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

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

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Abstract

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. The empirical evidence is based on Generalised Method of Moments and Instrumental Quantile Regressions. Our findings broadly show that ICT with public credit registries decrease the price of loans and increase the quantity of loans. While the net effects from the interaction of ICT with private credit bureaus do not lead to enhanced financial access, corresponding marginal effects show that ICT can complement private credit bureaus to increase loan quantity and decrease loan prices when certain thresholds of ICT are attained. We compute and discuss the ICT thresholds that are required to make this possible.

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. In particular, we are interested in studying the gains that can be made from information sharing for financial access in the context of Africa, where investments are increasingly needed in order for the continent to evolve and 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 and issues of information asymmetry in the financial sector. A substantial bulk of the current literature on African business accords on the imperative for more sources of investment because, for the most part, privatisation and liberalization projects initiated over the past decades have failed to generate the much needed external finance (see Tuomi, 2011; Rolfe & Woodward, 2004; Darley, 2012; Bartels et al., 2009).

Additionally, as documented by Penard et al. (2012), there is substantial room for improving the penetration of ICT in Africa because ICT growth is stabilizing, as seen in the high-end economies of North America, Europe and Asia. Moreover, according to the authors, there is an uneven penetration in mobile phones and the internet across the continent. For instance, as of 2010, whereas developed countries were experiencing saturation points in mobile phone and internet penetrations, corresponding penetration rates in Africa were respectively 41% and 9.6%. It follows that there is great potential for the leveraging of ICT, especially for development outcomes.

The concerns of surplus liquidity in African financial institutions (see 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 which, compared to less developed countries, have fewer financial access issues. Accordingly, a substantial chunk of existing literature has focused on countries in the Organisation of Economic Cooperation and Development (OECD), Latin America and Asia. Unfortunately, Africa which is facing more severe concerns in financial access has received less scholarly attention in contrast (Asongu et al., 2016a). To put things in perspective, no

African country had been studied by Galindo and Miller (2001). Love and Mylenko (2003) considered a group of four African countries and were followed by Barth et al. (2009) who covered nine countries.

The study by Triki and Gajigo (2014), is closest to the positioning of our inquiry. They use Probit models to assess 42 African countries for the 2006 to 2009 period. The present inquiry is distinct from Triki and Gajigo (2014) in three main perspectives: data, methodology and policy. In particular, we make use of a larger and more comprehensive dataset of countries for the period 2001-2011. We use Generalised Method of Moments (GMM) and Instrumental Variable Quantile Regressions (IV QR) in order to address concerns of endogeneity.

While, Triki and Gajigo (2014) have investigated the relationship between credit registries and financial access at the conditional means of access to finance, we believe that it is also important to investigate the linkages throughout the conditional distributions of access to finance in order to articulate financial institutions with low, intermediate and high levels of financial access. The policy relevance of this modelling approach is that blanket cross-country policies designed to improve financial access by means of information sharing offices may not be effective *unless* they are contingent on existing levels of financial access and tailored differently across financial institutions with different characteristics of financial access.

Triki and Gajigo (2014) acknowledge the failure to account for endogeneity as a caveat of their inquiry. Specifications in the present inquiry are tailored to address the concern of endogeneity by controlling for: (i) time invariant omitted variables and simultaneity with the Generalised Method of Moments (GMM) approach and (ii) simultaneity and the unobserved heterogeneity with an Instrumental Variable Quantile Regressions (IVQR) approach.

Additionally, in our study ICT-related policy variables are integrated into the modelling exercise in order to examine how internet and mobile phone penetrations complement information sharing offices in decreasing information asymmetry for enhanced financial access, in terms of increased quantity of loans and reduced price of loans¹.

Overall, assessing loan and price effects of reducing information asymmetry with ICT is of policy interest, because the findings would inform policy makers on complementary instruments to information sharing offices that can be employed to boost access to finance in order to enable poor households and small businesses capitalise on mobilised savings to increase economic consumption, investment and productivity which ultimately culminate in reduced unemployment and higher economic growth.

¹ Throughout the study, the term financial access is used interchangeably with 'loan quantity' and/or 'loan price'.

The rest of the paper is structured as follows. The stylized facts, background and theoretical underpinnings can be found in Section 2. Section 3 covers the data and methodology. The empirical results and policy implications are discussed in Section 4. Section 5 concludes and provides future research directions.

2. Stylized facts, background and theoretical underpinnings

2.1 Stylized facts and background

Less than 20% of African households have access to formal financial services (IFAD, 2011). The stylized facts maintain that the main factors limiting 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 services, some households and small corporations may still be faced with constraints in lending requirements like strict documentation and collaterals. Moreover, in cases where the underlying requirements in lending are fulfilled, financial access could still be limited by high costs (e.g. transaction fees) and considerable minimum saving requirements.

