Graduate Institute of International and Development Studies
International Economics Department
Working Paper Series

Working Paper No. HEIDWP14-2016

Market Discipline and Liquidity Risk: Evidence from the Interbank Funds Market

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This paper identifies bank-specific-characteristics and market conditions that contribute to determine prices and demand for liquidity in the interbank market as wells as banks' access to this market. Results indicate that riskier banks pay higher prices and borrow less liquidity, concurrent with the existence of market discipline. More capitalized and liquid banks tend to pay less for their funds and to have greater access to the interbank market. We find that banks pay higher prices and hoard liquidity when liquidity positions across them are more imbalanced and during a monetary policy tightening. Besides, small banks are found to suffer more as their credit risk and liquidity risk increase. We show that lending relationships benefit banks in hedging liquidity risk. We also document that central bank liquidity increments are associated with a downward pressure on interbank funds' prices and augmented market activity. Overall, our results have implications for financial stability and for the transmission of the monetary policy as well.

Key Words: interbank markets; market discipline; liquidity risk; risk taking; monetary policy; financial stability.

JEL Codes: E43, E58, L14, G12, G21

[ϕ] The opinions and statements in this article are the sole responsibility of the author, and do not represent neither those of Banco de la República nor of its Board of Directors. Any remaining errors are the author's own. I thank Harry Huizinga, Yi Huang, Carlos León and Wolf Wagner for their valuable comments and suggestions. I am grateful to Jorge Cely for his cooperation with data collecting. This research has benefited greatly from The Bilateral Assistance and Capacity Building Program for Central Banks (BCC), a partnership program between the Graduate Institute of International and Development Studies (GIIDS) in Geneva and the Swiss Economics Secretariat (SECO). I thank the GIIDS for the hospitality during my research visit to Geneva. [V.26/05/2016].

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1. Introduction

The unsecured interbank funds market is used by banking institutions to hedge short-term liquidity and also for central banks to assess the transmission of the monetary policy. Because there is no collateral pledged to the loan, participants of the unsecured market have powerful incentives to monitor each other and to keep stable lending relationships to get properly access to this market when they face liquidity shocks (Rochet & Tirole, 1996; Carlin et al. 2007). Thus, in normal times the interbank market tends to be a stable source of short-term funding for banks. However, in times of increasing uncertainty or market turmoil interbank market liquidity can evaporate quickly. This was observed during the global financial crisis of 2007-08, in which concerns on counterparty risk, liquidity risk and market conditions, such as increasing volatility of asset prices, caused disruptions in the U.S interbank market (Brunnermeier and Pedersen, 2009; Diamond and Rajan, 2011; Gorton and Metrick, 2012). Understanding how these elements affect prices and the availability of liquidity in interbank markets has been a growing concern in the literature due to the implications for financial stability and for the transmission of the monetary policy as well.

In this paper we propose a model that allows identifying how counterparty risk, liquidity risk and market conditions influence the prices, demand and access to the interbank market liquidity. We are particularly interested in to identify the existence of market discipline via peer monitoring and to understand the behavior of banks under tight liquidity conditions; such as during a monetary policy tightening and when liquidity positions across banks are more imbalanced. While most of the recent literature focuses on liquidity pricing in interbank markets of advanced economies and especially during the global financial crisis of 2008, we are more interested in to model the behavior of banks in emerging markets during regular liquidity conditions.

The proposed model is founded on market discipline and liquidity hoarding theories. Regarding market discipline we argue that participants of the unsecured interbank market have incentives to monitor their counterparts due to the lack of collateral to hedge counterparty risk. Thus, riskier banks are expected to be charged with higher prices and to be credit rationed (as in Furfine, 2001; Ashcraft and Bleakley, 2006; King, 2008). With regard to liquidity hoarding we claim that increased counterparty risk and imbalanced liquidity positions across banking institutions tend to induce higher prices and liquidity hoarding for precautionary reasons (Acharya and Merrouche, 2013; Heider et al., 2015).

Our analytical framework is close to that in Cocco et al., (2009); Fecht et al., (2011) and Braüning and Fecht (2015). However, our approach focuses only on borrowing banks and further accounts for the drivers of the liquidity demand, based on the prediction of Heider et al., (2015) in which the decision to borrow (but not the decision to lend) in the unsecured market depends on banks' own risk. Therefore, the proposed model relates the specific-characteristics of the borrowing bank with its observed prices and demand for fund in the interbank market. We employ a Heckman model to correct for the selection bias in the sample of borrowing banks in the interbank market that allows identifying the drivers of a bank to access for liquidity to the interbank market. Thus, we provide evidence not only on the determinants of the prices that banks pay for liquidity, but also on their observed demand for funds and on the drivers of their access for liquidity in the interbank market.

We use micro-level data from unsecured loans among financial institutions participating in the Colombian interbank market. Our sample comprises non-publicly available data on daily overnight bilateral unsecured operations among 53 banking institutions from January 2011 to December 2014. Unique to this paper, we employ observed data on overnight interbank loans instead of using approximations of the interest rates and volumes extracted from large-value payment systems. Hence, we can directly observe the characteristics of the interbank loans (i.e. rates, volumes, maturities and counterparts) as they are registered by the participants on a daily basis. Therefore, we avoid the drawbacks of the traditional algorithms employed in the literature to extract information on interest rates and the volume of the funds[1]. Besides, we employ daily liquidity reports including banks' reserve balances, cash holdings, liquid assets, and required reserves, which allow properly gauging the banks' liquidity position throughout time. We match

[1] Most of the empirical literature extracts information on interbank loans from large-value-payment systems by employing the algorithms of Furfine (2001) and Heijmans, et al. (2010). Under those approaches interest rate, volumes and counterparts involved in the loan are identified by crossing the flows of money between two counterparts in a given period of time. However, this method is typically affected by the inclusion of other payments or block payments in the retrocession of the loan, which distort the computed interest rate causing drops in the sample.

this data with bank-specific-characteristics of size, risk, capitalization and liquidity position that are computed by using monthly balance-sheet reports.

Our results contribute to understanding salient features on the behavior of participants of the interbank market, mainly related to the role of counterparty risk and liquidity risk. First, we find that riskier banks pay higher prices and can borrow less funds according with the existence of market discipline (King, 2008). Further, we find that more capitalized and liquid banks tend to pay less for their funds, and can borrow more liquidity in the market. This result remarks the importance of capital and liquidity regulatory requirements to enhance financial stability (See, Pierret, 2015; BIS, 2016).

Second, we show that size plays a key role in determining both prices and demand of liquidity in the interbank market. In particular, we document that large banks pay less for liquidity and can borrow more funds, which concurs with the behavior of surplus banking institutions exerting market power in interbank markets (Acharya et al, 2012) as well as with evidence of implicit government guarantees (Angelini et al, 2011). In addition to this, small banks are found to suffer more in presence of higher credit risk and liquidity risk (Fetch, et al, 2011). This result brings support to the theoretical model of Heider et al (2015) in which counterparty risk and liquidity hoarding are intrinsically linked.

