# Reducing Information Asymmetry with ICT: A critical review of loan price and quantity effects in Africa

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**Abstract**

**Purpose**- This study investigates loan price and quantity effects of information sharing offices with ICT, in a panel of 162 banks consisting of 42 African countries for the period 2001-2011.

**Design/methodology/approach**- The empirical evidence is based on a panel of 162 banks in 42 African countries for the period 2001-2011. Misspecification errors associated with endogenous variables and unobserved heterogeneity in financial access are addressed with Generalised Method of Moments and Instrumental Quantile Regressions.

**Findings**- Our findings uncover several major themes. *First*, ICT when integrated with the role of public credit registries significantly lowered the price of loans and raised the quantity of loans. *Second*, while the net effects from the interaction of ICT with private credit bureaus do not improve financial access, the corresponding marginal effects show that ICT could complement the characteristics of private credit bureaus to reduce loan prices and increase loan quantity, but only when certain thresholds of ICT are attained. We compute and discuss the policy implications of these ICT thresholds for banks with low, intermediate and high levels of financial access.

**Originality/value**-This is one of the few studies to assess how the growing ICT can be leveraged in order to reduce information asymmetry in the banking industry with the ultimate aim of improving financial access in a continent where lack of access to finance is a critical policy syndrome.

*JEL Classification*: G20; G29; L96; O40; O55
*Keywords*: Financial access; Information asymmetry; ICT

## 1. Introduction

There have been very few papers that study information sharing for financial access. Most specifically, we are interested in studying the gains that can be made from information sharing in terms of enhanced access to financial services in the context of the African banking sector, where investments are increasingly needed in order for the continent to develop. When compared to the rest of the world, the African continent has more room for information and communication technology (henceforth ICT) penetration. Moreover, there are growing concerns that there is excess liquidity in African banking institutions, due primarily to the growing problems of information asymmetry in the sector. A substantial bulk of the current literature on African business emphasises the need for more domestic private investment because, for the most part, the structural adjustment programmes initiated over the past decades have failed to generate the much needed external finance (Tuomi, 2011; Rolfe & Woodward, 2004; Darley, 2012; Bartels *et al.*, 2009).

Additionally, as documented by Penard *et al.* (2012), there is ample room for improving the penetration of ICT in Africa because ICT growth is stagnating in the high-end economies of North America, Europe and Asia. For instance, as of 2010, whereas developed countries were experiencing saturation points in mobile phone and internet penetrations of 41 percent, the corresponding diffusion rate in Africa was 9.6 percent. Therefore, we may infer that there is considerable potential for leveraging ICT for economic development outcomes in the African continent.

The concerns of surplus liquidity in African financial institutions (Saxegaard, 2006; Fouda, 2009; Asongu, 2014, p.70) are traceable to information asymmetry between lenders and borrowers. In this light, policies conducive to the establishment of information sharing offices have been founded on the need to address the surplus liquidity issues as well as a plethora of factors that are endogenous to increasing information asymmetry, namely: physical access, affordability and eligibility to lending from banks (Allen *et al.*, 2011; Batuo & Kupukile, 2010).

Studies on information sharing offices have for the most part been positioned on developed countries. Most specifically, a substantial number of existing papers focused on countries in the Organisation for Economic Co-operation and Development (OECD), Latin America and Asia. This is ironic because these high-income nations have fewer financial access problems compared with less developed countries (Asongu *et al.*, 2016a). To put things in perspective, no African country was included in the study by Galindo and Miller

(2001). Love and Mylenko (2003) considered only four African countries. This was then followed by Barth *et al*. (2009) who covered nine African countries.

The study by Triki and Gajigo (2014), is closest to the positioning of our present inquiry. They used Probit models to evaluate the effects of public and private credit bureaus on access to finance by enterprises in 42 African countries for the 2006 to 2009 period. Our study is distinct from Triki and Gajigo (2014) in three main ways. *First,* we make use of a larger and more comprehensive dataset of countries for a longer time period 2001-2011. *Second*, in terms of methodology, we use a Generalised Method of Moments (GMM) in order to address concerns of endogeneity by controlling for time invariant omitted variables and heterogeneity in access to finance. Indeed, Triki and Gajigo (2014) acknowledged the failure to account for such endogenous variable errors as a caveat of their inquiry. Additionally, we investigate the linkages throughout the conditional distributions of access to finance using Instrumental Variable Quantile Regressions (IVQR). Such allows us to understand the role of information sharing credit registries in facilitating access to finance in banks with low, intermediate and high levels of intermediation. The policy relevance of this Quantile Regression is that it highlights the deficiency of traditional one-size fits all policies designed to improve financial access across countries through the functions of information sharing offices. Such blanket arrangements may not be effective *unless* they are contingent on existing levels of financial access and tailored to suit the unique characteristics of institutions with different levels of financial intermediation.

*Third*, we integrate ICT-related policy variables into the modelling exercise in order to examine how internet and mobile phone penetrations complement the role of information sharing offices in lessening information asymmetry. Such should enhance financial access, in terms of increased quantity of loans and reduced price of loans[1].

Overall, assessing the impact on loan price and quantity of policies to reduce information asymmetry with ICT is of particular interest to governments in emerging and developing economies. This is because the findings would inform policy makers on which technology platforms could be employed to boost access to financial services. Such should enable poor households and small businesses to increase consumption, investment and

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[1] Throughout the study, the term financial access is used interchangeably with 'loan quantity' and/or 'loan price'. Sections 2.2 and 2.3 link financial access to loan price and quantity while discussing how the role of information sharing offices are related to loan price and quantity. In these sections, we further substantiate the positioning of the current study by justifying how the banking industry collect and shares information with credit registries through the use of technological platforms like mobile phone and internet in order to improve or make adjustment to loan prices and quantity of loans.

productivity which would ultimately culminate in higher employment and economic well-being. Another study closest to this paper is Asongu (2017) which directly investigated the relationship between information asymmetry and financial access, excluding ICT as a policy variable. In the current inquiry, we recognise the need to include those policy instruments which public and private registries could use to efficiently enhance the flow of information between banks and their customers. Therefore, within this policy framework, we employ ICT in terms of mobile phone and internet penetration rates. Theoretically speaking, these are the mechanisms by which the functioning of information sharing offices can be directly supervised by governments. This concept is consistent with recent literature on the relevance on ICT as a policy tool in promoting positive macroeconomic outcomes (Asongu *et al*., 2017).

Our results broadly show that the integration of ICT with the role of public credit registries for collecting and sharing information on credit transactions significantly decrease the price of loans and increase the quantity of loans extended by banks. By contrast, the net effects from the interaction of ICT with the functions of private credit bureaus do not lead to a marked improvement in access to financial intermediation. Such substantiates our decision to clearly account for the distinction in the main goals and regulatory structures of public credit registries (PCRs) and private credit bureaus (PCBs) in our empirical modelling. Nevertheless, the corresponding marginal effects show that ICT can complement the functions of private credit bureaus to lower loan prices and raise loan quantity, but only after certain thresholds of ICT penetration rates are attained. We compute and discuss the feasibility of these ICT thresholds which are required to boost the efficiency of these technology platforms.

The findings contribute both to the scholarly and policy literature in two key ways.

*First*, by employing the ICT moderating proxies, our study complements a recent strand of African development literature which has exclusively articulated the relevance of information sharing offices in reducing information asymmetry, leading to better access to finance. Examples of these papers include: Triki and Gajigo (2014) and Asongu (2017) which were discussed in the prior paragraphs; Kusi *et al*. (2017) and Kusi and OpokuMensah (2018) confirmed that information sharing reduces bank credit risk and the cost of funding; Muaza and Alagidede (2017) concluded that, the rewards of financial access from collecting and the sharing of information on loan transactions is less apparent in French civil law countries, compared with their English common law counterparts[2].

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[2] Moreover, a recent bulk of African financial development literature has failed to recognise the relevance of information sharing offices in financial access (Fowowe, 2014; Daniel, 2017; Wale & Makina, 2017;

*Second*, on the policy front, the study employs policy ICT variables that can be leveraged to modulate the effect of the availability and design of information sharing offices on households' and firms' access to finance. To this end, by providing thresholds at which ICT can effectively complement the activities of information sharing offices to boost financial access, the study provides specific critical cut-off points which policymakers should target where the management of ICT diffusion rate is concerned. The confirmation of positive ICT thresholds is consistent with a recent strand of economic development literature which characterizes the effectiveness of the inclusion of moderating policy variables in empirical modelling in the following terms: "*no positive thresholds, no policy*" (Asongu *et al*., 2018a, p.1).

The rest of the paper is structured as follows. Section 2 outlines the stylized facts, background and theoretical underpinnings. Section 3 describes the data and methodology. Section 4 discusses the empirical results with related policy implications. Section 5 concludes and provides future research directions.

## 2. Stylized facts, background and theoretical underpinnings
### 2.1 Stylized facts and background

Less than 20 percent of African households have access to formal financial services (IFAD, 2011). The stylized facts maintain that the main factors limiting formal financial access include: poor transport facilities, low population densities and limited communication infrastructure. According to the narrative, even in regions with comparatively higher rates of financial intermediation, some households and small corporations may still be faced with credit constraints allied with strict documentation and considerable collaterals. Moreover, in cases where the underlying lending conditions are fulfilled, financial access could still be limited by high costs (e.g. transaction fees) and substantial minimum saving requirements.

Credit reference offices are institutions that are designed to collect and share information on the financial records of borrowers (both individual and commercial) from many sources. These may include public bodies such as courts, government departments, utilities, retailers, banks and credit card providers (Tchamyou & Asongu, 2017a). Once the data is collected, it is cross-checked for accuracy and then consolidated into a comprehensive

Chikalipah, 2017; Osah & Kyobe, 2017; Bocher *et al*., 2017; Oben & Sakyi, 2017; Chapoto & Aboagye, 2017; Ofori-Sasu *et al*., 2017; Iyke & Odhiambo, 2017; Boadi *et al*., 2017).

report for use by lenders to better understand the creditworthiness of their borrowers. The published data would normally encompass both positive and negative borrower credit histories. Examples of positive information include reports on the size of loans and repayment profiles of debtors while negative information is overwhelmingly dominated by default data and court judgements.

According to Mylenko (2008), prior to the year 2008, information sharing offices were solidly established for the most part in Asia, Latin America, European and North American countries. However, the global financial crisis and growing ICT, prompted the creation of credit reference agencies across Africa. Indeed, before 2008, with the exception of South Africa, not many African countries had well-functioning credit reference bureaus, either private or public. What is more, the majority of institutions for collecting and disseminating credit information were publicly owned with a stated goal of supervising the banking sector rather than satisfying a market demand for reliable borrower information. Consequently, the price of loans in Africa remained high when compared with the other emerging and developing regions for two main reasons. *First*, the inability of credit registries to provide timely and accurate information on borrowers' credit history. *Second*, the limited use of new and innovative technologies by credit bureaus to disseminate credit information on borrowers and their lenders online. This latter point articulates the complementary role of ICT in facilitating the goal of information sharing agencies to reduce information asymmetry and consequently enhance access to finance for all economic operators.