Credit reference offices are institutions that are designed to collect information on the debt of borrowers (both individual and commercial) from many sources. These include: retail lenders, bank and credit card corporations (mostly for individuals) and public sources (Asongu & Tchamyou, 2016). Once the data is collected, it is cross-checked for a comprehensive report and consolidated. Such data from credit histories can encompass both positive and negative data. Positive information consists of credit histories on attitudes towards repayment while negative information overwhelmingly consists of default data.

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 institution of credit reference agencies across Africa. In essence, before 2008, with the exception of South Africa, not many African countries had well-functioning credit reference bureaus. In addition, the mission of such information sharing offices was substantially restricted to banking sector supervision. Hence, the price of loans remained high for two main reasons. On the one hand the incapacity of credit agencies to provide timely and accurate information on borrowers' history. On the other hand the absence of relevant technology and incentives. This latter point articulates the complementary role of ICT in facilitating the role of information sharing services on financial access.

2.2 Theoretical highlights

Two principal views exist in the literature on the theoretical connection between credit reference agencies and access to finance (see Claus & Grimes, 2003). The first perspective is oriented towards bank liquidity provisions, whereas the second considers the capacity of financial institutions to enhance assets' risk characteristics. Both views however are founded on the main goal of financial intermediation. This goal is to enhance financial intermediation efficiency by transforming mobilised deposits into credit for economic operators. 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 offices in financial intermediation is to reduce costs in information and transactions, that are the result of information asymmetry between lenders and borrowers in the banking industry.

In the light of the above, the relationship between financial access and information sharing offices, faces two problems: moral hazard from borrowers and adverse selection from lenders. 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 levelled by financial institutions in order to compensate for the adverse selection. On the other hand, once loans have been granted to borrowers, they are liable of moral hazard: a behaviour that consists of concealing activities to which the loan is granted with the ultimate aim of avoiding and/or limiting compliance with their financial obligations.

Credit bureaus are also responsible for informing the borrowers on the perils of defaulting on their debts, especially on unsustainability of debt defaults because the informal financial sector is considered as a viable alternative to the formal banking sector. Information sharing offices can thus reduce a borrower's moral hazard by playing a role in market discipline.

In summary: information sharing offices mitigate adverse selection ex-ante of lending while they also reduce moral hazard, ex-post of lending. By conception and definition, the mission of information sharing offices is facilitated by ICT.

3. Data and Methodology

3.1 Data

We examine of panel of 162 banks in 42 African countries², 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. In essence, 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*’.

Consistent with Triki and Gajigo (2014), information sharing offices are measured with public credit registries and private credit bureaus. 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 dummy variables for the unobserved heterogeneity are used as control indicators. The dummies include bank: ownership (foreign 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 in essence, deposits are the principal source of bank financing. A higher proportion of deposits in liquid liabilities can increase loan quantity and/or interest rate margins, since good organisation is necessary for effectiveness in mobilisation and adequate management. Intuitively, while the number of bank branches should positively affect loan quantity, it should also negatively influence the price of loans.

With regards to market-related features, the following signs are expected. From intuition, 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. However, if GDP per capita is decreasing over time, it can affect both loan quantity and loan price as a result of decreasing demand. We anticipate negative signs because the population on average across Africa has been growing at a faster rate than GDP, leading to a decreasing GDP per capita for this period (Asongu, 2013a).

Population density is anticipated to influence both the price and quantity of loans positively. This is because increasing demand for loans, owing to high density in population, increases

² The list of countries we are studying is available in Appendix 5.

loan price. Moreover, we anticipate inflation 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 Le Roux & Kelsey, 2016; Kelsey & Le Roux, 2016). In essence, given that less investment (and hence quantity) of loans are apparent during economic uncertainty (e.g. high inflation), loan price is anticipated to increase with inflation uncertainty because the interest rates levelled on loans are usually adjusted for inflation.

In contrast, establishing anticipated signs for 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 associated with management and coordination issues linked to bank size. Furthermore, addressing the challenges that come with increasing bank size is also a cause of inefficiency, owing to issues encountered with resolving conflicts related to customer needs and requirements. In the same vein, 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 source of variables employed in the study. Appendix 3 and Appendix 4 respectively present the summary statistics and correlation matrix.

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.

(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. In essence, 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 enables some bite on 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 & Bond (1995) and Blundell & Bond (1998) has better estimation properties than the difference estimator used in Arellano & Bond (1991). This inquiry adopts an extension by Roodman (2009ab) of Arellano and Bover (1995) which uses forward orthogonal deviations instead of first differences because the empirical strategy has been documented by Baltagi (2008) and Love and Zicchino (2006) to restrict over-identification or limit 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.

