.027***</b> (0.000)	<b>1.038***</b> (0.000)
Public Credit Registries (PCR)	<b>-0.171***</b> (0.000)	---	<b>-0.123***</b> (0.000)	---	-0.0005 (0.170)	---	<b>-0.001***</b> (0.000)	---
Private Credit Bureaus (PCB)	---	0.006 (0.148)	---	-0.012 (0.131)	---	0.000005 (0.953)	---	<b>0.0003***</b> (0.001)
Mobile Phones	<b>-0.005**</b> (0.018)	<b>-0.008***</b> (0.001)	---	---	<b>-0.0001*</b> (0.090)	-0.0001 (0.118)	---	---
Internet	---	---	<b>-0.018***</b> (0.001)	<b>-0.027***</b> (0.009)	---	---	<b>0.0003*</b> (0.081)	<b>0.0004***</b> (0.001)
PCR × Mobile Phones	<b>0.001***</b> (0.001)	---	---	---	0.000003 (0.369)	---	---	---
PCB × Mobile Phones	---	<b>0.00007**</b> (0.011)	---	---	---	0.0000004 (0.763)	---	---
PCR × Internet	---	---	<b>0.003***</b> (0.001)	---	---	---	<b>0.00002***</b> (0.004)	---
PCB × Internet	---	---	---	<b>0.002***</b> (0.001)	---	---	---	<b>-0.00003***</b> (0.000)
GDP growth	<b>0.042***</b> (0.000)	<b>0.022***</b> (0.001)	<b>0.030***</b> (0.007)	0.009 (0.253)	<b>0.0003**</b> (0.042)	0.0001 (0.176)	0.0002 (0.191)	-0.00008 (0.587)
Inflation	<b>0.00002***</b> (0.000)	<b>0.00003***</b> (0.000)	<b>0.00002***</b> (0.000)	<b>0.00002***</b> (0.000)	0.0001 (0.626)	-0.00007 (0.798)	-0.00004 (0.800)	<b>-0.0003*</b> (0.065)
Public Investment	<b>-0.022**</b> (0.013)	<b>-0.017*</b> (0.063)	<b>-0.064***</b> (0.000)	<b>-0.046***</b> (0.000)	<b>-0.0005***</b> (0.008)	<b>-0.0007***</b> (0.002)	<b>-0.0009***</b> (0.000)	<b>-0.0006*</b> (0.033)
Foreign Aid	0.009 (0.367)	0.010 (0.263)	0.023 (0.173)	0.008 (0.505)	-0.003 (0.155)	<b>-0.0008***</b> (0.005)	<b>-0.0007***</b> (0.005)	-0.0004 (0.159)
Trade	<b>0.018***</b> (0.000)	<b>0.014***</b> (0.000)	<b>0.011*</b> (0.065)	<b>0.029***</b> (0.000)	<b>0.0004***</b> (0.000)	0.0001 (0.293)	<b>0.0003***</b> (0.001)	<b>0.0002*</b> (0.079)
Net Effect with Mobile Phones	0.134	na	---	---	na	na	---	---
Net Effect with the Internet	---	---	-0.102	na	---	---	-0.0008	0.00009
Thresholds of ICT (-/+)	171(+)	na	41(+)	6(+)	na	na	50(+)	10(+)
AR(1)	(0.008)	<b>(0.155)</b>	(0.012)	<b>(0.165)</b>	<b>(0.133)</b>	<b>(0.151)</b>	<b>(0.112)</b>	<b>(0.173)</b>
AR(2)	(0.089)	(0.097)	<b>(0.110)</b>	(0.084)	(0.057)	(0.055)	(0.041)	(0.042)
Sargan OIR	<b>(0.743)</b>	<b>(0.447)</b>	<b>(0.145)</b>	<b>(0.494)</b>	(0.002)	(0.001)	(0.002)	(0.031)
Hansen OIR	<b>(0.544)</b>	<b>(0.713)</b>	<b>(0.707)</b>	<b>(0.665)</b>	<b>(0.163)</b>	<b>(0.185)</b>	<b>(0.195)</b>	<b>(0.103)</b>
DHT for instruments								
(a) Instruments in levels								
H excluding group	<b>(0.744)</b>	<b>(0.446)</b>	<b>(0.904)</b>	<b>(0.778)</b>	<b>(0.363)</b>	<b>(0.279)</b>	<b>(0.102)</b>	<b>(0.647)</b>
Dif(null, H=exogenous)	<b>(0.361)</b>	<b>(0.753)</b>	<b>(0.433)</b>	<b>(0.476)</b>	<b>(0.147)</b>	<b>(0.213)</b>	<b>(0.420)</b>	(0.042)
(b) IV (years, eq(diff))								
H excluding group	<b>(0.634)</b>	<b>(0.684)</b>	<b>(0.557)</b>	<b>(0.546)</b>	<b>(0.081)</b>	<b>(0.120)</b>	(0.053)	(0.072)
Dif(null, H=exogenous)	<b>(0.300)</b>	<b>(0.540)</b>	<b>(0.775)</b>	<b>(0.699)</b>	<b>(0.716)</b>	<b>(0.579)</b>	<b>(0.989)</b>	<b>(0.467)</b>
Fisher	<b>17865.2***</b>	<b>32600.5***</b>	<b>40948.8***</b>	<b>348448***</b>	<b>1200.55***</b>	<b>31046.2***</b>	<b>1491.91***</b>	<b>47676.5***</b>
Instruments	41	41	41	41	41	41	41	41
Countries	45	45	45	45	45	45	45	45
Observations	275	276	272	273	257	258	255	256