**2.2 Information sharing and financial access: theoretical and empirical evidence**

*2.2.1.Theoretical underpinnings*

The objective of this section is twofold. *First*, it links financial access to loan price and quantity. *Second*, it discusses how information sharing offices are related to loan price and quantity. From a logical standpoint, a reduction in loan price signifies greater access to credit, particularly for households and microenterprises which are generally financially underserved. These investors are now incentivised to borrow at the cheaper rate. Similarly, an increase in loan quantity reflects alleviation in the ability of banks to transform deposits into credit. Such should lead to an improvement in access to financial services for economic agents. Therefore, loan price and loan quantity have been used as proxies for financial access in recent literature on the effects of information sharing agencies on household and/or corporate access to finance (see for example, Asongu, 2017; Asongu *et al*., 2018b).

Two principal views exist in the literature on the theoretical connection between credit reference agencies and access to finance (Claus & Grimes, 2003). The *first* perspective is oriented towards bank liquidity provisions, whereas the *second* considers the capacity of financial institutions to manage credit transactions and associated risk characteristics. Both views however are founded on the premise that the main goal of financial institutions is to boost intermediation by reducing the cost of transforming mobilised deposits into credit. The theoretical foundations of the linkage between information sharing offices and improved financial intermediation are substantiated by the imperfect market information literature. The principal role of information sharing registries in financial intermediation is to reduce the costs of information on credit transactions that are caused by information asymmetry between lenders and borrowers in the banking industry. By addressing this problem of asymmetric information, credit bureaus aim to lessen the financial constraints and raise competition, with concomitant improvement in the efficient allocation of capital.

In the light of the above, the relationship between financial access and information sharing offices faces two major problems: (i) adverse selection from lenders and (ii) moral hazard from borrowers. On the one hand, information sharing offices reduce adverse selection in banks by providing them with a comprehensive picture of the credit history of borrowers. Consolidated knowledge on information from borrowers reduces incremental interest rates that would have been levied by financial institutions in order to compensate for the risk of adverse selection. On the other, once loans have been granted to borrowers, they are liable of moral hazard — a behaviour that consists of concealing the nature and/or return on the activities to which the loan is granted with the ultimate aim of avoiding and/or limiting compliance with their repayment obligations. Consequently, a key role of credit bureaus is to inform borrowers on the perils of defaulting on their debts including those obtained from the informal sector. The informal financial sector is normally considered as a viable alternative to the formal banking sector by credit registries when compiling credit histories for borrowers. Information sharing offices can thus reduce a borrower's moral hazard by playing a role in the design and enforcement of policies aimed at encouraging market discipline. In summary: information sharing offices help (i) mitigate adverse selection ex-ante of lending and (ii) reduce moral hazard, ex-post of lending.

*2.2.2 Empirical literature*

While there is a bulk of literature on the effects of information sharing offices on financial access (Pagano & Jappelli, 1993; Padilla & Pagano, 2000; Karapetyan & Stacescu, 2014a, 2014b; Kusi *et al.*, 2017; Kusi & OpokuMensah, 2018; Muaza & Alagidede, 2017; Boateng *et al.*, 2018c; Asongu & Nwachukwu, 2018), two main strands are worthy of further explanation.

The first feature in the literature proposes that the free flow of information increases competition in the credit market, disciplines borrowers, reduces moral hazard and mitigates adverse selection. Accordingly, studies within this strand argue that the sharing of information between banks enables them to make quicker and more accurate decisions on the creditworthiness of their borrowers (Jappelli & Pagano, 2002, 2006; Padilla & Pagano, 1997, 2000; Bennardo *et al.*, 2015). Some conclusions in the literature include positions that the sharing of information between banks: renders borrowers less likely to default on their debts (Klein, 1992); is related to more compliance on debt obligations from borrowers (Karapetyan & Stacescu, 2014a); reduces bank credit risks (Kusi et al., 2017); mitigates funding cost (Kusi & Opoku Mensah, 2018) and is more beneficial for financial access in countries with English common tradition in relation to their counterparts with French civil law tradition (Muaza & Alagidede, 2017).

The second strand of the literature articulates the negative aspects of information sharing between banks. Dell'Ariccia and Marquez (2004) established that the systematic sharing of information is positively linked to banking crisis whereas Jappelli and Pagano (2006) propose that such information sharing has the tendency to increase risky lending and/or the extension of more funds to borrowers that may not eventually comply with their financial obligations towards banks. In summary, it is argued in this strand of the literature that increased sharing of information by credit registries motivates banks to look for other channels of improving their competitive positions. This may involve collecting strategic information that is not subsequently disclosed to information sharing offices (Vercammen,1995; Petersen & Rajan, 1995; Hauswald & Marquez, 2003; Karapetyan & Stacescu, 2014a, 2014b). Irrespective of positions adopted by the two contending strands, by conception and definition, the mission of information sharing offices is facilitated by ICT.

## 2.3 ICT, information sharing and financial access

While information sharing has been shown to impact on loan price and quantity provided by financial institutions (Triki & Gagigo, 2014; Asongu, 2017), the channel through which  ICT interacts with offices involved in the sharing of information to affect loan price and quantity of loans has not been discussed in the literature. Hence, this section further substantiates the positioning of the study by justifying how the banking industry collects and shares information with credit registries through the use of technology platforms like mobile phones and internet in order to improve and/or make adjustments to loan prices and quantity of loans.

ICT is a policy instrument for improving the work of information sharing offices because it is logically connected with the goal of disseminating information and reducing information asymmetry between lenders and borrowers. Therefore, in order to collect and share information with banks, credit bureaus are very likely to use ICT mechanisms. Moreover, according to Hellstrom (2008), ICT enables transparency through the free-flow of information by credit agencies online. For instance, Asongu *et al*. (2018c) recently reported that the sharing of information by means of ICT in the banking sector reduces market power for financial access because, ICT enables, *inter alia*: (i) the free flow of information and (ii) credit registries to distribute information more effectively. They further argued that ICT enables financial institutions to have up-to-date information, encourages the participation of customers in the lending process, reduces informational rents previously enjoyed by big banks and reduces the abuse of market power by large financial institutions.

To summarize, the use of ICT by information sharing offices has the potential to reduce information asymmetry between borrowers and lenders. *Firstly*, ex-ante of lending, the complementarity between ICT and information sharing offices reduces the risk of adverse selection faced by banks. Such enables them to have more timely and accurate information about borrowers' creditworthiness. *Secondly*, ex-post of lending, moral hazard might be considerably reduced because the diffusion of information enables  credit registries to educate borrowers on the relevance of accountability and transparency. Such reduces the likelihood that borrowers will default on their debts once credit has been obtained. It is suggested that information sharing offices are most likely to use various ICT mechanisms to communicate with borrowers and their lenders in an effort to reduce moral hazard. *Third,* the sharing of information by means of ICT has the potential to reduce informational rents enjoyed by a few large sized financial institutions within the banking sector. Such increases financial sector

competition and access to financial services including savings and loan extension (Asongu & Nwachukwu, 2017). This is essentially because ICT reduces the power of those institutions with privileged market information, decentralises information and reduces information monopoly (Snow, 2009). This perspective conforms to the literature on the relevance of ICT in management effectiveness (Boulianne, 2009; Diamond, 2010; Pierskalla & Hollenbach, 2013; Grossman *et al*., 2014; Weidmann & Shapiro, 2015; Manacorda & Tesei, 2016). It is reasonable to propose that such management effectiveness naturally extends to the banking industry.

## 3. Data and Methodology

### 3.1 Data

We examine a panel of 162 banks in 42 African countries[3], with data from the World Bank Development Indicators and Bankscope, for the period 2001-2011. The periodicity, choice of countries and number banks are constrained by data availability. For example, information on credit bureaus from the World Bank Development indicators is only available from 2001. In accordance with Coccorese and Pellecchia (2010), dependent variables for '*loan price*' and '*loan quantity*' are respectively the '*price charged on loans*' and '*logarithms of loans*'. These variables are used as proxies for financial access in line with the recent financial development literature (Asongu, 2017; Asongu *et al*. 2018b). We have already explained how loan price and quantity are associated with financial access in Section 2.2.1. These dependent variables are also persistent because of a high correlation between their contemporary and lagged values. Moreover, substantial differences between minimum and maximum values of the dependent variables are clearly apparent. As will be discussed in subsequent sections, the persistence and high range of the dependent variables provides justification for the use of Generalized Method of Moments and Quantile regressions as estimation strategies.

Consistent with Triki and Gajigo (2014), information sharing offices are measured with public credit registries (PCRs) and private credit bureaus (PCBs). Internet penetration and mobile phone penetration are used to measure ICT. Market-oriented features (*GDP per capita growth*, *inflation* and *population density*), bank-related characteristics (*Deposits/Assets* and *Bank branches*) and binary dummy variables for the unobserved heterogeneity are used as control indicators. The dummies include the following bank attributes: ownership (foreign

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[3] The list of countries we are studying is available in Appendix 5.

versus vs. domestic), size (large vs. small) and '*compliance with Sharia finance*' (Islamic vs. non-Islamic).

In line with economic theory, we expect the following signs with regard to *bank-oriented* features. We expect the 'deposit to asset ratio' should increase both the quantity and price of loans. This is because deposits are the principal source of bank financing. A higher proportion of deposits in liquid liabilities can increase loan quantity and/or interest rate charges, since good organisation is necessary for effective mobilisation of savings and its management. Intuitively, an increase in the number of bank branches should raise the loan quantity as well as the price of loans. This last is primarily due to the higher overhead costs.

With regards to *market-related* features, the following signs are expected. Theoretically speaking, GDP per capita (which is included to account for business cycle fluctuations) is expected to influence the quantity of loans positively. Conversely, the anticipated sign for loan price is ambiguous because it is contingent on market dynamism and expansion. For example, if GDP per capita is decreasing over time, it can affect both loan price and quantity negatively as a result of falling demand. We anticipate negative signs because the population on average across Africa has been growing at a faster rate than GDP, leading to a declining GDP per capita for this period (Asongu, 2013a). Population density is anticipated to raise both the price and quantity of loans. This is because a growing demand for loans, owing to high density in population, increases loan price. Moreover, we suggest that inflation is likely to decrease the quantity of loans and increase the price of loans. This is essentially because investors prefer to invest in economic environments that are less ambiguous (see Kelsey, & le Roux, 2017a, 2017b). Hence, given that less investment are observed during periods of economic uncertainty (e.g. inflation), loan quantity is predicted to fall. By contrast, the price of loans is predicted to increase with inflation because the nominal interest rates levied on loans are usually adjusted for inflation.

Establishing the anticipated signs for the dummy variables is difficult. For example both small and big banks (for bank size heterogeneity) can be associated with positive and negative effects resulting from loan dynamics, though big banks are comparatively more efficient at managing and coordinating the several processes needed to improve access to financial services. Furthermore, addressing the challenges that come with increasing bank size is also a cause of inefficiency, owing to problems encountered with resolving the compliants of a growing customer base. Similarly, the incidence of foreign versus domestic banks (ownership heterogeneity) and Islamic versus non-Islamic banks (compliance with

Sharia finance) depends on a multitude of features, which include: market dynamism and expansion as well as staffs' organisational capabilities.