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

$$LQ_{i,t} - LQ_{i,t-\tau} = \sigma_0 + \sigma_1 (LQ_{i,t-\tau} - LQ_{i,t-2\tau}) + \sigma_2 (ISO_{i,t} - ISO_{i,t-\tau}) + \sigma_3 (ICT_{i,t} - ICT_{i,t-\tau}) + \sigma_4 (Inter_{i,t} - Inter_{i,t-\tau}) + \sum_{h=1}^5 \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + \varepsilon_{i,t-\tau} \quad (2)$$

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)); σ_0 is a constant; τ 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*), η_i is the country-specific effect, ξ_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.

As concerns exclusion restrictions and identification, all explanatory variables are considered as suspected endogenous or predetermined variables whereas only *years* are acknowledged to be strictly exogenous (this is consistent with Dewan & Ramaprasad, 2014; Asongu & Nwachukwu, 2016a), 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), 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). 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 impacts 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 are 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.

$$PCB_{i,t} = \alpha + \delta_j(PCB_{i,t-1}) + \varepsilon_{i,t} \quad (3)$$

Where: $PCB_{i,t}$, is the private credit bureaus indicator of bank i at period t , α is a constant, $PCB_{i,t-1}$, represents private credit bureaus in bank i at period $t-1$, and $\varepsilon_{i,t}$ the error term.

$$Internet_{i,t} = \alpha + \delta_j(Internet_{i,t-1}) + \varepsilon_{i,t} \quad (4)$$

Where: $Internet_{i,t}$, is the internet penetration rate of bank i at period t , α is a constant, $Internet_{i,t-1}$, represents internet penetration rate in bank i at period $t-1$, and $\varepsilon_{i,t}$ the error term.

The procedure of instrumentation in Eq. (3) consists of regressing the information sharing office on their first lags. The corresponding fitted values are then saved and later used as the independent variable of interest in Eq. (5). The specifications are Heteroscedasticity and Autocorrelation Consistent (HAC) in standard errors. The θ^{th} quintile 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)

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

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 10th or 25th quintiles (with $\theta=0.10$ or 0.25 respectively) are examined by approximately weighing the residuals. The conditional quintile of financial access or y_i given x_i is:

$$Q_y(\theta / x_i) = x_i' \beta_\theta, \quad (6)$$

where, unique slope parameters are modelled for each θ^{th} specific quintile.

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.³ Based on the information criteria, the following findings can be established. From the third specification of Table 1, we see that the net effect from the interaction between public credit registries and mobile phones is 0.0019 ($([-0.00003 \times 34.107] + 0.003)$), when the mean value of mobile phone penetration is 34.107, the unconditional effect of public credit registries equals 0.003, while the corresponding unconditional impact of it is seen to be -0.00003. We thus find that there is a negative marginal effect and a positive net effect, for the role of mobile phones in public credit registries, for financial access in the perspective of loan prices.

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.

³ “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, 2016, p.9)

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 (0.576)	0.143 (0.149)	-0.001 (0.848)	-0.094* (0.068)	0.0008 (0.927)	0.164*** (0.000)	-0.016* (0.058)	0.021 (0.614)
Price of Loans (-1)	0.686*** (0.000)	0.803*** (0.000)	0.640*** (0.000)	0.781*** (0.000)	0.653*** (0.000)	0.838*** (0.000)	0.690*** (0.000)	0.853*** (0.000)
Mobile Phones	0.00002 (0.706)	0.0001** (0.048)	---	---	0.00003 (0.663)	-0.00008 (0.343)	---	---
Internet	---	---	0.0001 (0.373)	-0.0002 (0.283)	---	---	0.0008*** (0.000)	0.0001 (0.313)
PCR	-0.002** (0.010)	0.003*** (0.002)	-0.001** (0.022)	-0.0003 (0.503)	---	---	---	---
PCB	---	---	---	---	0.0005*** (0.000)	0.00003 (0.851)	0.0002*** (0.006)	0.00005 (0.510)
PCR*Mobile Phones	0.00001** (0.024)	-0.00003*** (0.001)	---	---	---	---	---	---
PCB*Mobile Phones	---	---	---	---	-0.000005*** (0.000)	0.0000006 (0.730)	---	---
PCR*Internet	---	---	0.00002* (0.087)	0.000002 (0.878)	---	---	---	---
PCB*Internet	---	---	---	---	---	---	0.00001*** (0.009)	-0.00001 (0.799)
GDPpcg	0.0007** (0.032)	-0.0003 (0.478)	0.0007* (0.055)	-0.0001 (0.804)	0.0003 (0.275)	0.0001 (0.730)	-0.0001 (0.657)	-0.0003 (0.331)
Inflation	0.0006*** (0.000)	0.001*** (0.000)	0.0008*** (0.000)	0.001*** (0.000)	0.0005*** (0.002)	0.0004 (0.130)	0.0008*** (0.000)	0.0008*** (0.001)
Pop. density	0.00002** (0.041)	0.00001 (0.148)	0.00001 (0.100)	0.00001 (0.400)	0.00004*** (0.002)	0.00001 (0.333)	0.00004*** (0.001)	0.0000007 (0.430)
Deposit/Assets	0.038*** (0.001)	0.025*** (0.004)	0.035*** (0.000)	0.050** (0.029)	0.046*** (0.000)	0.014 (0.427)	0.045*** (0.000)	0.035** (0.036)
Bank Branches	-0.00002 (0.923)	-0.0007** (0.010)	-0.0003 (0.347)	0.0001 (0.573)	-0.0007*** (0.002)	-0.0002 (0.371)	-0.001*** (0.000)	-0.0004 (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) and AR(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)