Third, we find that the likelihood of a bank to participate in the interbank market is associated with the concentration of the bank's lending relationships and with the bank's net position in the interbank market. We relate this result with evidence on the benefits of keeping stable lending relationships to mitigate liquidity risk (Cocco et al, 2009; Braüning and Fecht, 2015; Craig et al, 2015). Lastly, we find that liquidity shocks that collectively affect the behavior of banks have an important influence on the prices that they pay for liquidity and on the availability of liquidity. In particular, we find that increases in central bank' liquidity supply is associated with lower prices in the interbank market and increased market activity. Further, we document that during periods of monetary policy tightening borrowing banks tend to pay higher prices although this policy does not prevent them from borrow in the market. These results provide evidence on the role of the central bank in alleviating liquidity tensions in the interbank market (as in León and Sarmiento, 2016) and are consistent with the transmission channel of the monetary policy through the interbank market (See, Christensen et al., 2009; Allen et al., 2009; Freixas et al., 2011; Abbassi and Linzert, 2012).

Overall, our results provide evidence on the existence of market discipline among participants of the interbank market and on the role of liquidity risk and liquidity hoarding in explaining the behavior of banks in this market. Results also point out the benefits of higher capital and liquidity buffers to reduce funding costs and increase access to interbank market liquidity. Moreover, our findings highlight the role of the central bank in alleviating liquidity strains throughout the interbank market. Thus, we shed light on prudential regulation for safeguarding financial stability and also on the linkages between liquidity and counterparty risk with the transmission of the monetary policy.

The remaining of this paper is organized as follows. Section 2 discusses related literature. Section 3 provides background on the recent evolution of the Colombian interbank market and shows a first piece of evidence on the nexus between bank size and the bank behavior in the interbank market. Section 4 presents the variables employed in the model. Section 5 describes the data. Section 6 presents the model and the estimation strategy. Section 7 discusses the results. Section 8 present robustness exercises. Finally, section 9 concludes.

2. Related Literature

Market discipline considers that if a bank is taking too much risk and its creditors can identify this behavior they will request a higher return (i.e. risk premium) that will be reflected in the market prices (Berger, 1991; Flannery, 2001). The literature on market discipline has been focused on the prices of deposits, subordinated debt and CDS (See for instance, Sironi, 2003; Flannery, 2010; Demirgüç-Kunt, and Huizinga, 2013). However, holders of those instruments "not always" are well-informed on the banks' risk-taking (i.e. retail depositors). Peer-monitoring tend to be more effective due to banks usually have more information on their peers' riskiness and are able to observe their behavior from different markets (Rochet y Tirole, 1996). Under this view, Furfine (2001) document that banks with higher profitability, capitalization, and less ratio of nonperforming loans tend to pay lower interest rates on federal funds loans. Similarly, King (2008) shows that riskier banks consistently pay more than safe banks for interbank loans (unsecured and secured) and are less likely to use these loans as a source of liquidity, which imply that those banks are rationed by their peers in the market. However, it is also observed that asymmetric information and implicit state guarantees can deter market discipline. Angelini et al, (2011) show that conditions for larger borrowers became relatively more favorable during the global financial crisis of 2007-09, evidencing that the “too-big-to-fail” dilemma increased during the crisis.

Evidence also shows that banks tend to charge higher prices in unsecured interbank loans to counterparts that exhibit higher liquidity risk and when liquidity positions across banks are more imbalanced (Cocco et. al, 2009; Fecht et. al, 2011; Abbassi et. al, 2013). Bonner and Eijffinger (2012) find that German banks close to the liquidity requirement pay higher prices for their interbank funds. Further, Acharya et al., (2012) find that during the global financial crisis, surplus liquidity banks in the interbank market exerted market power by rationing liquidity to deficit banks. In response to this behavior central banks have implemented different liquidity facilities to bring adequate liquidity to banks in times of higher uncertainty in financial markets (See for instance, Christensen et al., 2009; Abbassi and Linzert, 2012). Recently, León and Sarmiento (2016) document that the connective structure of central bank’s repo network can be particularly helpful to mitigating liquidity tensions in the money market. Overall, these findings claim the key role of liquidity risk in explaining the behavior of banks in the interbank market.

The drivers of liquidity hoarding have been also highlighted in the recent literature. In general, increasing uncertainty on the availability of short-term liquidity and high volatility of asset prices tend to force banks to hoard liquidity for precautionary reasons (Diamond and Rajan, 2011). This behavior is related with counterparty risk and liquidity risk concerns. On the one hand, Gale and Yorulmazer (2013) argue that avoiding counterparty risk and hoarding are unrelated. In the first case not supplying liquidity to other counterparts entails concerns on the credit quality of its counterparties, whereas hoarding obey to concerns on its own access to liquidity in the future. Under the first view, Acharya and Skeie (2011) develop a model in which banks hoard liquidity in anticipation of insolvency of their counterparties in the interbank market. Ashcraft et al (2011) show evidence that U.S. banks that exhibited more payment volatility hold higher reserves during the day consistent with their model for precautionary demand for liquidity.

On the other hand, Heider et al, (2015) show that liquidity hoarding and counterparty risk are intrinsically linked. In their framework, banks' holdings of liquidity are endogenous and because of banks are forward-looking, they decide to hoard liquidity in anticipation of an interbank market malfunctioning related to asymmetric information about counterparty risk. On this regard, Pierret (2015) shows that liquidity buffers allow banks to take advantage of lower funding costs while also reduce the risk of insolvency. Consequently, these studies show that accounting for counterparty risk, the banks' liquidity position and market liquidity conditions is crucial to understand the behavior of banks in the interbank markets.

3. The interbank market

The Colombian interbank funds market is the unsecured market for liquidity in which participants impose counterparty limits among them based on their credit risk assessments. This is of a bilateral (i.e. over-the-counter) nature. Thus, counterparty risk plays a key role in the determination of both the price and the quantity of liquidity banks can trade in this market. During the period 2011-2014 around 75% of the interbank loans were agreed at an overnight maturity evidencing that it is a short-time market for liquidity. Participants of the interbank market are banking institutions that we can divide into three groups: i) commercial banks, ii) financial companies specialized in retail loans and corporate loans for small and medium firms; and iii) financial corporations that operate as investment banks. During the evaluated period 53 banking institutions participated in the interbank market. Spite of the differences in the banking business, these credit institutions usually exchange liquidity among them, although large commercial banks tend to be the more active participants filling the role of super-spreaders of the central bank liquidity through out the interbank market (See, León, Machado, Sarmiento, 2016).