Appendix 1 summarizes the expected signs of the control variables and Appendix 2 provides the definitions and sources of variables employed in the study. Appendix 3 and Appendix 4 present the summary statistics and correlation matrix in that order.

## 3.2 Methodology

### 3.2.1 Generalised methods of moments: specification, identification and exclusion restrictions

The GMM empirical approach is adopted by this inquiry for five principal reasons. While the first-two are basic requirements for using the estimation strategy, the last-three are advantages that are associated with the choice of the empirical approach (Tchamyou, 2018; Tchamyou *et al.*, 2018).

(1) The empirical approach takes into account persistence in loan quantity and price given that the criterion or rule of thumb to ascertain persistence in the two dependent variables is met. The correlation between loan price and loan quantity and their first lags are respectively 0.845 and 0.996, which are above the 0.800 rule of thumb.

(2) The N (or 162)>T(or 11) criterion needed for a GMM technique is also met given that the number of time series in each cross section is lower than the number of cross sections.

(3) Endogeneity is accounted for in all regressors by the estimation technique because instrumental variables are employed for suspected endogenous regressors. Moreover, the use of time-invariant omitted variables also helps to control for endogeneity.

(4) Biases in the difference estimator are addressed with the system estimator.

(5) Cross-country variations are incorporated into the specifications.

As shown by Bond et al. (2001), the system GMM estimator used by Arellano and Bond (1995) and Blundell and Bond (1998) has better estimation properties than the difference estimator used in Arellano and Bond (1991). This inquiry adopts an extension by Roodman (2009ab) of Arellano and Bover (1995) which uses forward orthogonal deviations instead of first differences. The advantages of such a modified empirical strategy were documented by Baltagi (2008) and Love and Zicchino (2006) to include a restriction on over-identification or limitation on instrument proliferation. In the specification, a *two-step* approach is adopted because it controls for heteroscedasticity.

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

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

$$LQ_{i,t} - LQ_{i,t-\tau} = \sigma_1(LQ_{i,t-\tau} - LQ_{i,t-2\tau}) + \sigma_2(ISO_{i,t} - ISO_{i,t-\tau}) + \sigma_3(ICT_{i,t} - ICT_{i,t-\tau})$$
$$+ \sigma_4(Inter_{i,t} - Inter_{i,t-\tau}) + \sum_{h=1}^{5} \delta_h(W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + \varepsilon_{i,t-\tau} \qquad , \quad (2)$$

where $LQ_{i,t}$ is the loan quantity of bank $i$ at period $t$; $ISO$ is an information sharing office (PCR (Private Credit Registries) or PCB (Public Credit Bureaus)); $\sigma_0$ is a constant; $\tau$ is the degree of auto-regression; $W$ is the vector of control variables (*GDP per capita growth, Inflation, Population density, Deposit/Assets* and *Bank Branches*), $\eta_i$ is the country-specific effect, $\xi_t$ is the time-specific constant and $\varepsilon_{i,t}$ the error term. Dummy variables are not included in the GMM specifications because fixed effects are eliminated. Equations (1) and (2) are replicated when the dependent variable is loan price.

With regards to exclusion restrictions and identification, all explanatory variables are considered as potential endogenous or predetermined variables whereas only *years* are acknowledged to be strictly exogenous (this is consistent with Dewan & Ramaprasad, 2014; Asongu & Nwachukwu, 2016a; Tchamyou, 2018), essentially because it is not likely for *years* to become endogenous in first difference (see Roodman, 2009b). Therefore, the procedure for treating *ivstyle* (years) is 'iv (years, eq(diff))' whereas the *gmmstyle* is used for suspected endogeneous variables.

With the above background, the strictly exogenous instruments or years influence the outcome variables exclusively through the suspected endogenous or predetermined variables. Furthermore, the statistical validity of the exclusion restriction is assessed with the Difference in Hansen Test (DHT) for instrument exogeneity. Accordingly, the null hypothesis of this test should not be rejected for the instruments to elucidate loan quantity and loan price exclusively via the predetermined variables. Hence, whereas in the standard instrumental variable (IV) estimation technique, failure to reject the null hypothesis of the Sargan Overidentifying Restrictions (OIR) test is an indication that instruments do not elicit the outcome variable beyond the endogenous variables (see Beck *et al.*, 2003; Asongu & Nwachukwu, 2016b; Boateng *et al.*, 2018), in the GMM approach which employs forward orthogonal deviations, the information criterion employed to investigate if *years* exhibit strict exogeneity is the DHT. Therefore, in the findings that are reported in Section 4, the exclusion restriction assumption

is validated if the alternative hypothesis of the DHT corresponding to IV (year, eq(diff)) is rejected.

*3.2.2 Instrumental Quantile regressions*

In order to account for existing levels of loan price and loan quantity, the current study employs the Quantile Regressions (QR) technique. This technique is consistent with the literature on conditional determinants (see Keonker & Hallock, 2001; Billger & Goel, 2009; Okada & Samreth, 2012; Asongu, 2013b; Tchamyou & Asongu, 2017b). The approach consists of assessing the nexus between information sharing offices and the outcome variables throughout the conditional distributions of loan price and quantity, with particular emphasis on banks with low, intermediate and high levels of financial access.

The existing literature on information sharing has been oriented towards the conditional mean of financial access (see Asongu *et al*., 2016b; Triki & Gajigo, 2014). While mean effects are relevant, the underlying literature is extended with an estimation approach that controls for existing levels of loan price and quantity. In addition, studies that use Ordinary Least Squares (OLS) to emphasise mean effects is based on the assumption that error terms are normally distributed. However, with QR, the hypothesis of normally distributed errors does not hold. In addition, the QR is robust to presence of outliers because parameters are estimated at various points in the conditional distribution of the dependent variable (Koenker & Bassett, 1978).

The concern about endogeneity is addressed by using an Instrumental Variable QR (IVQR) procedure. The instrumentation procedures for an information sharing office (e.g. private credit bureaus) and an ICT indicator (e.g. Internet penetration) are respectively in Eqs. (3) and (4) below.

$$PCB_{i,t} = \alpha + \delta_j \left( PCB_{i,t-1} \right) + \eta_i + \varepsilon_{i,t} \ , \tag{3}$$

where, $PCB_{i,t}$, is the private credit bureaus indicator of bank $i$ at period $t$, $\alpha$ is a constant, $PCB_{i,t-1}$, represents private credit bureaus in bank $i$ at period $t-1, \eta_i$ is the bank-specific effects and $\varepsilon_{i,t}$ the error term.

$$Internet_{i,t} = \alpha + \delta_j \left( Internet_{i,t-1} \right) + \eta_i + \varepsilon_{i,t} \ , \tag{4}$$

where, $Internet_{i,t}$, is the internet penetration rate of bank $i$ at period $t$, $\alpha$ is a constant, $Internet_{i,t-1}$, represents internet penetration rate in bank $i$ at period $t-1, \eta_i$ is the bank-specific effects and $\varepsilon_{i,t}$ the error term.

The procedure of instrumentation in Eq. (3) consists of regressing the information sharing offices on their first lags. The corresponding fitted values are then saved and later used as the independent variables of interest in Eq. (5). The specifications are Heteroscedasticity and Autocorrelation Consistent (HAC) in standard errors. The $\theta^{th}$ quantile estimator of loan quantity and loan price is obtained by solving for the following optimization problem, which is disclosed without subscripts for simplicity in Eq. (5)

$$\min_{\beta \in R^k} \left[ \sum_{i \in \{i: y_i \geq x_i'\beta \}} \theta |y_i - x_i'\beta| + \sum_{i \in \{i: y_i < x_i'\beta \}} (1-\theta) |y_i - x_i'\beta| \right], \tag{5}$$

where, $\theta \in (0,1)$.

As opposed to OLS that is fundamentally based on minimizing the sum of squared residuals, with QR, the weighted sum of absolute deviations are minimised. For example, the $10^{th}$ decile or $25^{th}$ quartile (with $\theta$ =0.10 or 0.25 respectively) are examined by approximately weighing the residuals. The conditional quantile of financial access or $y_i$ given $x_i$ is:

$$Q_y(\theta / x_i) = x_i'\beta_\theta , \tag{6}$$

where, unique slope parameters are modelled for each $\theta^{th}$ specific quantile.

This formulation is analogous to $E(y / x) = x_i'\beta$ in the OLS slope where parameters are investigated only at the mean of the conditional distribution of loan quantity and price.

For the model in Eq. (6), the dependent variable $y_i$ is either loan quantity or loan price whereas $x_i$ contains a constant term, *public credit registries, private credit bureaus, ICT, GDP per capita growth, Inflation, Population density, Deposit/Assets, Bank Branches, Small banks, Domestic banks* and *Islamic banks.*

## 4. Empirical results

### 4.1 Presentation of results

Table 1 and Table 2 present GMM results related to loan price and loan quantity respectively. Each table has eight specifications, consisting of four specifications pertaining respectively to public credit registries and private credit bureaus. Each of the set of four specifications has two sub-sets of specifications pertaining respectively to mobile phone and internet penetrations. Each of the ICT-related specification embodies two more sub-specifications reflecting a full sample and a partial sample.

The full sample is from 2001-2011 while the partial sample is from 2005-2011. Two main reasons motivate the choice of a partial sample. It enables the study to limit concerns about over-identification or instrument proliferation because T is reduced from 11 to 7. Moreover, the data on information sharing offices in most countries is only available from the year 2005.

We employ four principal information criteria to assess the validity of the GMM model with forward orthogonal deviations.[4] Based on the information criteria, the following findings can be confirmed. From the third specification in Table 1, we see that the net effect from the interaction between public credit registries and mobile phones is 0.00198 ((i.e., [-0.00003 × 34.107] + 0.003), when the mean value of mobile phone penetration is 34.107, the unconditional effect of public credit registries (PCRs) equals (0.003), while the corresponding conditional impact of PCRs is found to be (-0.00003). Consequently, we conclude that there is a negative marginal effect and a positive net effect, for the role of mobile phones in facilitating the essential characteristics of public credit registries for improving access to financial services where the management of loan prices are concerned.

In Table 2, we find that there is a positive net effect from the interaction between private credit bureaus and mobile phones (of 0.0006). We find that the significant control variables in Tables 1 and 2, have the expected signs as hypothesised in Section 3.1.