	Dependent variable: Quantity 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	0.306*** (0.000)	0.089 (0.575)	0.118** (0.042)	-0.255 (0.125)	0.264*** (0.000)	0.004 (0.954)	0.210*** (0.000)	0.150 (0.117)
Quantity of Loans (-1)	0.934*** (0.000)	1.009*** (0.000)	0.962*** (0.000)	0.995*** (0.000)	0.935*** (0.000)	0.997*** (0.000)	0.951*** (0.000)	0.994*** (0.000)
Mobile Phones	-0.002*** (0.000)	-0.0006 (0.108)	---	---	-0.002*** (0.000)	0.00004 (0.899)	---	---
Internet	---	---	-0.002** (0.026)	0.001 (0.186)	---	---	-0.003** (0.012)	0.001 (0.166)
PCR	0.004 (0.474)	-0.002 (0.782)	0.003 (0.207)	0.005* (0.054)	---	---	---	---
PCB	---	---	---	---	0.0004 (0.632)	0.001** (0.026)	-0.0003 (0.548)	0.0005 (0.213)
PCR*Mobile Phones	-0.00004 (0.481)	0.00002 (0.736)	---	---	0.000004 (0.544)	---	---	---
PCB*Mobile Phones	---	---	---	---	---	-0.00001** (0.017)	---	---
PCR*Internet	---	---	-0.0001 (0.107)	-0.0001 (0.124)	---	---	---	---
PCB*Internet	---	---	---	---	---	---	0.00001 (0.515)	-0.00006** (0.044)
GDPpcg	0.004** (0.026)	0.007*** (0.003)	0.004** (0.022)	0.006*** (0.003)	0.005*** (0.001)	0.003 (0.185)	0.042** (0.015)	0.005*** (0.000)
Inflation	0.0003 (0.708)	-0.001* (0.058)	0.001 (0.226)	0.00003 (0.970)	0.001** (0.026)	0.0006 (0.546)	0.001* (0.089)	-0.0003 (0.637)
Pop. density	-0.0002** (0.013)	0.00002 (0.826)	-0.00002 (0.678)	-0.00005 (0.468)	-0.0001** (0.016)	0.00001 (0.719)	-0.00006 (0.304)	-0.00003 (0.447)
Deposit/Assets	0.023 (0.803)	0.039 (0.713)	0.124 (0.157)	0.177** (0.042)	0.059 (0.471)	0.136 (0.178)	0.090 (0.223)	0.119 (0.102)
Bank Branches	0.005** (0.012)	-0.002 (0.251)	0.001 (0.294)	-0.005*** (0.000)	0.003* (0.073)	-0.002** (0.060)	0.001 (0.666)	-0.004*** (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) and AR(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 QR related findings. In particular, Tables 3-4 are related nexuses between ICT and public credit registries, and Table 5-6 focus on relationships between ICT

and private credit bureaus. For each information sharing office, one table focuses 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 quintiles (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 can be established 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 in bottom quintiles; while the net effect from the interaction between public credit registries and internet is positive from the 0.25th to the 0.75th quintiles. 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 0.25th quintile whereas the net effect from the interaction between public credit registries and the internet is positive in the 0.25th and 0.50th quintiles.

In Table 5, private credit bureaus with the internet have a positive net effect on loan prices in the 0.75th quintile. In Table 6, private credit bureaus with the internet (mobile phone) have a negative net effect on loan quantity in the 0.50th quintile (from the 0.10th to the 0.75th quintiles). 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 (IV QR)