Figure 1 depicts the trend of the interbank rate compared with the central bank rate during the 2011-2014. It is observed that the interbank rate closely follows the central banks rate (CB), which obeys to the fact that the interbank rate is the target rate for the implementation of the monetary policy in Colombia. We observe some periods in which the interbank rate exceeds the central bank rate, especially during the tightening of the monetary policy: 02-2011 to 07-2012 and 04-2014 to 12-2014 (i.e. the shared region in Figure 1). We also observe that the volume of interbank loans varies greatly during the period (right axis) reflecting the role of liquidity squeezes that banks suffer, especially when they are close to the reserve maintenance period. Accordingly, in **Table 1** we compare the rates and volumes traded in the interbank market during the period. We observe that the average daily volume negotiated in the interbank market significantly fluctuates from 156 billion COP to 1.348 billion COP and exhibit an average level of 493 billion COP during the whole period (**Table 1**). Regarding the behavior of interbank rates, it is observed that while the spread of the interbank market rate to the central bank rate seems narrow, with a mean of 1 bps and a maximum of 17 bps, differences in borrowing rates across banks are noteworthy reaching up to 170 bsp or 5 standard deviations above the mean of the market (**Figure 2**). It is also observed that that this dispersion is greater during the periods of the monetary policy tightening. In period I the mean spread is 4.66 bsp while during the period II it was -3.97 bsp (**Table 1**). The wider dispersion of rates during the day reflects that there are important differences in terms of counterparty risk across banks (as reported by Gorton and Metrick, 2012 for the US federal funds market).

3.1.Bank-specific-characteristics and interbank market activity

In this subsection we compare differences in borrowing interbank rates between large and small banks in order to observe the role of bank size in the price of liquidity. We classify large (small) banks as those with assets value larger (lower) than the 66^{th} (33^{th}) percentile of the assets distribution during the evaluated period. Then we analyze if there are differences in terms of their counterparty and liquidity risk that may influence both the price and the demand of liquidity in the interbank market. First, we find that differences in the price of liquidity among small and large banks tend to be ample and persistent over time (**Figure 3**). It is observed that, on average, small banks tend to pay more for liquidity than large banks. Indeed, we confirm that there is a different distribution of rates between large and small banks suggesting that size matters in the liquidity pricing (**Figure 4)**. Second, we compare small and large banking institutions in terms of their counterparty risk, liquidity risk and interbank market activity (**Table 2**). On average, smaller banks pay 3.0 bps over the central bank rate for overnight liquidity in the interbank market while larger bank pay 1.5 bps under the central bank rate.

Regarding counterparty risk, we find that small banks exhibit lower z-score and more non-performing loans than large banks. The average z-score of small banks is (0.33) which is almost half of the value observed for large banks (0.61) suggesting that small banks may have a higher probability to become insolvent compared with large banks[2]. Besides, we find that small banks exhibit lower liquidity and capital ratios than large banks. While differences in capital ratios are relatively low (i.e. 18.2% for small banks and 21.5% for large banks) in terms of liquidity they are notably. On average, large banks hold a liquidity ratio of 28.68% that is twice the observed value for small banks (14.14%) (**Table 2 - panel a)**. These results reflect that accounting for size is important in the liquidity pricing. Further, we find that small banks exhibit higher counterparty and liquidity risk than large banks.

Differences between small and large banks also are observed in the way they behave in the interbank market (**Table 2 - panel b)**. On average, small banks borrow $41,8 billion COP and lend $228,4 billion in a month whilst large banks borrow $488,3 billion COP and lend $214,4 billion COP. Thus, small banks borrow ten times less liquidity in the interbank market than large banks but they lend relatively similar quantities than large banks. This suggests that larger banks behave as net borrowers of the interbank market while smaller banks behave as net lenders. We consider that small banks are more affected by their peers' credit risk assessments in the interbank market and also that they can be more vulnerable to liquidity shocks. Thus, when small banks try to obtain liquidity from the interbank market they have to pay more than their larger counterparts. The proposed model allows testing these hypotheses.

4. Variable definitions

We are interested into identify the determinants of the price and demand for liquidity in the interbank market. The price of liquidity (p_{it}) corresponds to the spread in bps between the volume-weighted average interest rate (r_{it}) paid for a bank *i* of all its overnight unsecured loans during the last 30 days (*t*) and the central bank rate in *t* (r_{cbt}), standardized by the interbank rate volatility in *t* (σr_{it}). More explicitly the spread is computed as:

$$p_{it} = \sum_{t=1}^{T} \frac{r_{i,t} - r_{cb,t}}{\sigma r_{i,t}} x\ q_{i,t}. \quad (1)$$

[2] The z-score gauges the number of *roa* standard deviations a bank's roa must decrease to surpass equity and in turn, it is an inverse measure of the probability of the bank's insolvency (Roy, 1952). We explain in detail the way to compute this indicator in the next section.

This measure of the price of liquidity allows accounting for the well-documented GARCH effect in interbank market interest rates (Hamilton, 1996). We use the spread to the central bank rate because of all participants of the interbank market have access to the regular central bank liquidity[3]. Thus, p_{it} gauges how costly the liquidity is compared with the central bank liquidity. In order to gauge the liquidity demand we compute the quantity borrowed by a bank *i* during the last 30 days (t):

$$q_{it} = \sum_{t=1}^{T} q_{it}. \quad (2)$$

We are particularly interested into identify the role of counterparty risk in explaining the prices and demand for liquidity in the interbank market. To do this, we employ alternative measures aimed at capturing the bank's counterparty risk. Initially, we compute the bank's *z-score* that gauges the bank risk-taking[4]. The indicator is defined as the sum of the mean rate of return on assets of a bank *i* (μ_{roa}) and the mean equity-to-assets ratio (*car*) divided by the standard deviation of the return on assets σ_{roa}, that is: $z\text{-}score_{it} = (\mu_{roa} + car_{it} / \sigma_{roa})$. It tells us the number of *roa* standard deviations a bank's ROA must decrease to surpass equity. Thus, lower z-score indicates higher probability of the bank to become insolvent[5]. Hence, we can identify if banks approaching insolvency tend to pay more for their liquidity suggesting evidence on market discipline[6].

We also include other measures of bank risk as the ratio of non-performing loans over total loans (*npl*) and capital ratio (*car*) defined as capital equity (Tier I and Tier II) over risk-weighted assets[7]. We expect that banks with higher credit risk in their loans portfolios and lower capital ratios pay more for liquidity given that their creditors tend to charge higher prices to less healthier banks (See, Furfine, 2001; Braüning and Fecht, 2015). Regarding the demand for

[3] All participants of the interbank market are credit institutions whit regular access to the central bank liquidity that includes intraday, daily liquidity-auctions and overnight liquidity facilities all based on repo operations.

[4] The z-score has been employed as a measure of the bank risk taking in the banking literature (see for instance, Demirgüç-Kunt and Huizinga, 2010; Tabak et al, 2012; Bertay et al., 2013).

[5] To compute the z-score, we use the approach of Lepetit and Strobel (2013) in which the mean and standard deviation estimates, μroa_i and σroa_i, are calculated over the full sample [1 … *T*], and combine these with current *t* values of the equity ratio (car_{it}).

[6] Sarmiento et al, (2015) find that banks consistently paying high borrowing rates in the interbank market exhibit low values of z-score evidencing their higher riskiness.