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[4] "*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 over-identification 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).*

# Table 1: Price Effects of Reducing Information Asymmetry (GMM)

| | Dependent variable: Price of Loans | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Public Credit Registries (PCR) | | | | Private Credit Bureaus (PCB) | | | |
| | Mobile Phones | | Internet | | Mobile Phones | | Internet | |
| | Full Sample | Partial Sample | Full Sample | Partial Sample | Full Sample | Partial Sample | Full Sample | Partial Sample |
| Constant | -0.006 | 0.143 | -0.001 | **-0.094*** | 0.0008 | **0.164*** | **-0.016*** | 0.021 |
| | (0.576) | (0.149) | (0.848) | **(0.068)** | (0.927) | **(0.000)** | **(0.058)** | (0.614) |
| Price of Loans (-1) | **0.686*** | **0.803*** | **0.640*** | **0.781*** | **0.653*** | **0.838*** | **0.690*** | **0.853*** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Mobile Phones | 0.00002 | **0.0001**** | --- | --- | 0.00003 | -0.00008 | --- | --- |
| | (0.706) | **(0.048)** | | | (0.663) | (0.343) | | |
| Internet | --- | --- | 0.0001 | -0.0002 | --- | --- | **0.0008*** | 0.0001 |
| | | | (0.373) | (0.283) | | | **(0.000)** | (0.313) |
| PCR | **-0.002**** | **0.003*** | **-0.001**** | -0.0003 | --- | --- | --- | --- |
| | **(0.010)** | **(0.002)** | **(0.022)** | (0.503) | | | | |
| PCB | --- | --- | --- | --- | **0.0005*** | 0.00003 | **0.0002*** | 0.00005 |
| | | | | | **(0.000)** | (0.851) | **(0.006)** | (0.510) |
| PCR × Mobile Phones | **0.00001**** | **-0.00003*** | --- | --- | --- | --- | --- | --- |
| | **(0.024)** | **(0.001)** | | | | | | |
| PCB × Mobile Phones | --- | --- | --- | --- | **-0.000005*** | 0.0000006 | --- | --- |
| | | | | | **(0.000)** | (0.730) | | |
| PCR × Internet | --- | --- | **0.00002*** | 0.000002 | --- | --- | --- | --- |
| | | | **(0.087)** | (0.878) | | | | |
| PCB × Internet | --- | --- | --- | --- | --- | --- | **-0.00001*** | -0.000001 |
| | | | | | | | **(0.009)** | (0.799) |
| GDPpcg | **0.0007**** | -0.0003 | **0.0007*** | -0.0001 | 0.0003 | 0.0001 | -0.0001 | -0.0003 |
| | **(0.032)** | (0.478) | **(0.055)** | (0.804) | (0.275) | (0.730) | (0.657) | (0.331) |
| Inflation | **0.0006*** | **0.001*** | **0.0008*** | **0.001*** | **0.0005*** | 0.0004 | **0.0008*** | **0.0008*** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.002)** | (0.130) | **(0.000)** | **(0.001)** |
| Pop. density | **0.00002**** | 0.00001 | 0.00001 | 0.00001 | **0.00004*** | 0.00001 | **0.00004*** | 0.0000007 |
| | **(0.041)** | (0.148) | (0.100) | (0.400) | **(0.002)** | (0.333) | **(0.001)** | (0.430) |
| Deposit/Assets | **0.038*** | **0.025*** | **0.035*** | **0.050**** | **0.046*** | 0.014 | **0.045*** | **0.035**** |
| | **(0.001)** | **(0.004)** | **(0.000)** | **(0.029)** | **(0.000)** | (0.427) | **(0.000)** | **(0.036)** |
| Bank Branches | -0.00002 | **-0.0007**** | -0.0003 | 0.0001 | **-0.0007*** | -0.0002 | **-0.001*** | -0.0004 |
| | (0.923) | **(0.010)** | (0.347) | (0.573) | **(0.002)** | (0.371) | **(0.000)** | (0.168) |
| Net effect of the Mobile | nsa | 0.0019 | --- | --- | nsa | na | --- | --- |
| Net effect of the Internet | --- | --- | nsa | na | --- | --- | nsa | na |
| AR(1) | (0.000) | (0.088) | (0.000) | **(0.296)** | (0.000) | (0.002) | (0.000) | (0.221) |
| AR(2) | **(0.811)** | **(0.189)** | **(0.803)** | **(0.433)** | **(0.850)** | **(0.693)** | **(0.847)** | **(0.355)** |
| Sargan OIR | (0.001) | **(0.671)** | (0.238) | **(0.918)** | (0.000) | **(0.407)** | (0.000) | **(0.205)** |
| Hansen OIR | (0.006) | **(0.309)** | (0.072) | **(0.541)** | (0.003) | (0.057) | (0.041) | (0.069) |
| DHT for instruments | | | | | | | | |
| (a)Instruments in levels | | | | | | | | |
| H excluding group | (0.003) | (0.090) | (0.038) | **(0.767)** | (0.010) | **(0.296)** | (0.020) | **(0.958)** |
| Dif(null, H=exogenous) | **(0.159)** | **(0.647)** | (0.295) | (0.345) | (0.032) | (0.053) | **(0.253)** | (0.012) |
| (b) IV (years, eq(diff)) | | | | | | | | |
| H excluding group | (0.072) | **(0.181)** | (0.148) | **(0.501)** | (0.085) | (0.012) | (0.033) | (0.038) |
| Dif(null, H=exogenous) | (0.008) | **(0.734)** | (0.110) | **(0.506)** | (0.002) | **(0.954)** | (0.325) | **(0.540)** |
| Fisher | **70.20*** | **105.40*** | **71.88*** | **61.99*** | **48.89 *** | **109.18*** | **41.94*** | **83.38*** |
| Instruments | 42 | 41 | 42 | 41 | 42 | 40 | 42 | 40 |
| Banks | 144 | 112 | 144 | 111 | 144 | 109 | 144 | 108 |
| Observations | 698 | 140 | 679 | 139 | 690 | 138 | 671 | 137 |

*, **, ***: 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)andAR(2) tests and; b) the validity of the instruments in the Sargan OIR test. na: not applicable due to the insignificance of marginal effects. nsa: not specifically applicable because the information criteria does not valid the model.

**Table 2: Quantity Effects of Reducing Information Asymmetry (GMM)**

| | Public Credit Registries (PCR) | | | | Private Credit Bureaus (PCB) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mobile Phones | | Internet | | Mobile Phones | | Internet | |
| | Full Sample | Partial Sample | Full Sample | Partial Sample | Full Sample | Partial Sample | Full Sample | Partial Sample |
| Constant | **0.306*** | 0.089 | **0.118** | -0.255 | **0.264*** | 0.004 | **0.210*** | 0.150 |
| | **(0.000)** | (0.575) | **(0.042)** | (0.125) | **(0.000)** | (0.954) | **(0.000)** | (0.117) |
| Quantity of Loans (-1) | **0.934*** | **1.009*** | **0.962*** | **0.995*** | **0.935*** | **0.997*** | **0.951*** | **0.994*** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Mobile Phones | **-0.002*** | -0.0006 | --- | --- | **-0.002*** | 0.00004 | --- | --- |
| | **(0.000)** | (0.108) | | | **(0.000)** | (0.899) | | |
| Internet | --- | --- | **-0.002** | 0.001 | --- | --- | **-0.003** | 0.001 |
| | | | **(0.026)** | (0.186) | | | **(0.012)** | (0.166) |
| PCR | 0.004 | -0.002 | 0.003 | **0.005*** | --- | --- | --- | --- |
| | (0.474) | (0.782) | (0.207) | **(0.054)** | | | | |
| PCB | --- | --- | --- | --- | 0.0004 | **0.001** | -0.0003 | 0.0005 |
| | | | | | (0.632) | **(0.026)** | (0.548) | (0.213) |
| PCR×Mobile Phones | -0.00004 | 0.00002 | --- | --- | 0.000004 | --- | --- | --- |
| | (0.481) | (0.736) | | | (0.544) | | | |
| PCB×Mobile Phones | --- | --- | --- | --- | --- | **-0.00001** | --- | --- |
| | | | | | | **(0.017)** | | |
| PCR×Internet | --- | --- | -0.0001 | -0.0001 | --- | --- | --- | --- |
| | | | (0.107) | (0.124) | | | | |
| PCB×Internet | --- | --- | ---- | --- | --- | --- | 0.00001 | **-0.00006** |
| | | | | | | | (0.515) | **(0.044)** |
| GDPpcg | **0.004** | **0.007*** | **0.004** | **0.006*** | **0.005*** | 0.003 | **0.042** | **0.005*** |
| | **(0.026)** | **(0.003)** | **(0.022)** | **(0.003)** | **(0.001)** | (0.185) | **(0.015)** | **(0.000)** |
| Inflation | 0.0003 | **-0.001*** | 0.001 | 0.00003 | **0.001** | 0.0006 | **0.001*** | -0.0003 |
| | (0.708) | **(0.058)** | (0.226) | (0.970) | **(0.026)** | (0.546) | **(0.089)** | (0.637) |
| Pop. density | **-0.0002** | 0.00002 | -0.00002 | -0.00005 | **-0.0001** | 0.00001 | -0.00006 | -0.00003 |
| | **(0.013)** | (0.826) | (0.678) | (0.468) | **(0.016)** | (0.719) | (0.304) | (0.447) |
| Deposit/Assets | 0.023 | 0.039 | 0.124 | **0.177** | 0.059 | 0.136 | 0.090 | 0.119 |
| | (0.803) | (0.713) | (0.157) | **(0.042)** | (0.471) | (0.178) | (0.223) | (0.102) |
| Bank Branches | **0.005** | -0.002 | 0.001 | **-0.005*** | **0.003*** | **-0.002** | 0.001 | **-0.004*** |
| | **(0.012)** | (0.251) | (0.294) | **(0.000)** | **(0.073)** | **(0.060)** | (0.666) | **(0.006)** |
| Net effect of the Mobile | na | na | --- | --- | na | 0.0006 | --- | --- |
| Net effect of the Internet | --- | --- | na | na | --- | --- | na | na |
| AR(1) | (0.000) | **(0.533)** | (0.000) | **(0.919)** | (0.000) | **(0.187)** | (0.000) | **(0.877)** |
| AR(2) | **(0.754)** | **(0.894)** | **(0.694)** | **(0.951)** | **(0.734)** | **(0.806)** | **(0.737)** | **(0.247)** |
| Sargan OIR | (0.000) | (0.065) | (0.000) | (0.007) | (0.003) | (0.007) | (0.000) | (0.015) |
| Hansen OIR | (0.038) | **(0.434)** | (0.001) | **(0.627)** | (0.041) | **(0.288)** | (0.017) | **(0.637)** |
| DHT for instruments (a)Instruments in levels | | | | | | | | |
| H excluding group | **(0.611)** | **(0.302)** | **(0.742)** | **(0.262)** | **(0.286)** | **(0.514)** | **(0.433)** | **(0.481)** |
| Dif(null, H=exogenous) | (0.013) | **(0.523)** | (0.000) | **(0.793)** | (0.036) | **(0.220)** | (0.008) | **(0.630)** |
| (b) IV (years, eq(diff)) | | | | | | | | |
| H excluding group | (0.038) | **(0.525)** | (0.005) | **(0.609)** | (0.023) | **(0.337)** | (0.018) | **(0.657)** |
| Dif(null, H=exogenous) | **(0.258)** | **(0.233)** | (0.055) | **(0.489)** | (0.455) | **(0.238)** | (0.217) | **(0.412)** |
| Fisher | **761.21*** | **1665.19*** | **1553.32*** | **3038.86*** | **896.39*** | **3991.86*** | **885.73*** | **2475.98*** |
| Instruments | 42 | 39 | 42 | 41 | 42 | 37 | 42 | 39 |
| Banks | 145 | 115 | 145 | 113 | 145 | 112 | 145 | 110 |
| Observations | 735 | 145 | 713 | 143 | 728 | 144 | 706 | 142 |

*, **, ***: 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)andAR(2) tests and; b) the validity of the instruments in the Sargan OIR test. na: not applicable due to the insignificance of marginal effects.