	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*** (0.000)	0.071*** (0.000)	0.065*** (0.000)	0.073*** (0.000)	0.095*** (0.000)	0.098*** (0.000)	0.083*** (0.000)	0.045*** (0.001)	0.065*** (0.000)	0.084*** (0.000)	0.097*** (0.000)	0.094*** (0.000)
Mobile Phones(IV)	-0.0001* (0.091)	-0.0004*** (0.000)	-0.0001** (0.018)	-0.00004 (0.590)	-0.00008 (0.354)	-0.00006 (0.603)	---	---	---	---	---	---
Internet (IV)	---	---	---	---	---	---	-0.0007*** (0.008)	-0.0005 (0.174)	-0.0004* (0.084)	-0.0006** (0.025)	-0.001*** (0.000)	-0.001** (0.019)
PCR (IV)	-0.002*** (0.008)	-0.004*** (0.004)	-0.003*** (0.000)	-0.002* (0.083)	-0.001 (0.295)	-0.002 (0.293)	-0.003*** (0.000)	-0.002*** (0.009)	-0.003*** (0.000)	-0.003*** (0.000)	-0.004*** (0.000)	-0.002 (0.180)
PCR(IV)*Mobile Phones(IV)	0.00001 (0.241)	0.00002* (0.082)	0.00002*** (0.006)	0.000009 (0.475)	0.000002 (0.868)	0.000004 (0.835)	---	---	---	---	---	---
PCR(IV)*Internet(IV)	---	---	---	---	---	---	0.00005** (0.026)	0.00002 (0.483)	0.00005** (0.016)	0.00006** (0.025)	0.00007** (0.031)	0.00003 (0.583)
GDPpcg	-0.0008** (0.046)	-0.0009 (0.105)	-0.00001 (0.975)	-0.0005 (0.247)	-0.0006 (0.233)	-0.001** (0.046)	-0.0006 (0.114)	0.0001 (0.869)	-0.00002 (0.956)	-0.0004 (0.303)	-0.001** (0.011)	-0.0009 (0.153)
Inflation	0.001*** (0.000)	0.0001 (0.837)	0.001*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.003*** (0.000)	0.001*** (0.000)	0.0005 (0.423)	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.003*** (0.000)
Pop. density	0.00006*** (0.001)	0.00004 (0.185)	0.00006*** (0.000)	0.00008*** (0.000)	0.00006*** (0.001)	0.00006*** (0.007)	0.00007*** (0.000)	0.00007 (0.130)	0.00007*** (0.000)	0.00009*** (0.000)	0.0001*** (0.000)	0.00006*** (0.002)
Deposit/Assets	0.017** (0.019)	0.007 (0.503)	0.017*** (0.004)	0.020** (0.012)	0.017* (0.050)	0.036*** (0.008)	0.015** (0.033)	0.007 (0.569)	0.015** (0.035)	0.006 (0.407)	0.021*** (0.005)	0.042*** (0.001)
Bank Branches	-0.0005 (0.120)	0.001** (0.022)	-0.0007** (0.017)	-0.001*** (0.008)	-0.0009** (0.032)	-0.0001 (0.734)	-0.00005 (0.914)	0.001 (0.158)	-0.0006 (0.142)	-0.0003 (0.459)	0.0009* (0.096)	0.0003 (0.740)
Small Banks	0.008** (0.027)	0.012** (0.043)	0.011*** (0.001)	0.001 (0.717)	0.002 (0.605)	0.008 (0.233)	0.007* (0.072)	0.015** (0.046)	0.008* (0.058)	0.003 (0.537)	0.003 (0.506)	0.009 (0.173)
Domestic Banks	0.001 (0.560)	-0.010** (0.026)	-0.002 (0.362)	0.007** (0.041)	0.008** (0.046)	0.001 (0.852)	0.001 (0.700)	-0.014** (0.022)	-0.001 (0.759)	0.005 (0.118)	0.004 (0.192)	0.002 (0.635)
Islamic Banks	-0.017*** (0.009)	-0.003 (0.791)	-0.016** (0.016)	-0.015* (0.093)	-0.014 (0.175)	-0.013 (0.347)	-0.012* (0.091)	0.009 (0.570)	-0.013 (0.160)	-0.012 (0.248)	0.004 (0.661)	0.001 (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 R ² /R ²	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 (IV QR)