[7] Colombian regulation establishes that capital ratio should be greater than 9% and it is defined as equity capital over risk-weighted assets plus 100/9 of the value at risk of the bank's securities portfolio.

liquidity, we expect that riskier banks borrow fewer funds in the interbank market as their creditors exert market discipline over those banks (King, 2008; Gorton and Metrick, 2012). Further, in **section 3.1** we showed evidence in favor of the role of size on both the price and demand for liquidity. We control for this effect by including the natural log of the bank's value of assets (*size*). Evidence shows that larger banks are benefited from lower prices in the interbank market, which can be related with too-big-to-fail implicit guarantees (Angelini et al, 2011).

Bank's liquidity position is affected by the reserve requirements. Banks short in reserves may face liquidity squeezes when approaching their fulfillment date of their reserve requirements that force them to borrow funds from the interbank market. Thus, to account for the bank's liquidity position in terms of its reserves holdings, we include a measure of the bank's excess of reserves (*excess_reserves*). This variable is defined as the bank's reserve holdings less the amount a bank needs to hold on a daily basis for the balance of the reserve maintenance period in order to exactly fulfill reserve requirements, divided by the average daily required reserves during the month (as in Fecht et al, 2011). Thus, banks with low (or negative) values in this ratio are exhibiting a deficit of reserves and in turn, they are willing to pay more for liquidity in order to fulfill the reserves requirement.

Banks also suffer from liquidity shocks associated with unexpected withdraws from their depositors, assets management, and investment opportunities that conditioning the banks' liquidity (See, Ashcraft et. al. 2011). Evidence shows that when banks are exposed to relatively large liquidity shocks they might need to trade funds at unfavorable prices (Cocco et al, 2009). We account for this effect by including a measure of the bank's liquidity risk (*Liq_risk*) defined as the standard deviation of daily change in reserve holdings of the bank during the last 30 days, normalized by the reserve requirements (Fecht et al, 2011). We argue that banks with higher volatility in their reserve holdings can be facing recurrent liquidity shocks that may force them to borrow funds at higher prices and to demand more funds to cover their liquidity needs.

As we observed in the previous section, small banks present important differences in terms of counterparty and liquidity risks compared with large banks. We did find that smaller banks are less liquid and entail higher credit risk than large banks (**Table 2 –panel a**). Thus, we are interested in to test if those banks are more penalized by their creditors when they face higher liquidity and counterparty risk. To account for these effects we include two interaction terms (*small x liq_risk*) and (*small x npl*), where small is a dummy variable equal to one if the bank's assets are below the percentile 33^{th} of the assets distribution in the sample and 0 otherwise.

Lending relationships play a key role in determining the access of banks to the interbank market. Evidence shows that banks with stable lending relationships benefit from higher access to the interbank market that contributes to hedge liquidity risk (Cocco et al, 2009; Affinito, 2013; Afonso et al, 2013; Braüning and Fecht, 2015). To account for this effect we employ the borrowing preference index (*BPI*) computed as the amount of funds borrowed by the bank *i* from a bank *k* at time *t* (q_{kit}) over a period T relative to the overall amount borrowed by bank *i* over the same period *T*:

$$BPI = \frac{\sum_t q_{kit}}{\sum_{k\cdot} \sum_t q_{kit}} \quad (3)$$

Hence, if a bank has stable counterparts to borrow liquidity (high *BPI*) is more likely that he access the market on a regular basis to cover the liquidity needs[8]. Further, we also employ a dummy variable equal to one if the amount of borrowed funds by the bank in the interbank market was larger than the amount lent in the previous period (*t-1*), namely, *Net_borrow.* The rationality behind this variable is that if the bank had a net borrower position in the previous period is highly likely that it access again the interbank market to continue funding its operation with this market. We use these variables (*BPI* and *net_borrow*) to capture the likelihood of a bank to participate in the interbank market in our selection model.

Market conditions play a key role in determining the access of banks to the interbank market. We include several variables to account for the effects of market conditions in our specification. First, we include our measure of liquidity risk but computed across all banks *j* at time *t* that corresponds to the standard deviation of the normalized excess reserves among banks, namely *Market Liq_risk*. The intuition of this variable in the model is that in presence of liquidity imbalances across banks the liquidity demand tends to raise as more banks are in need of funds, and in turn, it would affect both prices and volumes in the interbank market. Second, as we mentioned before, all participants of the interbank market have access to the central bank's

[8] We set the variable to zero if the denominator is zero, which means that the banks did not borrow at all.

liquidity. Thus, we expect that increases in the liquidity supply by the central bank might raise interbank market's activity and put downward pressure on interbank prices. We account for this effect by including the log of the total liquidity supply of the central bank (*log_Liq_S*)[9]. Third, we control for the impact of the monetary policy tightening on the prices of interbank funds and the liquidity demand by including a dummy variable (*CBrate_inc*) equal to 1 during the periods in which the central bank increases the policy rate: 02/2011 to 07/2012 and 04/2014 to 12/2014. As we reported in **Figure 1** and **Table 1** increases in the central bank rate are associated with further increases in the interbank market rate. This variable allows testing the influence of monetary policy on the behavior of banks in the interbank market.

5. Data

Our analysis makes the use of three data sources supplied by the central bank of Colombia and the Financial Superintendence of Colombia (FSC). First, we use micro-level data from unsecured loans among financial institutions participating in the Colombian interbank market. Our sample comprises non-publicly available data on daily overnight bilateral unsecured operations among 53 banking institutions from January 2011 to December 2014. Unique to this paper, we employ observed data on overnight interbank loans instead of using approximations of the interest rates and volumes extracted from large-value payment systems. Thus, we can directly observe the characteristics of the interbank loans (i.e. rates, volumes, maturities and counterparts) as they are registered by the participants on a daily basis and reported to the SFC. Therefore, we avoid the drawbacks of the traditional algorithms employed in the literature to extract information on interest rates and the volume of the loans (See for instance, Furfine 2001; Heijmans, et al. 2010). We employ daily liquidity reports including banking institutions' reserve balances, cash holdings, liquid assets, and required reserves, which allow properly gauging the banks' liquidity position throughout time. We match this data with bank-specific-characteristics of size, risk, capitalization and liquidity that are computed by using monthly balance-sheet reports.

Table 3 presents summary statistics and definitions of the set of variables employed in the model for our sample of borrowing banks. In **Table A4** we show statistics on the counterparty and liquidity risks measures for non-borrowing banks of the interbank market. That is, those banks

[9] The liquidity supply includes the daily liquidity auctions of the central bank (repo operations), intraday repos by demand, and the liquidity facility, which has a penalty rate of 100 bsp over the central bank rate.

that either only lend funds or do not participate in the interbank market. Overall, we observe that those banks exhibit higher counterparty risk (i.e. lower z-score, higher nonperforming loans, and lower capitalization and size) compared with borrowing banks. Further, these banks exhibit similar levels of liquidity ratios and higher excess of reserves albeit they show more liquidity risk compared with borrowing banks. This result suggests, on the one hand, that non-borrowing banks tend to hold more reserves that may prevent them to borrow in the interbank market. On the other hand, because of these banks exhibit higher counterparty risk than borrowing banks, we may infer that they can be more affected by credit rationing in the unsecured interbank market. To cover their liquidity needs these banks can either borrow funds from the secured money market or from the central bank repo market. We account for this effect by employing a model that corrects for the potential selection bias in our sample of borrowing banks.