Tables 3-6 present IVQR related findings. In particular, Tables 3-4 are related to the relationships between ICT and public credit registries while Tables 5-6 focus on the

connections between ICT and private credit bureaus. For each information sharing office, one table concentrates on loan price (Table 3 and Table 5) while the other is on loan quantity (Table 4 and Table 6).

See Tables 1-2, for the findings in terms of marginal and net effects; for the purpose of the computation of net effects, mean values are based on instrumented ICT values, notably: 37.019 is the instrumented mean value of mobile phone penetration whereas 7.809 is the instrumented mean value of internet penetration. For all tables: (i) the consistent differences in estimated coefficients in OLS versus quantiles (with respect to sign, significance and magnitude of significance) justify the relevance of the QR empirical strategy and (ii) 'mobile phone'-related regressions are disclosed on the left-hand-side whereas internet-oriented estimations are presented on the right-hand-side.

The following findings are observed from Table 3 on price effects of public credit registries with ICT: The net effect from the interaction between public credit registries and mobile phones is negative for the bottom quantiles; while the net effect from the interaction between public credit registries and internet is positive from the $25^{th}$ to the $75^{th}$ quartiles. In Table 4 on loan effects from public credit registries with ICT, the net effect from the interaction between public credit registries and the mobile phone is positive in the $25^{th}$ quartile whereas the net effect from the interaction between public credit registries and the internet is positive only in the $25^{th}$ and $50^{th}$ quartiles.

In Table 5, private credit bureaus with the internet have a positive net effect on loan prices in the $75^{th}$ quartile. In Table 6, private credit bureaus with the internet (mobile phone) have a negative net effect on loan quantity in the $50^{th}$ quartile (from the $10^{th}$ decile to the $75^{th}$ quartile). The corresponding positive marginal effects from the interaction with mobile phones is an indication that positive net effect from mobile phones can be reached if certain thresholds of mobile phones are attained. Most of the significant control variables have the expected signs.

## Table 3: Price Effects of Public Credit Registries with ICT (IVQR)

| | Dependent variable: Price of Loans | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mobile Phones | | | | | | Internet | | | | | |
| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
| Constant | -0.084*** | 0.071*** | 0.065*** | 0.073*** | 0.095*** | 0.098*** | 0.083*** | 0.045*** | 0.065*** | 0.084*** | 0.097*** | 0.094*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) |
| Mobile Phones(IV) | -0.0001* | -0.0004*** | -0.0001** | -0.00004 | -0.00008 | -0.00006 | --- | --- | --- | --- | --- | --- |
| | (0.091) | (0.000) | (0.018) | (0.590) | (0.354) | (0.603) | | | | | | |
| Internet (IV) | --- | --- | --- | --- | --- | --- | -0.0007*** | -0.0005 | -0.0004* | -0.0006** | -0.001*** | -0.001** |
| | | | | | | | (0.008) | (0.174) | (0.084) | (0.025) | (0.000) | (0.019) |
| PCR (IV) | -0.002*** | -0.004*** | -0.003*** | -0.002* | -0.001 | -0.002 | -0.003*** | -0.002*** | -0.003*** | -0.003*** | -0.004*** | -0.002 |
| | (0.008) | (0.004) | (0.000) | (0.083) | (0.295) | (0.293) | (0.000) | (0.009) | (0.000) | (0.000) | (0.000) | (0.180) |
| PCR(IV) ×Mobile Phones(IV) | 0.00001 | 0.00002* | 0.00002*** | 0.000009 | 0.000002 | 0.000004 | --- | --- | --- | --- | --- | --- |
| | (0.241) | (0.082) | (0.006) | (0.475) | (0.868) | (0.835) | | | | | | |
| PCR(IV) ×Internet(IV) | --- | --- | --- | --- | --- | --- | 0.00005** | 0.00002 | 0.00005** | 0.00006** | 0.00007** | 0.00003 |
| | | | | | | | (0.026) | (0.483) | (0.016) | (0.025) | (0.031) | (0.583) |
| GDPpcg | -0.0008** | -0.0009 | -0.00001 | -0.0005 | -0.0006 | -0.001** | -0.0006 | 0.0001 | -0.00002 | -0.0004 | -0.001** | -0.0009 |
| | (0.046) | (0.105) | (0.975) | (0.247) | (0.233) | (0.046) | (0.114) | (0.869) | (0.956) | (0.303) | (0.011) | (0.153) |
| Inflation | 0.001*** | 0.0001 | 0.001*** | 0.001*** | 0.002*** | 0.003*** | 0.001*** | 0.0005 | 0.001*** | 0.002*** | 0.002*** | 0.003*** |
| | (0.000) | (0.837) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.423) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pop. density | 0.00006*** | 0.00004 | 0.00006*** | 0.00008*** | 0.00006*** | 0.00006*** | 0.00007*** | 0.00007 | 0.00007*** | 0.00009*** | 0.0001*** | 0.00006*** |
| | (0.001) | (0.185) | (0.000) | (0.000) | (0.001) | (0.007) | (0.000) | (0.130) | (0.000) | (0.000) | (0.000) | (0.002) |
| Deposit/Assets | 0.017** | 0.007 | 0.017*** | 0.020** | 0.017* | 0.036*** | 0.015** | 0.007 | 0.015** | 0.006 | 0.021*** | 0.042*** |
| | (0.019) | (0.503) | (0.004) | (0.012) | (0.050) | (0.008) | (0.033) | (0.569) | (0.035) | (0.407) | (0.005) | (0.001) |
| Bank Branches | -0.0005 | 0.001** | -0.0007** | -0.001*** | -0.0009** | -0.0001 | -0.00005 | 0.001 | -0.0006 | -0.0003 | 0.0009* | 0.0003 |
| | (0.120) | (0.022) | (0.017) | (0.008) | (0.032) | (0.734) | (0.914) | (0.158) | (0.142) | (0.459) | (0.096) | (0.740) |
| Small Banks | 0.008** | 0.012** | 0.011*** | 0.001 | 0.002 | 0.008 | 0.007* | 0.015** | 0.008* | 0.003 | 0.003 | 0.009 |
| | (0.027) | (0.043) | (0.001) | (0.717) | (0.605) | (0.233) | (0.072) | (0.046) | (0.058) | (0.537) | (0.506) | (0.173) |
| Domestic Banks | 0.001 | -0.010** | -0.002 | 0.007** | 0.008** | 0.001 | 0.001 | -0.014** | -0.001 | 0.005 | 0.004 | 0.002 |
| | (0.560) | (0.026) | (0.362) | (0.041) | (0.046) | (0.852) | (0.700) | (0.022) | (0.759) | (0.118) | (0.192) | (0.635) |
| Islamic Banks | -0.017*** | -0.003 | -0.016** | -0.015* | -0.014 | -0.013 | -0.012* | 0.009 | -0.013 | -0.012 | 0.004 | 0.001 |
| | (0.009) | (0.791) | (0.016) | (0.093) | (0.175) | (0.347) | (0.091) | (0.570) | (0.160) | (0.248) | (0.661) | (0.946) |
| Net effect of the Mobile | na | -0.0032 | -0.0022 | na | na | na | --- | --- | --- | --- | --- | --- |
| Net effect of the Internet | --- | --- | --- | --- | --- | --- | -0.0026 | na | -0.0026 | -0.0025 | -0.0034 | na |
| Pseudo R²/R² | 0.216 | 0.116 | 0.150 | 0.158 | 0.149 | 0.136 | 0.222 | 0.093 | 0.151 | 0.169 | 0.173 | 0.142 |
| Fisher | 21.67*** | | | | | | 22.71*** | | | | | |
| Observations | 728 | 728 | 728 | 728 | 728 | 728 | 700 | 700 | 700 | 700 | 700 | 700 |

***,**,*: significance levels of 1%, 5% and 10% respectively. IV: Instrumented Variable. OLS: Ordinary Least Squares. R² (Pseudo R²) for OLS (Quantile Regressions). Lower quantiles (e.g., Q 0.1) signify nations where Market Power is least. na: not applicable due to the insignificance of marginal effects.

## Table 4: Quantity Effects of Public Credit Registries with ICT (IVQR)

| | Dependent variable: Quantity of Loans | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mobile Phones** | | | | | | **Internet** | | | | | |
| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
| Constant | **3.806***** | **2.762***** | **2.982***** | **3.361***** | **4.596***** | **4.943***** | **3.920***** | **2.752***** | **2.970***** | **3.495***** | **4.492***** | **5.400***** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Mobile Phones(IV) | **0.003*** | **0.004**** | 0.003 | 0.003 | **0.006**** | **0.005***** | --- | --- | --- | --- | --- | --- |
| | **(0.088)** | **(0.012)** | (0.337) | (0.288) | **(0.011)** | **(0.002)** | | | | | | |
| Internet (IV) | --- | --- | --- | --- | --- | --- | **0.039***** | **0.020***** | **0.030**** | **0.063***** | **0.035***** | **0.021***** |
| | | | | | | | **(0.000)** | **(0.0006)** | **(0.022)** | **(0.000)** | **(0.000)** | **(0.001)** |
| PCR (IV) | **0.066**** | **0.104***** | 0.064 | 0.080 | -0.016 | -0.049 | **0.075***** | **0.088***** | **0.081*** | **0.101**** | 0.012 | -0.005 |
| | **(0.016)** | **(0.001)** | (0.300) | (0.222) | (0.719) | (0.229) | **(0.000)** | **(0.000)** | **(0.052)** | **(0.016)** | (0.637) | (0.734) |
| PCR(IV)×Mobile Phones(IV) | **-0.0005**** | **-0.0008***** | -0.0003 | -0.0006 | 0.00009 | 0.0004 | --- | --- | --- | --- | --- | --- |
| | **(0.045)** | **(0.006)** | (0.615) | (0.302) | (0.836) | (0.220) | | | | | | |
| PCR(IV) ×Internet(IV) | --- | --- | --- | --- | --- | --- | **-0.002***** | **-0.002***** | -0.002 | **-0.002**** | -0.0001 | 0.0002 |
| | | | | | | | **(0.003)** | **(0.000)** | (0.125) | **(0.033)** | (0.821) | (0.606) |
| GDPpcg | -0.014 | **0.020**** | -0.019 | -0.031 | 0.002 | -0.014 | -0.018 | **0.020**** | **-0.031*** | -0.031 | -0.008 | -0.027 |
| | (0.221) | **(0.048)** | (0.317) | (0.191) | (0.856) | (0.129) | (0.118) | **(0.032)** | **(0.083)** | (0.174) | (0.574) | (0.027) |
| Inflation | **-0.024***** | -0.004 | -0.010 | **-0.031**** | **-0.025***** | -0.002 | **-0.022***** | -0.008 | -0.010 | **-0.028*** | **-0.022***** | -0.007 |
| | **(0.000)** | (0.329) | (0.329) | **(0.025)** | **(0.005)** | (0.637) | **(0.001)** | (0.160) | (0.344) | **(0.058)** | **(0.006)** | (0.309) |
| Pop. density | **-0.001***** | **-0.0007**** | **-0.001**** | -0.0007 | **-0.001*** | **-0.001**** | **-0.001***** | **-0.002***** | **-0.002***** | -0.0009 | **-0.001***** | **-0.0009*** |
| | **(0.002)** | **(0.013)** | **(0.024)** | (0.386) | **(0.050)** | **(0.018)** | **(0.000)** | **(0.000)** | **(0.000)** | (0.263) | **(0.001)** | **(0.065)** |
| Deposit/Assets | **1.867***** | **1.057***** | **2.034***** | **2.544***** | **1.306***** | **1.279***** | **1.741***** | **1.217***** | **2.063***** | **2.432***** | **1.173***** | **1.018***** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Bank Branches | **-0.063***** | **-0.043***** | **-0.055***** | **-0.072***** | **-0.052***** | **-0.052***** | **-0.100***** | **-0.056***** | **-0.075***** | **-0.140***** | **-0.095***** | **-0.078***** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Small Banks | **-0.775***** | **-1.190***** | **-1.268***** | **-0.715***** | **-0.326**** | **-0.250**** | **-0.820***** | **-1.010***** | **-1.171***** | **-0.872***** | **-0.457***** | **-0.418***** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.001)** | **(0.028)** | **(0.012)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.001)** | **(0.001)** |
| Domestic Banks | **0.401***** | 0.078 | **0.408**** | **0.460**** | **0.440***** | **0.436***** | **0.451***** | 0.117 | **0.447***** | **0.523***** | **0.606***** | **0.600***** |
| | **(0.000)** | (0.378) | **(0.010)** | **(0.010)** | **(0.000)** | **(0.000)** | **(0.000)** | (0.253) | **(0.005)** | **(0.005)** | **(0.000)** | **(0.000)** |
| Islamic Banks | **-0.587***** | **0.322**** | -0.085 | -0.287 | **-1.193***** | **-1.340***** | **-0.546***** | 0.081 | 0.104 | -0.357 | **-0.982***** | **-1.205***** |
| | **(0.000)** | **(0.031)** | (0.822) | (0.481) | **(0.000)** | **(0.000)** | **(0.007)** | (0.726) | (0.815) | (0.487) | **(0.003)** | **(0.000)** |
| Net effect of the Mobile | 0.0474 | 0.0743 | na | na | na | na | --- | --- | --- | --- | --- | --- |
| Net effect of the Internet | --- | --- | --- | --- | --- | --- | 0.0593 | 0.0723 | na | 0.0853 | na | na |
| Pseudo R²/R² | 0.198 | 0.085 | 0.115 | 0.152 | 0.111 | 0.126 | 0.206 | 0.089 | 0.125 | 0.150 | 0.111 | 0.117 |
| Fisher | **31.37***** | | | | | | **27.13***** | | | | | |
| Observations | 751 | 751 | 751 | 751 | 751 | 751 | 719 | 719 | 719 | 719 | 719 | 719 |