	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*** (0.000)	2.762*** (0.000)	2.982*** (0.000)	3.361*** (0.000)	4.596*** (0.000)	4.943*** (0.000)	3.920*** (0.000)	2.752*** (0.000)	2.970*** (0.000)	3.495*** (0.000)	4.492*** (0.000)	5.400*** (0.000)
Mobile Phones(IV)	0.003* (0.088)	0.004** (0.012)	0.003 (0.337)	0.003 (0.288)	0.006** (0.011)	0.005*** (0.002)	---	---	---	---	---	---
Internet (IV)	---	---	---	---	---	---	0.039*** (0.000)	0.020*** (0.0006)	0.030** (0.022)	0.063*** (0.000)	0.035*** (0.000)	0.021*** (0.001)
PCR (IV)	0.066** (0.016)	0.104*** (0.001)	0.064 (0.300)	0.080 (0.222)	-0.016 (0.719)	-0.049 (0.229)	0.075*** (0.000)	0.088*** (0.000)	0.081* (0.052)	0.101** (0.016)	0.012 (0.637)	-0.005 (0.734)
PCR(IV)*Mobile Phones(IV)	-0.0005** (0.045)	-0.0008*** (0.006)	-0.0003 (0.615)	-0.0006 (0.302)	0.00009 (0.836)	0.0004 (0.220)	---	---	---	---	---	---
PCR(IV)*Internet(IV)	---	---	---	---	---	---	-0.002*** (0.003)	-0.002*** (0.000)	-0.002 (0.125)	-0.002** (0.033)	-0.0001 (0.821)	0.0002 (0.606)
GDPpcg	-0.014 (0.221)	0.020** (0.048)	-0.019 (0.317)	-0.031 (0.191)	0.002 (0.856)	-0.014 (0.129)	-0.018 (0.118)	0.020** (0.032)	-0.031* (0.083)	-0.031 (0.174)	-0.008 (0.574)	-0.027 (0.027)
Inflation	-0.024*** (0.000)	-0.004 (0.329)	-0.010 (0.329)	-0.031** (0.025)	-0.025*** (0.005)	-0.002 (0.637)	-0.022*** (0.001)	-0.008 (0.160)	-0.010 (0.344)	-0.028* (0.058)	-0.022*** (0.006)	-0.007 (0.309)
Pop. density	-0.001*** (0.002)	-0.0007** (0.013)	-0.001** (0.024)	-0.0007 (0.386)	-0.001* (0.050)	-0.001** (0.018)	-0.001*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.0009 (0.263)	-0.001*** (0.001)	-0.0009* (0.065)
Deposit/Assets	1.867*** (0.000)	1.057*** (0.000)	2.034*** (0.000)	2.544*** (0.000)	1.306*** (0.000)	1.279*** (0.000)	1.741*** (0.000)	1.217*** (0.000)	2.063*** (0.000)	2.432*** (0.000)	1.173*** (0.000)	1.018*** (0.000)
Bank Branches	-0.063*** (0.000)	-0.043*** (0.000)	-0.055*** (0.000)	-0.072*** (0.000)	-0.052*** (0.000)	-0.052*** (0.000)	-0.100*** (0.000)	-0.056*** (0.000)	-0.075*** (0.000)	-0.140*** (0.000)	-0.095*** (0.000)	-0.078*** (0.000)
Small Banks	-0.775*** (0.000)	-1.190*** (0.000)	-1.268*** (0.000)	-0.715*** (0.001)	-0.326** (0.028)	-0.250** (0.012)	-0.820*** (0.000)	-1.010*** (0.000)	-1.171*** (0.000)	-0.872*** (0.000)	-0.457*** (0.001)	-0.418*** (0.001)
Domestic Banks	0.401*** (0.000)	0.078 (0.378)	0.408** (0.010)	0.460** (0.010)	0.440*** (0.000)	0.436*** (0.000)	0.451*** (0.000)	0.117 (0.253)	0.447*** (0.005)	0.523*** (0.005)	0.606*** (0.000)	0.600*** (0.000)
Islamic Banks	-0.587*** (0.000)	0.322** (0.031)	-0.085 (0.822)	-0.287 (0.481)	-1.193*** (0.000)	-1.340*** (0.000)	-0.546*** (0.007)	0.081 (0.726)	0.104 (0.815)	-0.357 (0.487)	-0.982*** (0.003)	-1.205*** (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 R ² /R ²	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 (IV QR)