6. The Model

We employ a Heckman-type correction model to account for the potential selection bias (Heckman, 1979). This model is proposed because of if the bank's decision to participate in the interbank market is non-random the estimated coefficients would be inconsistent. Recent evidence confirms the presence of selection bias in the interbank market suggesting the use of Heckman-type models to overcome for this problem (Fecht et. al, 2011; Braüning and Fecht, 2015; Acharya and Merrouche, 2013). The model combines a selection mechanism for participating in the interbank market with a regression model. The selection equation is as follows:

$$z^*_{it} = \gamma' w_{it} + \mu_{it}. \quad (4)$$

The regression model is:

$$q_{it} = \beta' X_{it} + \varepsilon_{it}. \quad (5)$$

In (4) z^*_{it} is not observed; the variable is observed as:

$$z_{it} \begin{cases} 1 & if\ z^*_{it} > 0 \text{ with Prob}_{(z_{it}=1)} = \phi(\gamma' w_{it}) \\ 0 & o.w. \quad \text{with Prob}_{(z_{it}=0)} = 1 - \phi(\gamma' w_{it}) \end{cases} \quad (6)$$

Where ϕ is the standardized normal cumulative distribution function, X_{it} is a vector of variables that determine q_{it}, and w_{it} are a set of variables assumed to determine whether q_{it} is observed. Thus, the latent variable q_{it} is only observed if z_{it}=1, which, in our case, indicates that the bank borrows liquidity in the interbank market. Therefore, in the selected sample we have that:

$$E [q_{it} | z_{it}=1] = \beta' X_{it} + \rho \sigma_{\varepsilon} \lambda (\gamma' w_{it}) \qquad (7)$$

In (7) λ is the inverse Mills ratio. Besides, ($\mu_{it,}\varepsilon_{it}$) are assumed to be bivariate normal with μ_{it} ~N(0,1); ε_{it} ~N(0,σ_{ε}) and corr($\mu_{it,}\varepsilon_{it}$)=$\rho$. Thus, if $\rho \neq 0$, standard OLS models applied to (5) yield biased results. The model in (7) is run on the full sample of borrowing and non-borrowing banks and is estimated by maximum likelihood, which provides consistent, asymptotically efficient parameter estimates (Green, 2012). Note that the dependent variable in (7) is either the price of liquidity (p_{it}) defined in (1) or the quantity of liquidity borrowed (q_{it}) specified in (2). In the regression model (5), the set of explanatory variables, X_{it}, is composed by bank-specific-characteristics and market conditions.

In the selection equation (4), we employ two additional variables that condition the likelihood of a bank to borrow from the interbank market and that are part of w_{it}, namely, *BPI* and *net borrow*. The rationality behind of this is that if a bank has stable counterparts that provide funds on a regular basis (BPI >0) is highly likely that the bank accesses the interbank market in case he needs to cover liquidity shortages. Further, if the bank had a net borrower position in the previous period is more likely that he borrows again from the interbank market in *t* to continue funding within this market. Therefore, these variables are included lagged one period. Thus, we capture both the lending relationship and the net position effects on the probability of a bank to borrow from the interbank market.

7. Results

In this section we present results differentiating among the regression model and the selection models when we employ as dependent variable the price of liquidity and the demand for liquidity, respectively. We also present results of models with alternative covariates of risk in order to test the robustness of our results.

7.1.The price of liquidity in the interbank market

In **Table 5** we present results of the regression model where the dependent variable is the price of liquidity (p_{it}) measured as the spread of the bank's interest rate to the central bank rate in *bsp*. The baseline Model (1) includes measures of counterparty risk along with the central bank liquidity supply and the dummy variable capturing the period during the monetary policy tightening as market conditions. This specification allows identifying the impact of counterparty risk on the liquidity pricing. We find that increases of the bank' *z-score* (i.e. lower probability of insolvency) are associated with lower prices in the interbank market. The estimated coefficient suggests that increase of one standard deviation in the bank's z-score is associated with a decrease of 17 bsp in the price of liquidity. Thus, bank engaging on less risk-taking are found to pay less for liquidity suggesting evidence on market discipline. Results also indicate that holding higher credit risk in the bank's portfolio is associated with higher prices for liquidity in the interbank market. Hence, an increase of 1% in the share of nonperforming loans over total loans leads to 11 bps additional in the price of interbank funds. This result indicates that riskier banks seem to be charged with a risk premium in the interbank market (as find by Furfine 2001).

We find that more capitalized banks pay less for liquidity. The estimated coefficient indicates that an increase of 1% in capital ratio (*car*) is associated with a discount of 23 bsp on the price of interbank funds. This result brings further evidence on market discipline as healthier banks are associated with lower prices for liquidity. We relate this result with the benefits from bank capitalization under the agency cost theory, in which more capitalized banks tend to assume less risk as a result of higher control by the banks' shareholders (See, Vollmer and Wiese, 2013). We identify that the price of liquidity decreases in bank size. The estimated coefficient of *size* (log of assets) suggests that an increase in size (in millions) by a factor of *e* leads to a discount of 19 bps in the price of liquidity. This result is in line with evidence from the U.S. German, and Portuguese interbank funds markets (See, Furfine, 2001; Cocco et al, 2009; Gorton and Metrick, 2012; Abbasi, et al, 2013). The rationality of this behavior is that smaller banks prefer lending to larger banks even at lower rates due to too-big-to-fail considerations. Angelini et at. (2011) find that during the global financial crisis of 2008 the cheaper funding cost from large banks in the U.S. interbank market is associated with the existence of moral hazard risks linked to too-big-to-fail implicit subsidies.

Results indicate that market liquidity conditions are also relevant for the liquidity pricing in interbank markets. Increases in the liquidity supply by the central bank are associated with lower prices in the interbank market. The coefficient of *liq_supply* suggests that an increase in the supply of liquidity (in millions) by a factor of *e* leads to a reduction of 2.6 bsp in the price of the interbank funds. It indicates that the central bank liquidity can put downward pressure on market interest rates. Besides, we identify that periods of monetary policy tightening are associated with higher prices of interbank funds. Our dummy variable, *CB rate_inc* that captures the period in which the central bank increased the policy rate, 02 /2011 to 07 /2012 and 04/2014 to 12/2014, has a positive and statistically significant impact on the price of liquidity.