***,**,*: significance levels of 1%, 5% and 10% respectively. IV: Instrumented Variable. OLS: Ordinary Least Squares. R² (Pseudo R²) for OLS (Quantile Regressions). Lower quantiles (e.g., Q 0.1) signify nations where Market Power is least. na: not applicable due to the insignificance of marginal effects.

## Table 5: Price Effects of Private Credit Bureaus with ICT (IVQR)

### Dependent variable: Price of Loans

| | Mobile Phones | | | | | | Internet | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
| Constant | 0.080*** | 0.067*** | 0.077*** | 0.077*** | 0.084*** | 0.093*** | 0.078*** | 0.061*** | 0.057*** | 0.069*** | 0.084*** | 0.091*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Mobile Phones(IV) | -0.0002*** | -0.0003*** | -0.0005*** | -0.0003*** | -0.0002** | -0.0001 | --- | --- | --- | --- | --- | --- |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.042) | (0.355) | | | | | | |
| Internet (IV) | --- | --- | --- | --- | --- | --- | 0.0003 | -0.0003 | 0.0006 | 0.0005** | 0.00006 | 0.00001 |
| | | | | | | | (0.247) | (0.329) | (0.127) | (0.035) | (0.865) | (0.976) |
| PCB (IV) | 0.0008*** | 0.0002 | 0.0001 | 0.0006** | 0.0006* | 0.001*** | 0.0009*** | 0.0007*** | 0.0008*** | 0.0006*** | 0.0006** | 0.0009*** |
| | (0.007) | (0.540) | (0.678) | (0.017) | (0.081) | (0.003) | (0.000) | (0.000) | (0.002) | (0.000) | (0.010) | (0.006) |
| PCB(IV)×Mobile Phones(IV) | -0.000001 | 0.000006 | 0.0000007* | -0.0000004 | -0.000001 | -0.000005 | --- | --- | --- | --- | --- | --- |
| | (0.684) | (0.142) | (0.094) | (0.894) | (0.670) | (0.209) | | | | | | |
| PCB(IV)×Internet(IV) | --- | --- | --- | --- | --- | --- | -0.00003*** | -0.000004 | -0.00003 | -0.00002 | -0.00004* | -0.00004 |
| | | | | | | | (0.000) | (0.700) | (0.186) | (0.174) | (0.071) | (0.120) |
| GDPpcg | -0.0009** | -0.001** | -0.0007 | -0.001** | 0.0004 | 0.0006 | -0.0004 | 0.00005 | 0.0001 | -0.0002 | 0.0001 | 0.0005 |
| | (0.038) | (0.012) | (0.284) | (0.024) | (0.405) | (0.316) | (0.316) | (0.936) | (0.851) | (0.535) | (0.734) | (0.264) |
| Inflation | 0.001*** | 0.0002 | 0.001*** | 0.002*** | 0.002*** | 0.003*** | 0.002*** | 0.0005 | 0.001*** | 0.002*** | 0.002*** | 0.002*** |
| | (0.000) | (0.620) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.283) | (0.000) | (0.000) | (0.000) | (0.000) |
| Pop. density | 0.00004*** | 0.00003 | 0.00003 | 0.00004*** | 0.00005*** | 0.00007*** | 0.00005*** | 0.00005** | 0.00004** | 0.00005*** | 0.00006*** | 0.00007*** |
| | (0.000) | (0.103) | (0.189) | (0.004) | (0.001) | (0.000) | (0.000) | (0.015) | (0.048) | (0.000) | (0.000) | (0.000) |
| Deposit/Assets | 0.022*** | 0.008 | 0.014 | 0.024*** | 0.026*** | 0.038*** | 0.020*** | -0.001 | 0.017 | 0.016** | 0.021** | 0.042*** |
| | (0.001) | (0.347) | (0.209) | (0.001) | (0.005) | (0.000) | (0.004) | (0.872) | (0.148) | (0.017) | (0.020) | (0.000) |
| Bank Branches | -0.001*** | -0.001*** | -0.0004 | -0.0009*** | -0.001** | -0.001*** | -0.002*** | -0.002*** | -0.002*** | -0.003*** | -0.001*** | -0.002** |
| | (0.000) | (0.000) | (0.308) | (0.008) | (0.029) | (0.002) | (0.000) | (0.000) | (0.000) | (0.000) | (0.004) | (0.018) |
| Small Banks | 0.009** | 0.012** | 0.006 | 0.002 | 0.004 | 0.010 | 0.005 | 0.008 | 0.002 | 0.001 | 0.005 | 0.007 |
| | (0.012) | (0.025) | (0.318) | (0.512) | (0.462) | (0.114) | (0.198) | (0.149) | (0.750) | (0.633) | (0.288) | (0.337) |
| Domestic Banks | -0.001 | -0.005 | -0.003 | 0.0035 | 0.003 | -0.0003 | -0.001 | -0.012*** | -0.002 | 0.003 | 0.003 | 0.0006 |
| | (0.736) | (0.261) | (0.552) | (0.325) | (0.408) | (0.947) | (0.699) | (0.009) | (0.609) | (0.237) | (0.506) | (0.913) |
| Islamic Banks | -0.021* | -0.001 | -0.012 | -0.014* | -0.005 | -0.013 | -0.008 | 0.015 | -0.003 | -0.010 | -0.012 | -0.015 |
| | (0.058) | (0.880) | (0.305) | (0.093) | (0.603) | (0.243) | (0.139) | (0.216) | (0.826) | (0.260) | (0.321) | (0.306) |
| Net effect of the Mobile | na | na | na | na | na | na | --- | --- | --- | --- | --- | --- |
| Net effect of the Internet | --- | --- | --- | --- | --- | --- | 0.0006 | na | na | na | 0.0002 | na |
| Pseudo R²/R² | 0.245 | 0.155 | 0.181 | 0.171 | 0.156 | 0.140 | 0.232 | 0.136 | 0.160 | 0.167 | 0.155 | 0.135 |
| Fisher | 23.83*** | | | | | | 21.73*** | | | | | |
| Observations | 729 | 729 | 729 | 729 | 729 | 729 | 701 | 701 | 701 | 701 | 701 | 701 |

***,**,*: significance levels of 1%, 5% and 10% respectively. IV: Instrumented Variable. OLS: Ordinary Least Squares. R² (Pseudo R²) for OLS (Quantile Regressions). Lower quantiles (e.g., Q 0.1) signify nations where Market Power is least. na: not applicable due to the insignificance of marginal effects.