\*, \*\*, \*\*\*: significance levels of 10%, 5% and 1% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, 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 and Hansen OIR tests. GDP: Gross Domestic Product.



**Table 4: Non-formal finance, ICT and Information Asymmetry**

	Dependent variable : Non-formal Financial Development							
	Nonformal Financial Development (Prop.4)				Financial Development Non-formalization (Prop.8)			
	Mobile Phones		Internet		Mobile Phones		Internet	
	PCR	PCB	PCR	PCB	PCR	PCB	PCR	PCB
Constant	<b>-1.551***</b> (0.000)	<b>-1.386***</b> (0.000)	-0.831 (0.192)	<b>-2.315***</b> (0.000)	<b>-0.022*</b> (0.072)	-0.0003 (0.978)	<b>-0.018**</b> (0.034)	<b>-0.025**</b> (0.044)
Prop.4 (-1)	<b>1.043***</b> (0.000)	<b>1.086***</b> (0.000)	<b>1.058***</b> (0.000)	<b>1.072***</b> (0.000)	---	---	---	---
Prop.8 (-1)	---	---	---	---	<b>1.118***</b> (0.000)	<b>1.068***</b> (0.000)	<b>1.063***</b> (0.000)	<b>1.060***</b> (0.000)
Public Credit Registries (PCR)	<b>-0.213***</b> (0.000)	---	<b>-0.130***</b> (0.000)	---	-0.00007 (0.897)	---	<b>-0.0007***</b> (0.004)	---
Private Credit Bureaus (PCB)	---	0.005 (0.288)	---	-0.007 (0.355)	---	<b>0.0003***</b> (0.003)	---	<b>0.0005***</b> (0.000)
Mobile Phones	<b>-0.004*</b> (0.092)	-0.004 (0.112)	---	---	<b>0.0001**</b> (0.017)	0.00007 (0.272)	---	---
Internet	---	---	<b>-0.014*</b> (0.096)	-0.016 (0.185)	---	---	<b>0.0004*</b> (0.091)	<b>0.0007***</b> (0.000)
PCR × Mobile Phones	<b>0.002***</b> (0.000)	---	---	---	-0.0000005 (0.911)	---	---	---
PCB × Mobile Phones	---	0.00004 (0.282)	---	---	---	-0.000002 (0.101)	---	---
PCR × Internet	---	---	<b>0.003***</b> (0.000)	---	---	---	0.00001 (0.191)	---
PCB × Internet	---	---	---	<b>0.001***</b> (0.006)	---	---	---	<b>-0.00003***</b> (0.000)
GDP growth	<b>0.031***</b> (0.000)	<b>0.018**</b> (0.016)	<b>0.020*</b> (0.055)	0.006 (0.418)	<b>-0.0007***</b> (0.000)	<b>-0.0006***</b> (0.0001)	<b>-0.0007***</b> (0.003)	<b>-0.0007***</b> (0.000)
Inflation	<b>0.00003***</b> (0.000)	<b>0.00004***</b> (0.000)	<b>0.00003***</b> (0.000)	<b>0.00003***</b> (0.000)	-0.00006 (0.811)	-0.00002 (0.948)	0.0001 (0.653)	-0.0002 (0.209)