	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*** (0.000)	0.067*** (0.000)	0.077*** (0.000)	0.077*** (0.000)	0.084*** (0.000)	0.093*** (0.000)	0.078*** (0.000)	0.061*** (0.000)	0.057*** (0.000)	0.069*** (0.000)	0.084*** (0.000)	0.091*** (0.000)
Mobile Phones(IV)	-0.0002*** (0.000)	-0.0003*** (0.000)	-0.0005*** (0.000)	-0.0003*** (0.000)	-0.0002** (0.042)	-0.0001 (0.355)	---	---	---	---	---	---
Internet (IV)	---	---	---	---	---	---	0.0003 (0.247)	-0.0003 (0.329)	0.0006 (0.127)	0.0005** (0.035)	0.00006 (0.865)	0.00001 (0.976)
PCB (IV)	0.0008*** (0.007)	0.0002 (0.540)	0.0001 (0.678)	0.0006** (0.017)	0.0006* (0.081)	0.001*** (0.003)	0.0009*** (0.000)	0.0007*** (0.000)	0.0008*** (0.002)	0.0006*** (0.000)	0.0006** (0.010)	0.0009*** (0.006)
PCB(IV)*Mobile Phones(IV)	-0.000001 (0.684)	0.000006 (0.142)	0.0000007* (0.094)	-0.0000004 (0.894)	-0.000001 (0.670)	-0.000005 (0.209)	---	---	---	---	---	---
PCB(IV)*Internet(IV)	---	---	---	---	---	---	-0.00003*** (0.000)	-0.000004 (0.700)	-0.00003 (0.186)	-0.00002 (0.174)	-0.00004* (0.071)	-0.00004 (0.120)
GDPpcg	-0.0009** (0.038)	-0.001** (0.012)	-0.0007 (0.284)	-0.001** (0.024)	0.0004 (0.405)	0.0006 (0.316)	-0.0004 (0.316)	0.00005 (0.936)	0.0001 (0.851)	-0.0002 (0.535)	0.0001 (0.734)	0.0005 (0.264)
Inflation	0.001*** (0.000)	0.0002 (0.620)	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.003*** (0.000)	0.002*** (0.000)	0.0005 (0.283)	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)
Pop. density	0.00004*** (0.000)	0.00003 (0.103)	0.00003 (0.189)	0.00004*** (0.004)	0.00005*** (0.001)	0.00007*** (0.000)	0.00005*** (0.000)	0.00005** (0.015)	0.00004** (0.048)	0.00005*** (0.000)	0.00006*** (0.000)	0.00007*** (0.000)
Deposit/Assets	0.022*** (0.001)	0.008 (0.347)	0.014 (0.209)	0.024*** (0.001)	0.026*** (0.005)	0.038*** (0.000)	0.020*** (0.004)	-0.001 (0.872)	0.017 (0.148)	0.016** (0.017)	0.021** (0.020)	0.042*** (0.000)
Bank Branches	-0.001*** (0.000)	-0.001*** (0.000)	-0.0004 (0.308)	-0.0009*** (0.008)	-0.001** (0.029)	-0.001*** (0.002)	-0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.003*** (0.000)	-0.001*** (0.004)	-0.002** (0.018)
Small Banks	0.009** (0.012)	0.012** (0.025)	0.006 (0.318)	0.002 (0.512)	0.004 (0.462)	0.010 (0.114)	0.005 (0.198)	0.008 (0.149)	0.002 (0.750)	0.001 (0.633)	0.005 (0.288)	0.007 (0.337)
Domestic Banks	-0.001 (0.736)	-0.005 (0.261)	-0.003 (0.552)	0.0035 (0.325)	0.003 (0.408)	-0.0003 (0.947)	-0.001 (0.699)	-0.012*** (0.009)	-0.002 (0.609)	0.003 (0.237)	0.003 (0.506)	0.0006 (0.913)
Islamic Banks	-0.021* (0.058)	-0.001 (0.880)	-0.012 (0.305)	-0.014* (0.093)	-0.005 (0.603)	-0.013 (0.243)	-0.008 (0.139)	0.015 (0.216)	-0.003 (0.826)	-0.010 (0.260)	-0.012 (0.321)	-0.015 (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 R ² /R ²	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 (IV QR)