# Table 6: Quantity Effects of Private Credit Bureaus with ICT (IVQR)

**Dependent variable: Quantity of Loans**

| | Mobile Phones | | | | | | Internet | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
| Constant | 3.829*** | 2.386*** | 3.271*** | 3.345*** | 4.624*** | 4.862*** | 3.787*** | 2.277*** | 2.888*** | 3.489*** | 4.771*** | 5.156*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Mobile Phones(IV) | 0.002 | 0.003** | -0.001 | 0.007*** | 0.004* | 0.005*** | --- | --- | --- | --- | --- | --- |
| | (0.354) | (0.030) | (0.745) | (0.003) | (0.088) | (0.000) | | | | | | |
| Internet (IV) | --- | --- | --- | --- | --- | --- | 0.047*** | 0.018** | 0.051*** | 0.047*** | 0.049*** | 0.029*** |
| | | | | | | | (0.000) | (0.048) | (0.001) | (0.000) | (0.000) | (0.002) |
| PCB (IV) | -0.024*** | -0.008* | -0.027** | -0.029*** | -0.056*** | -0.008 | -0.006 | -0.0009 | -0.0002 | -0.017** | 0.0006 | 0.005 |
| | (0.006) | (0.096) | (0.018) | (0.001) | (0.000) | (0.150) | (0.303) | (0.856) | (0.984) | (0.029) | (0.879) | (0.197) |
| PCB(IV)×Mobile Phones(IV) | 0.0002*** | 0.0001** | 0.0003** | 0.0002** | 0.0006*** | 0.00009 | --- | --- | --- | --- | --- | --- |
| | (0.008) | (0.036) | (0.011) | (0.039) | (0.000) | (0.140) | | | | | | |
| PCB(IV) × Internet(IV) | --- | --- | --- | --- | --- | --- | 0.001* | 0.0005 | 0.0002 | 0.001** | 0.0005* | 0.000004 |
| | | | | | | | (0.061) | (0.253) | (0.759) | (0.018) | (0.078) | (0.987) |
| GDPpcg | -0.004 | 0.014* | -0.013 | -0.008 | 0.001 | -0.013* | -0.0002 | 0.008 | -0.038* | -0.015 | 0.008 | -0.018* |
| | (0.172) | (0.087) | (0.431) | (0.565) | (0.940) | (0.061) | (0.983) | (0.349) | (0.051) | (0.386) | (0.468) | (0.096) |
| Inflation | -0.022*** | -0.010** | -0.011 | -0.029*** | -0.022*** | -0.001 | -0.015** | -0.009* | -0.017 | -0.020* | -0.017*** | 0.005 |
| | (0.001) | (0.010) | (0.228) | (0.000) | (0.003) | (0.761) | (0.022) | (0.095) | (0.104) | (0.068) | (0.005) | (0.392) |
| Pop. density | -0.0009*** | -0.0002* | -0.002 | -0.0009** | -0.001*** | -0.0007** | -0.0008*** | -0.0007*** | -0.00002 | -0.0005 | -0.001*** | -0.0009** |
| | (0.002) | (0.096) | (0.583) | (0.039) | (0.005) | (0.028) | (0.009) | (0.001) | (0.964) | (0.370) | (0.005) | (0.048) |
| Deposit/Assets | 1.883*** | 0.949*** | 1.160*** | 2.525*** | 1.482*** | 1.327*** | 1.789*** | 1.157*** | 2.240*** | 2.314*** | 1.266*** | 1.162*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0..000) | (0.000) |
| Bank Branches | -0.050*** | -0.010* | -0.026** | -0.063*** | -0.059*** | -0.056*** | -0.106*** | -0.022** | -0.098*** | -0.111*** | -0.115*** | -0.082*** |
| | (0.000) | (0.073) | (0.049) | (0.000) | (0.000) | (0.000) | (0.000) | (0.023) | (0.000) | (0.000) | (0.000) | (0.000) |
| Small Banks | -0.830*** | -0.824*** | -1.318*** | -0.819*** | -0.400*** | -0.216** | -0.920*** | -0.689*** | -1.388*** | -0.759*** | -0.656*** | -0.508*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.004) | (0.019) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Domestic Banks | 0.392*** | 0.085 | 0.407*** | 0.517*** | 0.465*** | 0.404*** | 0.415*** | 0.035 | 0.524*** | 0.485*** | 0.622*** | 0.556*** |
| | (0.000) | (0.239) | (0.004) | (0.000) | (0.000) | (0.000) | (0.000) | (0.698) | (0.002) | (0.001) | (0.000) | (0.000) |
| Islamic Banks | -0.544*** | 0.434*** | 0.085 | -0.388 | -1.172*** | -1.294*** | -0.350 | 0.389* | -0.060 | -0.043 | -0.659** | -0.940*** |
| | (0.000) | (0.005) | (0.796) | (0.121) | (0.000) | (0.000) | (0.127) | (0.079) | (0.900) | (0.913) | (0.013) | (0.000) |
| Net effect of the Mobile | -0.0165 | -0.0042 | -0.0158 | -0.0215 | -0.0337 | na | --- | --- | --- | --- | --- | --- |
| Net effect of the Internet | --- | --- | --- | --- | --- | --- | na | na | na | -0.0091 | na | na |
| Pseudo R²/R² | 0.204 | 0.085 | 0.113 | 0.160 | 0.124 | 0.131 | 0.226 | 0.083 | 0.122 | 0.164 | 0.132 | 0.137 |
| Fisher | 34.85*** | | | | | | 30.37*** | | | | | |
| Observations | 754 | 754 | 754 | 754 | 754 | 754 | 722 | 722 | 722 | 722 | 722 | 722 |

***,**,*: significance levels of 1%, 5% and 10% respectively. IV: Instrumented Variable. OLS: Ordinary Least Squares. R² (Pseudo R²) for OLS (Quantile Regressions). Lower quantiles (e.g., Q 0.1) signify nations where Market Power is least. na: not applicable due to the insignificance of marginal effects.

It is important to note that the presentation of the findings has been limited to net effects because with interactive regressions, interpreting individual effects can be misleading. This is essentially because the issue of multicollinearity between interactive variables is overlooked in the specifications (Brambor *et al*., 2006). In the presence of multicollinearity, variables with a high degree of substitution have opposite signs in the regression output (Beck *et al*., 2003). Therefore, focusing on net effects (i.e. the sum of unconditional and conditional effects) for policy implications is essential for a comprehensive assessment of the relevance of the policy variable in moderating the effect of the independent variable of interest on the outcome variable (Brambor *et al*., 2006). Moreover, the analysis is not exclusively limited to net effects because where, marginal effects are consistent with theoretical expectations, thresholds at which the policy variable effectively modulates the independent variable of interest to achieve the desired effect on the outcome variable are computed. These findings are discussed in Section 4.2 with regards to the role that ICT policy reforms could pay in modifying the key functions of credit registries which are relevant for increasing access to credit.

## 4.2 Further discussion of results and policy implications

This section reconciles the findings of the present inquiry with existing literature. Additionally, it explores the policy implications of our findings in terms of how unexpected results can be leveraged for enhanced financial access for both households and firms. From the several regression outcomes it is obvious that the relationship between ICT and public credit registries (PCRs) leads to greater access to finance compared with the nexus between ICT and private credit bureaus (PCBs). Our results are not directly comparable with the previous studies reviewed in the introductory section which have directly examined the effects of information sharing offices (i.e., PCRs and PCBs) on financial access. Our assessment of the nexus between information sharing offices and access to credit is not direct because the relationship is contingent on the role of ICT. Nonetheless, we take a minimalist approach by assuming that ICT also indirectly influenced those characteristics of information sharing offices which are essential for promoting financial access.

From a broad perspective, the findings are not consistent with Singh *et al*. (2009) who reported that African nations which have information sharing offices enjoy comparatively higher degrees of financial access. The results are supported by Galindo and Miller (2001) who found that nations with better developed credit registries are associated with less

financial constraints, relative to countries with less developed information sharing offices. This narrative is consistent with the present study because from our sample, public credit registries are more developed compared with private credit bureaus. The suggestion is supported by evidence in Appendix 5 which shows that public credit registries are more widespread than private credit bureaus in many African countries.

Conversely, our findings do not align with Love and Mylenko (2003) who concluded that private credit bureaus are associated with more financial access when compared with public credit registries. Besides, our results are not supported with Triki and Gajigo (2014) who reported that countries with private credit bureaus enjoy higher levels of financial access relative to countries with public credit registries or neither institution.

It is also important to explore how the unexpected findings from private credit bureaus can be leveraged to enhance financial access. Accordingly, we have seen from the Quantile Regressions findings that private credit bureaus increase (decrease) loan price (quantity). Fortunately, corresponding marginal effects are negative (positive). This implies that at certain thresholds of ICT, the unconditional positive (negative) effect from private credit bureaus on loan prices (quantity) can be changed to negative (positive). Thus, the price effect of private credit bureaus with internet penetration in the 75th quartile of Table 5 can become negative if internet penetration reaches a threshold of 15 (0.0006/0.00004). This internet threshold makes economic sense because it is within the range (minimum to maximum) of internet penetration provided by the summary statistics (0.037 to 51.000).

Table 6 shows that the positive marginal effects from the interaction between mobile phones and private credit bureaus can convert the unconditional negative effects of private credit bureaus on the quantity of loans into overall positive effects on the quantity of loans. Hence, mobile phone penetration thresholds of 80 (0.008/0.0001), 90 (0.027/0.0003), 145 (0.029/0.0002), 93.33(0.056/0.0006) are needed respectively in the 10th decile, 25th, 50th and 75th quartiles to convert the unconditional negative effects into overall positive effects. These thresholds also make economic sense because they are within the range of mobile phone penetration disclosed by the summary statistics (0.000 to 147.202).

In the light of the above, the significant net negative effects may be taken as evidence that the penetration of ICT in Africa is a necessary but not a sufficient condition in the modulation of the role of information sharing offices in promoting financial access. This may be due to the low penetration of ICT or the ineffectiveness of ICT in providing timely and up-to-date credit information that are required by information sharing offices. The poor

infrastructure associated with ICT such as electricity outage and poor connection networks may also hamper the effectiveness of ICT in complementing information sharing offices to reduce information asymmetry in the banking industry in order to enhance financial access. As a policy implication both the quantity and quality of ICT need to be improved. In term of loan quantity, in order to increase ICT penetration, governments of our sample of African countries should design and implement policies that promote universal access and low pricing. On the quality perspective, information sharing offices need to be endowed with modern ICT infrastructure as well as information systems that enable the accurate, timely and effective collection and distribution of information on borrowers' characteristics between banks.

## 5. Conclusion and future research directions

This study has investigated loan price and quantity effects of information sharing offices with ICT in a panel of 162 banks consisting of 42 African countries for the period 2001-2011. The empirical evidence is based on Generalised Method of Moments and Instrumental Quantile Regressions. The following trends are uncovered.

*First,* the findings broadly show that the use of ICT to complement the functions of public credit registries would significantly decrease the price of loans and increase the quantity of loans. By contrast, the net effects from the interaction of ICT with private credit bureaus do not lead to a noticeable improvement in financial access. Nevertheless, the corresponding marginal effects show that ICT can complement the role of private credit bureaus to raise loan quantity and lower loan prices when certain thresholds of ICT usage are attained. These thresholds were computed and discussed for banks with low, intermediate and high levels of finance access.

*Second,* the statistically significant negative net effects demonstrate that ICT remains a necessary but not a sufficient complementary mechanism with which information sharing offices can reduce information asymmetry in the banking industry in order to promote financial access. This could also imply that the current policy to raise the ICT penetration rate in the regions has been unsuccessful both in terms of quantity and quality. Therefore, the feasibility of the estimated negative net effects should not be judged within the framework of publication bias or the file drawer concern in social sciences (Rosenberg, 2005; Franco *et al.*, 2014). There authors remarked that whereas strong and expected results are more likely to be accepted and published in scientific journals, weak, null and unexpected findings such as

the negative net effects reported in this study are readily discarded or consigned to the file drawer in social sciences. As a main policy implication, ICT needs to be improved for the sampled countries of the study both in terms of quantity and quality. With regards to quantity, governments of African countries need to design and implement policies that promote universal access to and low pricing of ICT. From a quality perspective, credit agencies need to be equipped with modern ICT infrastructure as well as information systems that enable the accurate, timely and effective collection and sharing of information between them and their clients, including banks, individual households and corporations.

Future studies can improve extant literature by assessing if the established linkages could withstand further scrutiny when investigated within comparative economic frameworks, notably, in terms of bank: ownership (foreign vs. domestic), size (large vs. small) and '*compliance with Sharia finance*' (Islamic vs. non-Islamic).