Public Investment	-0.014 (0.201)	<b>-0.022*</b> (0.071)	<b>-0.056***</b> (0.000)	<b>-0.045***</b> (0.000)	<b>-0.00009***</b> (0.000)	<b>-0.0008***</b> (0.005)	<b>-0.001***</b> (0.000)	<b>-0.001***</b> (0.001)
Foreign Aid	0.014 (0.180)	0.009 (0.349)	-0.024 (0.182)	0.017 (0.217)	<b>-0.001***</b> (0.002)	<b>-0.001***</b> (0.000)	<b>-0.001***</b> (0.000)	<b>-0.0004*</b> (0.076)
Trade	<b>0.019***</b> (0.000)	<b>0.015***</b> (0.000)	<b>0.011*</b> (0.095)	<b>0.031***</b> (0.000)	0.0001 (0.423)	-0.00004 (0.725)	<b>0.0002***</b> (0.005)	<b>0.0002*</b> (0.069)
Net Effect with Mobile Phones	-0.139	na	---	---	na	na	---	---
Net Effect with the Internet	---	---	-0.109	na	---	---	na	0.0002
Thresholds of ICT (-/+)	106.5(+)	na	43.33(+)	16(+)	na	na	na	16.66(-)
AR(1)	(0.006)	<b>(0.147)</b>	(0.009)	<b>(0.159)</b>	<b>(0.153)</b>	<b>(0.162)</b>	<b>(0.224)</b>	<b>(0.191)</b>
AR(2)	<b>(0.147)</b>	<b>(0.110)</b>	<b>(0.179)</b>	<b>(0.108)</b>	(0.027)	(0.037)	(0.029)	(0.025)
Sargan OIR	<b>(0.587)</b>	<b>(0.367)</b>	(0.087)	<b>(0.325)</b>	(0.007)	(0.005)	(0.004)	(0.048)
Hansen OIR	<b>(0.286)</b>	<b>(0.535)</b>	<b>(0.364)</b>	<b>(0.551)</b>	<b>(0.161)</b>	<b>(0.214)</b>	<b>(0.225)</b>	<b>(0.157)</b>
DHT for instruments								
(a) Instruments in levels								
H excluding group	<b>(0.807)</b>	<b>(0.547)</b>	<b>(0.908)</b>	<b>(0.838)</b>	<b>(0.666)</b>	<b>(0.451)</b>	<b>(0.539)</b>	<b>(0.816)</b>
Dif(null, H=exogenous)	<b>(0.121)</b>	<b>(0.466)</b>	<b>(0.135)</b>	<b>(0.315)</b>	(0.073)	<b>(0.168)</b>	<b>(0.149)</b>	(0.050)
(b) IV (years, eq(diff))								
H excluding group	<b>(0.389)</b>	<b>(0.488)</b>	<b>(0.205)</b>	<b>(0.431)</b>	<b>(0.179)</b>	<b>(0.181)</b>	<b>(0.102)</b>	<b>(0.174)</b>
Dif(null, H=exogenous)	<b>(0.211)</b>	<b>(0.517)</b>	<b>(0.801)</b>	<b>(0.670)</b>	<b>(0.281)</b>	<b>(0.438)</b>	<b>(0.823)</b>	<b>(0.283)</b>
Fisher	<b>13648.3***</b>	<b>9186.26***</b>	<b>25938.3***</b>	<b>406794***</b>	<b>3248.02***</b>	<b>593145***</b>	<b>1158.35***</b>	<b>1.8e+06***</b>
Instruments	41	41	41	41	41	41	41	41
Countries	45	45	45	45	45	45	45	45
Observations	275	276	272	273	257	258	255	256

\*, \*\*, \*\*\*: significance levels of 10%, 5% and 1% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, 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 and Hansen OIR tests. GDP: Gross Domestic Product.