	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*** (0.000)	2.386*** (0.000)	3.271*** (0.000)	3.345*** (0.000)	4.624*** (0.000)	4.862*** (0.000)	3.787*** (0.000)	2.277*** (0.000)	2.888*** (0.000)	3.489*** (0.000)	4.771*** (0.000)	5.156*** (0.000)
Mobile Phones(IV)	0.002 (0.354)	0.003** (0.030)	-0.001 (0.745)	0.007*** (0.003)	0.004* (0.088)	0.005*** (0.000)	---	---	---	---	---	---
Internet (IV)	---	---	---	---	---	---	0.047*** (0.000)	0.018** (0.048)	0.051*** (0.001)	0.047*** (0.000)	0.049*** (0.000)	0.029*** (0.002)
PCB (IV)	-0.024*** (0.006)	-0.008* (0.096)	-0.027** (0.018)	-0.029*** (0.001)	-0.056*** (0.000)	-0.008 (0.150)	-0.006 (0.303)	-0.0009 (0.856)	-0.0002 (0.984)	-0.017** (0.029)	0.0006 (0.879)	0.005 (0.197)
PCB(IV)*Mobile Phones(IV)	0.0002*** (0.008)	0.0001** (0.036)	0.0003** (0.011)	0.0002** (0.039)	0.0006*** (0.000)	0.00009 (0.140)	---	---	---	---	---	---
PCB(IV)*Internet(IV)	---	---	---	---	---	---	0.001* (0.061)	0.0005 (0.253)	0.0002 (0.759)	0.001** (0.018)	0.0005* (0.078)	0.000004 (0.987)
GDPpcg	-0.004 (0.172)	0.014* (0.087)	-0.013 (0.431)	-0.008 (0.565)	0.001 (0.940)	-0.013* (0.061)	-0.0002 (0.983)	0.008 (0.349)	-0.038* (0.051)	-0.015 (0.386)	0.008 (0.468)	-0.018* (0.096)
Inflation	-0.022*** (0.001)	-0.010** (0.010)	-0.011 (0.228)	-0.029*** (0.000)	-0.022*** (0.003)	-0.001 (0.761)	-0.015** (0.022)	-0.009* (0.095)	-0.017 (0.104)	-0.020* (0.068)	-0.017*** (0.005)	0.005 (0.392)
Pop. density	-0.0009*** (0.002)	-0.0002* (0.096)	-0.002 (0.583)	-0.0009** (0.039)	-0.001*** (0.005)	-0.0007** (0.028)	-0.0008*** (0.009)	-0.0007*** (0.001)	-0.00002 (0.964)	-0.0005 (0.370)	-0.001*** (0.005)	-0.0009** (0.048)
Deposit/Assets	1.883*** (0.000)	0.949*** (0.000)	1.160*** (0.000)	2.525*** (0.000)	1.482*** (0.000)	1.327*** (0.000)	1.789*** (0.000)	1.157*** (0.000)	2.240*** (0.000)	2.314*** (0.000)	1.266*** (0.000)	1.162*** (0.000)
Bank Branches	-0.050*** (0.000)	-0.010* (0.073)	-0.026** (0.049)	-0.063*** (0.000)	-0.059*** (0.000)	-0.056*** (0.000)	-0.106*** (0.000)	-0.022** (0.023)	-0.098*** (0.000)	-0.111*** (0.000)	-0.115*** (0.000)	-0.082*** (0.000)
Small Banks	-0.830*** (0.000)	-0.824*** (0.000)	-1.318*** (0.000)	-0.819*** (0.000)	-0.400*** (0.004)	-0.216** (0.019)	-0.920*** (0.000)	-0.689*** (0.000)	-1.388*** (0.000)	-0.759*** (0.000)	-0.656*** (0.000)	-0.508*** (0.000)
Domestic Banks	0.392*** (0.000)	0.085 (0.239)	0.407*** (0.004)	0.517*** (0.000)	0.465*** (0.000)	0.404*** (0.000)	0.415*** (0.000)	0.035 (0.698)	0.524*** (0.002)	0.485*** (0.001)	0.622*** (0.000)	0.556*** (0.000)
Islamic Banks	-0.544*** (0.000)	0.434*** (0.005)	0.085 (0.796)	-0.388 (0.121)	-1.172*** (0.000)	-1.294*** (0.000)	-0.350 (0.127)	0.389* (0.079)	-0.060 (0.900)	-0.043 (0.913)	-0.659** (0.013)	-0.940*** (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 R ² /R ²	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.

4.2 Further discussion of results and policy implications

This section reconciles the relationship of the findings with existing literature and further explores the implications of the findings in terms of how unexpected results can be leveraged for enhanced financial access. From the findings it is apparent that the relationship between ICT and public credit registries leads to increased financial access, compared to the nexus between ICT and private credit bureaus. Our findings are not directly comparable with the engaged studies in the introduction which have directly examined the relationship between information sharing offices and financial access. Our assessment of the nexus between information sharing offices and access to finance 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 the role of information sharing offices in financial access, established in previous studies.

From a broad perspective, the findings are not consistent with Singh et al. (2009) who have established that African nations which have information sharing offices enjoy comparatively higher degrees of financial access. The results are consistent with Galindo and Miller (2001) from the view that nations with better developed credit registries are associated with less financial constraints, compared to countries with less developed information sharing offices. This narrative is consistent with this study because from our sample, public credit registries are more developed compared to private credit bureaus. The perspective is substantiated by Appendix 5 which shows that compared to public credit registries, private credit bureaus are less apparent in many countries.

Conversely, our findings do not align with Love and Mylenko (2003) who have established that private credit bureaus are associated with more financial access when compared with public credit registries. Our findings are also not consistent with Triki and Gajigo (2014) who have concluded 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 (resp. decrease) loan price (resp. quantity). Fortunately, corresponding marginal effects are negative (resp. positive). This implies that at certain thresholds of ICT, the unconditional positive (resp. negative) effect from private credit bureaus on loan prices (resp. quantity) can be changed to negative (resp.

positive). Hence the price effect of private credit bureaus with internet penetration in the 0.75th of Table 5 can become negative if internet penetration reaches a threshold of 15 (0.0006/0.00004) per 100 people. 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).

In the light of the above, in Table 6, 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) per 100 people are needed respectively in the 0.10th, 0.25th, 0.50th and 0.75th quintiles to convert the unconditional negative effects into overall positive effects. The 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).

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 findings broadly show that ICT with public credit registries decrease the price of loans and increase the quantity of loans. While the net effects from the interaction of ICT with private credit bureaus do not lead to enhanced financial access, corresponding marginal effects show that ICT can complement private credit bureaus to increase loan quantity and decrease loan prices when certain thresholds of ICT are attained. These thresholds have been computed and discussed.

Future studies can improve extant literature by assessing if the established linkages withstand further scrutiny when investigated within comparative economic framework, 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	Expected sign on loan
		price	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	0.804	0.396	0.000	1.000	1255
	Large Size	0.195	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. Ssize: 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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