## Appendices

### Appendix 1: Summary of expected signs

|  | Variables | Expected sign on loan price | Expected sign on loan quantity |
|---|---|---|---|
| Bank-oriented features | Deposit/Asset ratio | + | + |
|  | Bank Branches | - | + |
| Market-related characteristics | GDP per capita growth | Uncertain | + |
|  | Population density | + | + |
|  | Inflation | + | - |
| Characteristics of the unobserved heterogeneity | Small versus(vs). Big banks | Uncertain | Uncertain |
|  | domestic vs. foreign banks | Uncertain | Uncertain |
|  | Islamic vs. non-Islamic banks | Uncertain | Uncertain |

### Appendix 2: Definitions of Variables

| Variables | Signs | Definitions of Variables | Sources |
|---|---|---|---|
| Mobile Phones | Mobile | Mobile phone subscriptions (per 100 people) | WDI (World Bank) |
| Internet Penetration | Internet | Internet penetration (per 100 people) | WDI (World Bank) |
| Loan Quantity | Quantity | Logarithm of Loans Quantity | BankScope |
| Price (charged on Loans or Quantity) | Price | (Gross Interest and Dividend income +Total Non-Interest Operating Income)/Total Assets | BankScope |
| Public credit registries | PCR | Public credit registry coverage (% of adults) | WDI (World Bank) |
| Private credit bureaus | PCB | Private credit bureaus coverage (% of adults) | WDI (World Bank) |
| GDP per capita | GDP | GDP per capita growth (annual %) | WDI (World Bank) |
| Inflation | Infl. | Consumer Price Index (annual %) | WDI (World Bank) |
| Populaton density | Pop. | People per square kilometers of land area | WDI (World Bank) |
| Deposits/Assets | D/A | Deposits on Total Assets | BankScope |
| Bank Branches | Bbrchs | Number of Bank Branches (Commercial bank branches per 100 000 adults) | BankScope |
| Small Banks | Ssize | Ratio of Bank Assets to Total Assets (Assets in all Banks for a given period) ≤ 0.50 | Authors' calculation and BankScope |
| Large Banks | Lsize | Ratio of Bank Assets to Total Assets (Assets in all Banks for a given period)>0.50 | Authors' calculation and BankScope |
| Domestic/Foreign banks | Dom/Foreign | Domestic/Foreign banks based on qualitative information: creation date, headquarters, government/private ownership, % of foreign ownership, year of foreign/domestic ownership…etc | Authors' qualitative content analysis. |
| Islamic/Non-Islamic | Islam/NonIsl. | Islamic/Non-Islamic banks based on financial statement characteristics (trading in derivatives and interest on loan payments…etc) | Authors' qualitative content analysis; Beck et al. (2010); Ali (2012). |

WDI: World Development Indicators. GDP: Gross Domestic Product. The following are dummy variables: Ssize, Lsize, Dom/Foreign and Islam/NonIsl.

## Appendix 3: Summary Statistics

|  |  | Mean | S.D | Minimum | Maximum | Observations |
|---|---|---|---|---|---|---|
| ICT | Mobile | 34.107 | 32.409 | 0.000 | 147.202 | 1776 |
|  | Internet | 7.268 | 8.738 | 0.037 | 51.000 | 1757 |
| Dependent variables | Price of Loans | 0.338 | 0.929 | 0.000 | 25.931 | 1045 |
|  | Quantity of Loans (ln) | 3.747 | 1.342 | -0.045 | 6.438 | 1091 |
| Information sharing | Public credit registries | 2.056 | 6.206 | 0.000 | 49.800 | 1240 |
|  | Private credit bureaus | 7.496 | 18.232 | 0.000 | 64.800 | 1235 |
| Market variables | GDP per capita growth | 13.912 | 96.707 | -15.306 | 926.61 | 1782 |
|  | Inflation | 10.239 | 22.695 | -9.823 | 325.00 | 1749 |
|  | Population density | 81.098 | 106.06 | 2.085 | 633.52 | 1782 |
| Bank level variables | Deposits/Assets | 0.664 | 0.198 | 0.000 | 1.154 | 1052 |
|  | Bank Branches | 6.112 | 6.158 | 0.383 | 37.209 | 1129 |
|  | Small Size | 0.195 | 0.396 | 0.000 | 1.000 | 1255 |
|  | Large Size | 0.804 | 0.396 | 0.000 | 1.000 | 1255 |
|  | Domestic | 0.753 | 0.431 | 0.000 | 1.000 | 1782 |
| Dummy variables | Foreign | 0.246 | 0.431 | 0.000 | 1.000 | 1782 |
|  | Islamic | 0.037 | 0.188 | 0.000 | 1.000 | 1782 |
|  | Non-Islamic | 0.962 | 0.188 | 0.000 | 1.000 | 1782 |

Ln: Logarithm. GDP: Gross Domestic Product. S.D: Standard Deviation. GDP: Gross Domestic Product.

**Appendix 4: Correlation Matrix (Uniform sample size : 684)**

| Market-Level Controls | | | Bank-Level Controls | | | | Dummy-Controls | | | | | | ICT | | Info. Sharing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP | Infl. | Pop. | D/A | Bbrchs | Price | Quantity | Ssize | Lsize | Dom. | Foreign | Islam | NonIsl. | Mobile | Internet | PCR | PCB | |
| 1.000 | 0.136 | 0.007 | -0.008 | -0.068 | -0.014 | -0.026 | -0.0002 | 0.0002 | 0.034 | -0.034 | 0.0001 | -0.0001 | -0.261 | -0.122 | 0.019 | -0.163 | GDP |
| | 1.000 | -0.028 | 0.037 | -0.236 | 0.256 | -0.009 | 0.046 | -0.046 | 0.028 | -0.028 | -0.050 | 0.050 | -0.315 | -0.238 | -0.205 | -0.178 | Inf. |
| | | 1.000 | 0.112 | 0.410 | -0.029 | -0.125 | -0.098 | 0.098 | -0.045 | 0.045 | -0.088 | 0.088 | 0.056 | 0.335 | 0.546 | -0.233 | Pop. |
| | | | 1.000 | -0.041 | 0.080 | 0.306 | -0.041 | 0.041 | -0.062 | 0.062 | -0.210 | 0.210 | -0.087 | -0.036 | -0.038 | -0.083 | D/A |
| | | | | 1.000 | -0.266 | -0.227 | -0.078 | 0.078 | 0.135 | -0.135 | -0.051 | 0.051 | 0.610 | 0.747 | 0.602 | 0.139 | Bbrchs |
| | | | | | 1.000 | -0.075 | 0.094 | -0.094 | 0.016 | -0.016 | -0.097 | 0.097 | -0.206 | -0.219 | -0.342 | 0.094 | Price |
| | | | | | | 1.000 | -0.171 | 0.171 | 0.052 | -0.052 | -0.067 | 0.067 | -0.096 | -0.118 | -0.096 | 0.007 | Quantity |
| | | | | | | | 1.000 | -1.000 | 0.026 | -0.026 | -0.020 | 0.020 | 0.146 | 0.089 | -0.084 | 0.080 | Ssize |
| | | | | | | | | 1.000 | -0.026 | 0.026 | 0.020 | -0.020 | -0.146 | -0.089 | 0.084 | -0.080 | Lsize |
| | | | | | | | | | 1.000 | -1.000 | 0.089 | -0.089 | 0.151 | 0.039 | 0.010 | 0.187 | Dom. |
| | | | | | | | | | | 1.000 | -0.089 | 0.089 | -0.151 | 0.039 | -0.010 | -0.187 | Foreign |
| | | | | | | | | | | | 1.000 | -1.000 | -0.045 | -0.039 | -0.014 | -0.071 | Islam |
| | | | | | | | | | | | | 1.000 | 0.045 | -0.032 | 0.014 | 0.071 | NonIsl. |
| | | | | | | | | | | | | | 1.000 | 0.634 | 0.304 | 0.519 | Mobile |
| | | | | | | | | | | | | | | 1.000 | 0.513 | -0.010 | Internet |
| | | | | | | | | | | | | | | | 1.000 | -0.151 | PCR |
| | | | | | | | | | | | | | | | | 1000 | PCB |

Info: Information. PCB: Private Credit Bureaus. PCR: Public credit registries. GDP: GDP per capita growth. Infl: Inflation. Pop: Population growth. D/A: Deposit on Total Assets. Bbrchs: Bank branches. Szize: Small banks. Lsize: Large banks. Domestic: Domestic banks. Foreign: Foreign banks. Islam: Islamic banks. NonIsl: Non-Islamic banks. Price: Price of Loans. Quantity: Quantity of Loans. ICT: Information and Communication Technology. Mobile: mobile phone penetration. Internet: internet penetration.
5% critical value (two-tailed) = 0.0750 for n = 684.

**Appendix 5: Country-specific average values from information sharing offices**

| | Public Credit Registries | Private Credit Bureaus |
|---|---|---|
| 1) Algeria | 0.216 | 0 .000 |
| 2) Angola | 2.412 | 0.000 |
| 3) Benin | 8.037 | 0.000 |
| 4) Botswana | 0 .000 | 48.150 |
| 5) Burkina Faso | 1.750 | 0.000 |
| 6) Burundi | 0.212 | 0.000 |
| 7) Cameroon | 2.312 | 0.000 |
| 8) Cape Verde | 17.042 | 0.000 |
| 9) Central African Republic | 1.412 | 0.000 |
| 10) Chad | 0.400 | 0.000 |
| 11) Comoros | 0.000 | 0.000 |
| 12) Congo Democratic Republic | 0.000 | 0.000 |
| 13) Congo Republic | 3.400 | 0.000 |
| 14) Côte d'Ivoire | 2.487 | 0.000 |
| 15) Djibouti | 0.200 | 0.000 |
| 16) Egypt | 2.062 | 5.271 |
| 17) Equatorial Guinea | 2.566 | 0.000 |
| 18) Eritrea | 0.000 | 0.000 |
| 19) Ethiopia | 0.087 | 0.000 |
| 20) Gabon | 12.716 | 0.000 |
| 21) The Gambia | 0.000 | 0.000 |
| 22) Ghana | 0.000 | 1.700 |
| 23) Guinea | 0.000 | 0.000 |
| 24) Guinea-Bissau | 1.000 | 0.000 |
| 25) Kenya | 0.000 | 1.750 |
| 26) Lesotho | 0.000 | 0.000 |
| 27)Liberia | 0.280 | 0.000 |
| 28) Libya | na | na |
| 29) Madagascar | 0.162 | 0.000 |
| 30) Malawi | 0.000 | 0.000 |
| 31) Mali | 2.812 | 0.000 |
| 32) Mauritania | 0.187 | 0.000 |
| 33) Mauritius | 27.866 | 0.000 |
| 34) Morocco | 1.200 | 4.812 |
| 35) Mozambique | 1.637 | 0.000 |
| 36) Namibia | 0.000 | 50.362 |
| 37) Niger | 0.825 | 0.000 |
| 38) Nigeria | 0.025 | 0.000 |
| 39) Rwanda | 0.425 | 0.275 |
| 40) Sao Tome & Principe | 0.000 | 0.000 |
| 41) Senegal | 3.787 | 0.000 |
| 42) Seychelles | 0.000 | 0.000 |
| 43) Sierra Leone | 0.000 | 0.000 |
| 44) Somalia | na | na |
| 45) South Africa | 0.000 | 57.312 |
| 46) Sudan | 0.000 | 0.000 |
| 47) Swaziland | 0.000 | 40.216 |
| 48) Tanzania | 0.000 | 0.000 |
| 49) Togo | 2.550 | 0.000 |
| 50) Tunisia | 15.975 | 0.000 |
| 51) Uganda | 0.000 | 0.512 |
| 52)Zambia | 0.000 | 0.975 |
| 53) Zimbabwe | 0.000 | 0.000 |

na: not applicable because of missing observations.

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