## **4.2 Further discussion of results and implications**

### *4.2.1 Theoretical linkage, nexus with the literature and practical implications*

ISB are theoretically expected to boost formal financial development and limit informal financial development because they are also expected to act as disciplining devices by discouraging borrowers from resorting to the informal financial sector as a viable alternative to the formal financial sector. While we have observed that ICT interacts with PCB to produce net positive effects on formal financial development, the interaction of PCR with the mobile phone has a positive marginal effect, albeit a negative net effect. It follows that while ICT is more likely to complement PCB in improving formal financial development, the negative net effect from the complementarity between PCR and mobile phone can be improved by increasing mobile penetration beyond a specific threshold (140). In what follows, we discuss the edge of PCB from the angles of existing literature and practical implications.

With respect to existing literature, on the one hand, the edge of PCB is broadly in line with the findings of Love and Mylenko (2003) who have shown that while the presence of private registries are linked to lower financial constraints and higher bank lending share, the impact of public credit registries is less apparent. The findings are also consistent with Triki and Gajigo (2014) who have concluded that, compared to PCR, PCB are more positively sensitive to finance access. Asongu et al. (2016b) have also found financial development dynamics to respond more positively to PCB, compared to PCR. On the other hand, the less positive complementarity of PCR with ICT, contrasts with the results of Singh et al. (2009) which maintain that PCR in Africa are very likely to enhance financial development. The conclusion by Galindo and Miller (2001) that credit registries are better drivers of financial development compared to credit bureaus is not apparent from the perspective of net effects. Asongu et al. (2016a) have established that ISB for the most part negatively affect financial access. The above comparisons should be understood in the light of the fact that the engaged studies have investigated ‘financial access’ whereas the dimension of our study with which we are engaging the comparison is ‘formal financial development’. Hence, as a caveat, ‘formal financial development’ may not be directly equitable to ‘financial allocation efficiency’ or ‘enhanced financial access’ because ‘formal financial development’ could be the result of increasing liquid liabilities or financial system deposits.

From a practical viewpoint, the edge of PCB could be traceable to the six distinctive characteristics that PCB enjoy vis-à-vis PCR, namely in terms of: purpose, coverage, status, ownership, data sources used and terms of access. (1) Whereas PCR entail public institutions which are set-up with the principal mission of banking sector supervision, PCB on the other hand are created fundamentally because of the need of and demand for information from borrowers. (2) While the coverage of PCR is provided for the most part by large corporations and limited as concerns the nature of information, PCB evolve beyond big corporations to incorporate information corporations with rich and longer histories like small and medium enterprises (SMEs). (3) While PCB are for profit, PCR are not for profit-making. (4) The propriety of PCB incorporates lending associations, governments, central banks and other independent parties while that of PCR is exclusively limited to central banks and governments. (5) Whereas data used by PCR is sourced from both bank and non-bank activities, the data used by PCB entail sources of PCR, including courts and tax authorities. (6) PCR access is restricted to data providers whereas PCB access is open to all types of lenders. It is apparent from the comparative distinctive features that the edge of PCB in complementing ICT to reduce IA for financial sector competition may be traceable to *inter alia*: motivations for creating ISB, data sources and performance incentives.

#### *4.2.2 Implications for financial financialization and disciplining of borrowers*

We have observed that valid inferences could not be established from findings on the RHS of Tables 2-4. This implies that the role of ICT in reducing IA does not affect financial sector competition. Hence, ISB may not be having the expected impact of reducing the influence of banks with high market power, through enhanced banking sector competition. Some channels through which ISB could boost banking sector competition include, among others: rendering credit markets contestable and mitigating informational rents (see Pagano & Jappelli, 1993, p. 2019). As a policy implication, in addition to ICT, other complementary mechanisms are needed to limit the substantial power that may be enjoyed by certain banks within the financial sector. This recommendation aligns with the fact that the substantially documented issues of excess liquidity in African banking institutions (Saxegaard, 2006; Fouda, 2009) are partly traceable to the lack of competition within the financial sector.

It is also apparent from Tables 3-4 that PCR are more effective in being complemented with ICT to negatively affect the informal and non-formal financial sectors. It should be noted that ISB also have the mission of playing the role of disciplining borrowers and preventing them from defaulting on their debts and/or seeking refuge in the non-formal and informal financial sectors. Therefore, the ISB also play a significant role in mitigating moral hazard on the part of borrowers. Under this scenario, PCR are more effective at counselling borrowers on the risk of reputational loss and resorting to informal finance. As a policy implication, instruments by which PCB mitigate IA with the help of ICT need to be improved in order to discipline borrowers more effectively.