In Model (2) we include variables that gauge the liquidity position both at the bank level and across banks in order to get further insights on the role of liquidity risk on the liquidity pricing. Results show that banks with *excess reserves* do not pay significantly different rates than banks short in reserves. However, we do find that higher volatility in their reserve holdings is associated with higher prices. This effect is captured by our measure of *Liq_risk* which is statistically significant, albeit with a relatively small effect. Hence, banks with higher uncertainty on their liquidity needs are associated with higher prices for liquidity (as in Fecht et al, 2011.). We also are particularly interested in to identify the extent in which the liquidity positions across banks affect the price of liquidity. We find that higher liquidity imbalances across banks are associated with higher prices. The estimated coefficient of *Market Liq_risk* is 0.075 and is highly significant. This result indicates that one standard deviation in the reserve holdings standardized by the reserve requirements across banks is associated with an increase in the price of interbank funds in 7.5 bsp. Note that the estimated coefficient of *Market Liq_risk* is considerable larger than the one observed at the bank level (0.023). This suggests that the price of liquidity in the interbank market is more sensible to changes in the market liquidity conditions consistent with the existence of short liquidity squeezes affecting banks liquidity status (Nyborg and Strebulaev, 2004; Fecht et al, 2011).

In Model (3) we include interaction terms to test if small banks are more penalized by their creditors in presence of higher credit and liquidity risk. The interaction of *small x npl* has a coefficient of 0.076 and is statistically significant. Hence, the total effect of *npl* on the price of liquidity for small banks is 0.178 which implies that small banks are more sensible to changes in their credit risk compared with large banks[10]. Thus, further deterioration in the quality of loans of small banks would affect more their funding costs in the interbank market. An increase of 1% in the ratio of nonperforming loans to total loans for small banks is associated with overprice of 17.8 bsp. We also identify that small banks are more affected by the uncertainty on their liquidity needs. The estimated coefficient of the interaction term *small x liq_risk* is positive and statistically significant. In spite of the coefficient has a lower level (0.009) the total effect of liquidity risk on small banks is 21.2% higher than the one observed for large banks[11]. This result is consistent with the view that small banks are more affected by liquidity squeezes (Fecht, et al, 2011). Results from counterparty risk and central bank liquidity measures remain significant and with similar levels than in Model (1) and Model (2) reflecting its robustness across different specifications.

7.2.The liquidity demand in the interbank market

Table 6 presents results on the regression model where the dependent variable is the log of the quantity borrowed by the bank in the interbank market defined in Eq. (2). This specification allows identifying the effects of counterparty risk, liquidity risk and market characteristics on the observed demand of liquidity in the interbank market; which complements our understanding of the behavior of banks in the interbank market.

The baseline Model (1) follows the same specification that we use in the price model. Thus, we include measures of counterparty risk along with the central bank liquidity supply and the dummy variable capturing the period during the monetary policy tightening as market conditions. Results indicate that healthier banks tend to borrow more liquidity in the interbank market. In particular, we find that a higher bank's *z-score* is associated with increased volumes of funds. A one standard deviation increase of the bank's z-score is associated with an increase of 3.40% in the amount of borrowed funds in the interbank market. Regarding credit risk, we find that the bank's volume of funds decreases with the credit risk exposure. The coefficient of *npl* is negative and statistically significant. An increase of 1% in the share of nonperforming loans over total

[10] That is, $\beta_{npl} + \beta_{small\ x\ npl} = 0.102 + 0.076 = 0.178$.
[11] The total effect of liquidity risk for small banks is computed as: $\beta_{liq\_risk} + \beta_{small\ x\ liq\_risk} = 0.042 + 0.009 = 0.051$. Note that the interaction adds an impact of 21.2% to the effect of liquidity risk compared with the benchmark group (i.e. large banks).

loans is associated with a fall in the bank's borrowing volumes of 6.8%. This result may suggest that riskier banks are rationed by their counterparts in the interbank market (as documented by Furfine, 2001; Gorton and Metrick, 2012). Further, we find that holding more capital is associated with higher access to liquidity. An increase of 1% in capital ratio is associated with an increase of 12.8% in the volume of liquidity. Overall, these results suggest that healthier banks can borrow more liquidity in accordance with the existence of market discipline. These findings may imply that riskier banks are either credit rationed in the unsecured market or tend to use collateral to cover their liquidity needs. Results further indicate that the volume of funds increases in bank size. The estimated coefficient of *size* (log of assets) has an important economic meaningful and is highly significant. This suggests that an increase in size (in millions) by a factor of *e* leads to an increase of 2.5% in the volume of funds. This result is in line with the view that larger banks behave more as net borrowers in the interbank market (Furfine, 2001) and is also consistent with our previous findings reported in **Table 2.**

We identify that increases in the liquidity supply of the central bank are associated with higher liquidity in the interbank market. The coefficient of *liq_supply* indicates that an increase in the central bank liquidity (in millions) by a factor of *e* raises the demand of liquidity in 1.6%. Hence, our results from both price and demand models confirm that the central bank's liquidity can put downward pressure on interest rates and increases market activity. This result is in line with the theoretical predictions of Freixas et al. (2011), and with the empirical evidence from the U.S. and German interbank markets (Christensen, et. al., 2009; Braüning and Fecht, 2015). In the same fashion, we find that increases in the central bank rate are associated with lower liquidity in the interbank market albeit with a small effect. The estimated coefficient of our dummy variable *CB rate_inc*, that captures the monetary policy tightening period is (0.005). This suggests that during periods of monetary policy contraction the volume of borrowed funds remains relatively stable while the price of liquidity do increase.

In Model (2) we further investigate the impact of liquidity risk on the liquidity demand. Unlike the price model, we find that banks with *excess reserves* are associated with lower demand for liquidity, albeit with a small impact (0.7%). On the contrary, banks with more liquidity imbalances tend to borrow more funds at the interbank market. The estimated coefficient of *Liq_risk* indicates that an increase of one standard deviation in the volatility of the banks' reserve holdings relatively to the required reserves leads to an increase in the volume of borrowed funds of 2.3%. These results suggest that banks large in reserves need less liquidity while banks with higher uncertainty on their liquidity needs tend to demand more interbank funds. Interestingly, we find that the estimated coefficient of *Market Liq_risk* is negative and statistically significant. That is, an increase of one standard deviation in the liquidity risk across banks is associated with a lower volume in 3.7%. Note that this effect is not only opposite to the one we find when liquidity risk is measured at the bank level but also is greater. This result can be indicating that a higher uncertainty on liquidity needs among banks reduces market activity as banks may hoard liquidity for precautionary reasons (See, Allen and Gale, 2004; Afonso et al. 2011; Acharya and Merrouche, 2013). For instance, in the model of Heider et al. (2015) when the level and dispersion of risk is high lenders in the unsecured market may be unwilling to lend and some borrowers can be rationed. Thus, our results bring further evidence on potential drivers of liquidity hoarding in interbank markets.