A fundamental implication of this study is that, the complementarity of ISB and ICT needs to be encouraged and consolidated in order to enhance financial sector competition and ultimately address surplus liquidity concerns in African financial institutions. Such complementarity would benefit from more qualified workers and greater information synchronisation via among others: regular training of ISB staff; ‘knowledge economy’ (KE)-driven economic policies; reliable high-speed access to the internet and instrumentation of ICT banking services.

## **5. Conclusion and future research directions**

In this study, we have examined the role of information and communication technology (ICT) in complementing information sharing bureaus (ISB) (or private credit bureaus (PCB) and public credit registries (PCR)) for financial sector competition. Hitherto unexplored dimensions of financial sector competition have been employed, namely: financial sector dynamics of formalization, informalization and non-formalization. The empirical evidence is based on 53 African countries for the period 2004-2011 and the Generalised Method of Moments (GMM) with forward orthogonal deviations. The following findings have been established. First, for formal financial development: (i) the marginal effect from the interaction between PCR and mobile phones is positive; the corresponding net effect is negative while the positive threshold is within range and (ii) whereas the marginal effects from the interactions between ICT and PCB are negative, the net effects of PCB with ICT are positive, while the corresponding negative thresholds are not within ranges. Second, on informal financial development, the marginal impact from the interaction between PCR and the internet is positive; the corresponding net

effect is negative while the positive threshold is within the internet penetration range. Third, with regards to informal financial development, the marginal effect from the interaction between ISB and ICT is positive; the net effects are negative while the corresponding positive thresholds are within range. Policy implications have been discussed.

By introducing the concept of financialization, the study has united two streams of research by: improving the macroeconomic literature on measuring financial development and responding to an evolving field of development literature by means of informal finance. Moreover, a practical method by which to disentangle the effects of reducing IA on various financial sectors is suggested by the study. The findings can be extended by assessing the established linkages throughout the conditional distributions of financial sector competition. The motivation for the future research direction is that the relevance of established nexuses may be contingent on initial levels for competition within the financial sector, such that the linkages differ in countries with low, intermediate and high levels of financial sector competition.

## Appendices

### Appendix 1: Summary Statistics (2004-2011)

	Variables	Mean	S.D	Min.	Max.	Obs.
Financial Sector Development	Formal Financial Development (Prop.1)	28.037	20.970	2.926	92.325	377
	Semi-formal Financial Development (Prop. 2)	0.199	0.715	0.000	4.478	424
	Informal Financial Development (Prop. 3)	5.350	5.106	-18.89	25.674	424
	Non-formal Financial Development (Prop. 4)	5.550	5.171	-18.89	25.674	424
	Financial Formalization (Prop. 5)	0.773	0.168	0.235	1.469	377
	Financial Semi-formalization (Prop. 6)	0.007	0.029	0.000	0.244	377
	Financial Informalization (Prop. 7)	0.219	0.168	-0.469	0.764	377
	Financia Non-formalization (Prop. 8)	0.226	0.168	-0.469	0.764	377
Information Asymmetry	Public Credit registries (PCR)	2.155	5.812	0.000	49.8	381
	Private Credit Bureaus (PCB)	4.223	13.734	0.000	64.8	380
ICT	Mobile Phone Penetration	36.659	32.848	0.214	171.51	420
	Internet Penetration	6.822	8.852	0.031	51.00	414
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. GDPg: GDP growth. Obs: Observations.

## Appendix 2: Correlation Analysis (Uniform sample size : 293)

Financial Sector Competition								Info. Asymmetry		Control Variables					ICT		
Prop.1	Prop.2	Prop.3	Prop.4	Prop.5	Prop.6	Prop.7	Prop.8	PCR	PCB	GDPg	Inflation	PubIvt	NODA	Trade	Mobile	Internet	
1.000	0.110	0.127	0.142	0.565	-0.052	-0.556	-0.565	0.411	0.310	-0.094	-0.071	0.058	-0.311	0.141	0.515	0.687	Prop.1
	1.000	-0.013	0.130	-0.031	0.872	-0.128	0.031	-0.023	-0.100	-0.060	0.260	-0.040	0.007	-0.086	-0.087	0.064	Prop.2
		1.000	0.989	-0.604	-0.068	0.617	0.604	0.127	-0.569	-0.083	-0.082	-0.054	0.033	-0.006	-0.055	0.148	Prop.3
			1.000	-0.604	0.057	0.593	0.604	0.123	-0.579	-0.091	-0.044	-0.059	0.034	-0.018	-0.067	0.156	Prop.4
				1.000	-0.092	-0.983	-1.000	0.094	0.613	-0.004	0.008	0.128	-0.246	0.119	0.430	0.361	Prop.5
					1.000	-0.091	0.092	-0.059	-0.084	-0.077	0.289	-0.012	0.123	-0.074	-0.133	-0.044	Prop.6
						1.000	0.983	-0.083	-0.598	0.018	-0.061	-0.125	0.224	-0.105	-0.407	-0.354	Prop.7
							1.000	-0.094	-0.613	0.004	-0.008	-0.128	0.246	-0.119	-0.403	-0.361	Prop.8
								1.000	-0.140	-0.026	-0.081	0.068	-0.154	0.207	0.369	0.437	PCR
									1.000	-0.101	-0.035	-0.047	-0.329	0.084	0.388	0.131	PCB
										1.000	-0.169	0.129	0.122	0.037	-0.178	-0.099	GDPg
											1.000	-0.081	-0.0004	-0.006	-0.054	0.046	Inflation
												1.000	0.059	0.130	0.079	-0.025	PubIvt
													1.000	-0.309	-0.504	0.379	NODA
														1.000	0.198	0.104	Trade
															1.000	0.631	Mobile
																1.000	Internet

Prop.1: Formal Financial Sector Development. Prop.2: Semi-Formal Financial Sector Development. Prop.3: Informal Financial Sector Development. Prop. 4: Non-Formal Financial Development. Prop.5: Financial Sector Formalization. Prop.6: Financial Sector Semi-Formalization. Prop.7: Financial Sector Informalization. Prop.8: Financial Sector Non-Formalization. Info: Information. PCR: Public Credit Registries. PCB: Private Credit Bureaus. GDPg: GDP growth. Popg: Population growth. PubIvt: Public Investment. NODA: Net Official Development Assistance. Info: Information. ICT: Information and Communication Technology. Mobile: Mobile Phone Penetration. Internet: Internet Penetration.

### Appendix 3: Variable Definitions

Variables	Signs	Variable Definitions	Sources
Formal Financial Development	Prop.1	Bank deposits/GDP. Bank deposits here refer to demand, time and saving deposits in deposit money banks (Lines 24 and 25 of International Financial Statistics (IFS); October 2008).	
Semi-formal financial development	Prop.3	(Financial deposits – Bank deposits)/ GDP. Financial deposits are demand, time and saving deposits in deposit money banks and other financial institutions. (Lines 24, 25 and 45 of IFS, October, 2008).	
Informal financial development	Prop.3	(Money Supply – Financial deposits)/GDP	
Informal and semi-formal financial development	Prop.4	(Money Supply – Bank deposits)/GDP	Asongu (2014; 2015ab)
Financial intermediary formalization	Prop.5	Bank deposits/ Money Supply (M2). From ‘informal and semi-formal’ to <i>formal</i> financial development (formalization)	
Financial intermediary ‘semi-formalization’	Prop.6	(Financial deposits - Bank deposits)/ Money Supply. From ‘informal and formal’ to <i>semi-formal</i> financial development (Semi-formalization)	
Financial intermediary ‘informalization’	Prop.7	(Money Supply – Financial deposits)/ Money Supply. From ‘formal and semi-formal’ to <i>informal</i> financial development (Informalisation).	
Financial intermediary ‘semi-formalization and informalization’	Prop.8	(Money Supply – Bank Deposits)/Money Supply. Formal to ‘ <i>informal and semi-formal</i> ’ financial development: (Semi-formalization and informalization).	
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 Technology	Mobile	Mobile phone subscriptions (per 100 people)	World Bank (WDI)
	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	PubIvt	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 4: Persistence of the dependent variables

	Prop.1	Prop.2	Prop.3	Prop.4	Prop.5	Prop.6	Prop.7	Prop.8
Prop.1(-1)	0.9900							
Prop.2(-1)		0.8801						
Prop.3(-1)			0.9096					
Prop.4(-1)				0.9105				
Prop.5 (-1)					0.9841			
Prop.6(-1)						0.8775		
Prop.7(-1)							0.9855	
Prop.8(-1)								0.9841

Prop.1 (-1): Lagged value of Proposition 1.



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