Model (3) allows testing if small banks are more rationed by their creditors due to higher credit and liquidity risk exposure. These effects are captured by the interaction terms between the variables of small bank with credit and liquidity risk. First, the estimated coefficient of *small x npl* is -0.025 and then, the total effect of *npl* on the demand of liquidity for small banks is -0.101. Then, an increase in 1% in the ratio of nonperforming loans to total loans is associated with a reduction of 10.1% in the volume of funds borrowed for small banks. This result indicates that small banks do suffer more than large banks when the quality of loans worsens. Besides, small banks also are more affected by the uncertainty on their liquidity needs. The estimated coefficient of the interaction term *small x liq_risk* is 0.005. Hence, the total effect of an increase of one standard deviation in the liquidity risk of small banks is associated with a greater volume of borrowed funds of 2.4%. This result joined to one we obtained from the price model, indicates that small banks do suffer more from liquidity squeezes, as they tend to borrow more liquidity (and at higher prices) when their liquidity positions are more imbalanced.

7.3. The access to the interbank market liquidity

The proposed Heckman model combines a selection mechanism with a regression model that allows identifying both the likelihood of a bank to borrow liquidity from the interbank market and the determinants of the prices (and quantities) paid (borrowed) by banks in the market. We already discussed results on the determinants of prices and volumes in sections 7.1 and 7.2, respectively. In this subsection we present the results on the selection equation stated in (4) and (6). Specifically, on the variables included into w_{it}, which are assumed to determine whether q_{it} (or p_{it}) is observed and that allow us understand the drivers of a bank to borrow funds from the interbank market.

In **Table 7** we present the results of the selection model where the dependent variable is the probability to borrow liquidity from the interbank market. Note that the set of variables included in the selection model are the same that we include in the regression models plus the two additional variables that are included lagged one period, namely *BPI* and *net_borrow*. The latter variables are assumed to be the core determinants of a bank to access the interbank market to borrow funds. Model (1) corresponds to the selection equation when we employ the price of liquidity as a dependent variable; while Model (2) is the specification in which we use the quantity of borrowed funds as a dependent variable. Both selection models are run on the full set of borrowing and non-borrowing banks in order to account for the selection bias. Therefore, the number of observations rises from 1,138 to 1,892. It is worthnoting that results do not vary significantly from one model to the other. However, we do observe that some variables become more relevant in one model than in the other. It obeys that, in spite of the set of variables is the same in both specifications, the dependent variable changes in magnitudes (i.e. bps vs. ln of millions). Because this is a selection model, it compares the influence of the explanatory variables when the dependent variable is observed (i.e. the bank borrows liquidity) against the opposite case (i.e. when the bank does not borrow).

First, we find that parameters of the selection equation are significant. Specially, ρ, that gauges the correlation between residuals of the regression model and the selection equation. This result implies that it is important to use a Heckman type model to account for the selection bias. In other words, it indicates that if we apply standard OLS methods to the regression model in (5) it will yield biased estimates. Second, we find that our additional variables of the selection equation aimed at capturing the likelihood of a bank to borrow from the interbank market exhibit the highest coefficients and are also statistically significant. Thus, a higher concentration of the borrower with his counterparts and the net position of the bank in the interbank market are found to be key determinants of the probability of a bank to access the interbank market. In the first case, the estimated coefficient of *BPI* indicates that if a bank has stable counterparts that provide funding in the market he has a 27.7% and 20.4% more probability to access the market to borrow liquidity compared with a bank with less stable counterparts. This result shows the importance of lending relationships in interbank markets to hedge liquidity risk (See, Cocco, et at, 2009: Afonso et al, 2013; Braüning and Fetch, 2015; Craig et al, 2015). In the second case, we find that banks with a net borrower position in the previous period have a 14.0% and 12.4% more probability to borrow funds from the interbank market, respectively. This indicates that those banks have more incentives to participate in the interbank market due to they need to continue funding their operations with this market.

Results of the estimated coefficients related with counterparty risk indicate that banks with higher z-score are more likely to borrow liquidity from the interbank market. Interestingly, banks with a higher share of nonperforming loans are less likely to borrow from the interbank market. A one percent increase in the share of nonperforming loans is associated with 18.1% and 17.2% less probability to borrow from the interbank market, respectively. Further, more capitalized banks have higher probability to borrow from the interbank market. These results confirm our previous evidence on market discipline as riskier banks are found to have less access to the interbank market. This can be related with the fact that in an unsecured market participants care about counterparty risk and exert peer monitoring on their counterparts (Rochet and Tirole, 1996). The estimated coefficient of size indicates that the larger the bank the higher the likelihood to borrow from the interbank market. In the regression models we found that larger banks pay less and borrow more liquidity. In addition, we also showed in **section 3** that larger banks are net borrowers in the interbank market. Overall, these results are indicating that larger banks have a competitive advantage over smaller banks, which can be associated with economies of scale (Sarmiento and Galán 2015) or with the existence of too-big-to-fail implicit guarantees (Davies and Tracey, 2014; Angelini et al, 2011).

Regarding liquidity risk we find that banks with greater liquidity risk are more likely to borrow from the interbank market, whilst the opposite is true for banks with excess reserves. The estimated coefficients of *excess reserves* in Model (2) suggests that banks large in reserves are 1.3% less likely to borrow from the interbank market, while banks facing higher liquidity risk are

4.2% more likely to borrow liquidity. This result indicates that banks large in reserves do not need to borrow liquidity whereas banks short in reserves or with higher uncertainty on their liquidity needs are more prone to borrow funds from the interbank market. However, in the regression models we find that banks facing higher liquidity risk are charged with higher prices and can borrow lees funds than banks with more stable liquidity positions. Besides, the selection model shows that the probability to borrow liquidity from the interbank market falls as liquidity positions across banks are more imbalanced. Increases in our measure of *Market Liq_risk* are associated with a decrease in the probability to borrow funds of 1.2% and 1.5%, respectively. This result brings further evidence of a potential liquidity hoarding under higher uncertainty on liquidity conditions among banks.

Results on the interaction terms between small banks with credit and liquidity risk measures complement our findings from the regression models. We find that small banks are more vulnerable to changes in their credit risk as their probability to borrow funds decreases more compared with the probability for large banks. The total estimated coefficients indicate that small banks have 26.6% and 21.7% less probability to borrow funds, while for large banks this probabilities are -18.1% and -17.2%. This suggests that when credit risk increases small banks have less access to interbank liquidity compared with large banks. Results also indicate that the probability to access the interbank market for a small bank facing higher liquidity risk does not differs statistically from a large bank in the same situation. However, in the regression model we do find that small banks pay more as their liquidity risk increases. These findings contribute to support our prediction that small bank are more vulnerable as their credit and liquidity risk increases.

Regarding the role of the monetary policy on the behavior of banks in the interbank market we observe that an increase in the central bank liquidity is associated with a higher probability to borrow funds in the interbank market. In particular, an increase in the central bank liquidity (in millions) by a factor of *e* raises the probability of a bank to borrow fund by 2.9% and 3.7%, respectively. Interestingly, we find that during the monetary policy tightening period the likelihood to borrow funds from the interbank market increases although in a low level. This result may indicate that such as policy does not prevent banks from borrow in the interbank market. Visual inspection to **Figure 1** shows that during those periods the interbank market activity does not fall albeit we do observe a higher volatility.

8. Robustness checks

The proposed Heckman model corrects for the selection bias in our sample of borrowing banks of the interbank market. However, this type of models can be sensible to the model's specification (Heckman, 1979). Therefore, we employ alternative measures of risk to test the robustness of our model and to check the validity of our findings under alternative specifications.

First, we employ the bank's profitability measured by the bank's return on assets (ROA) instead of the bank's z-score. We argue that more profitable banks may exhibit lower prices for liquidity due to higher profits can signal the bank's financial health. Second, we use the ratio of risky loans over total loans (*risky loans*) to gauge the ex-ante credit risk of the bank instead of using the ratio of nonperforming loans, which is an ex-post measure of credit risk (See, Ioannidou and Penas, 2010)[12]. Third, we include the amount of funds borrowed by the bank in the interbank market over the bank's capital equity (*borrow_car*) instead of using the bank's capital ratio (*car*). This variable allows to identify how leveraged (or funding-dependent) the bank is from the interbank market. We expect that banks heavily founded with the interbank market might suffer more from unfavorable prices. Fourth, we employ the ratio of total assets to liquid assets (*liq_position*) as an alternative measure of the liquidity position of the bank[13]. We expect that banks with a higher share of liquid assets pay less for their liquidity in the interbank market due to they are in better position to raise funding from secured markets in case of higher prices in the unsecured market. Lastly, we include the interaction terms *small x risky loans* and *small x liq_position* to test whether small banks are more affected as their credit and liquidity risk exposure increases. Note that we keep our measures of market conditions along with *size* and the additional variables capturing the likelihood of a bank to borrow from the interbank market (*BPI* and *net_borrow*) due to we just need to test how alternative covariates of risk influencing our baseline specifications.

[12] Risky loans are based on internal loan ratings performed by banks. Colombian financial regulation establishes that banks' loan losses provisions should be set according to the level of risk loans.
[13] Liquid assets include cash holdings, negotiable and available to sell public and private debt instruments and pledged collateral in repurchase agreement operations.

8.1. The price of liquidity under alternative measures of risk

Table 8 presents the parameter estimates of the regression and selection models run on our sample of borrowing and non-borrowing banks. In Model (1) the dependent variable is the price of liquidity in bps, while in Model (2) it is the log of the volume of funds borrowed by the bank (in millions of COP). In both models Column I refer to the regression model and Column II to the selection equation. First, we find that parameters of the selection equation (Panel B, Column II) in both models are significant. This result confirms that using the proposed Heckman model allows to account for the selection bias. Second, regarding the estimated parameters of the alternative covariates capturing counterparty and liquidity risk, both models yield similar results to the ones we obtained in our baseline models. However, they exhibit lower levels albeit remain significant in comparison with the estimated coefficients in our baseline specifications. Thus, our models are robust to alternative measures of risk.

In particular, Model (1) shows that more profitable banks (higher *ROA*) benefit from lower prices and higher access to the interbank market, confirming our previous findings on market discipline. Besides, banks with more *risky loans* are found to pay more and to have less access to the interbank market. This result is consistent with our findings when the ratio of nonperforming loans is employed. Thus, banks engaging on more credit risk are charged with higher prices and are also credit rationed in the interbank market. The ratio of borrowed funds in the interbank market to the bank's capital (*borrow_car*) has a positive and significant effect on the price of liquidity. The estimated coefficient indicates that an increase of 1% in this ratio is associated with an overpriced of 8.1 bps. Interestingly, the likelihood of a bank to borrow from the interbank market increases with the bank's funding dependence (5.9%). Evidence shows that banks relying more on non-core funding sources face more risk as they become more dependent from wholesale funding, which can be unstable, especially in times of grater uncertainty (See, Demirgüç-Kunt and Huizinga, 2010; Altunbas, et al., 2011). Besides, larger banks are associated with lower prices and higher access to interbank funds, as we found in our previous specifications.

Regarding liquidity risk, we find that banks with *excess reserves* do not pay significantly different rates than banks short in reserves. However, we do find that banks with higher ratio of total assets to liquid assets are associated with higher prices and are less likely to borrow interbank funds. We argue that more liquid banks are in better position to obtain liquidity from the money market. The rationality is that if prices in the unsecured interbank market are high they can use their liquid assets in the secured market to cover their liquidity needs. Bonner and Eijffinger (2012) find that German banks close to the liquidity ratio pay higher prices for their interbank funds. Likewise, Pierret (2015) shows that liquid banks benefit from lower funding costs and lower insolvency risk. Thus, we provide further support to the benefits of reserve requirements and liquidity ratios to mitigate the liquidity shocks faced by banks.

The interaction term of *small x risky loans* confirms that small banks are more affected as their loans deteriorate by exhibiting both higher prices and less access to interbank funding. Similarly, the interaction of *small x liq_position* indicates that small banks with lower liquid assets pay more for interbank funds and have less access to interbank markets. These results hereby confirm our previous findings on the higher affectation of small banks when their exposure to credit and liquidity risk increases.

Results on our measures of market conditions remain relatively similar to the ones we found in our baseline specifications in the previous section. More imbalanced liquidity positions across banks are associated with higher prices and with a lower likelihood for a bank to borrow funds. Besides, higher liquidity by the central bank lowers funding prices and increases the probability of a bank to borrow funds. Thus, central bank can increase market activity and lowers interbank rates. During periods of monetary policy tightening interbank rates raise and banks are also more likely to borrow interbank funds. Overall, these results are consistent with our baseline price model. Lastly, results from the selection equation confirm that banks with stable counterparts (higher BPI) and with a net borrower position are more likely to borrow funds from the interbank market (Column II). The associated probabilities are 23.1% and 16.4%, respectively, which reflect the chief influence of lending relationships in explaining the access of banks to interbank markets.

8.2. The liquidity demand under alternative measures of risk

In Model (2) the dependent variable is the log of the volume of funds borrowed by the bank in the interbank market. Results suggest that banks with higher ROA are associated with more volume funds and are more likely to borrow from the interbank market. Thus, more profitable banks are found to have higher access to interbank funding. On the contrary, banks with higher credit risk in their portfolio are found to borrow fewer funds and also to have less access to the interbank market. This result confirms that riskier banks can be credit rationed in interbank markets, which is in line with evidence from the U.S. interbank market (Gorton and Metrick, 2012). Interestingly, banks with a higher proportion of interbank funding relative to their capital equity (*borrow_car*) are found to borrow more from the market and to be more likely to funding within this market. However, we find in Model (1) that those banks are associated with higher prices. Therefore, these results indicate that banks may have access to non-core funding sources on a regular basis but at higher prices. Besides, results confirm that larger banks borrow more and have more access to the interbank market consistent with our previous findings.

Regarding liquidity risk we find evidence that banks large in reserves borrow less and are less likely to access the interbank market to borrow liquidity. Banks with less liquid assets relative to their total assets (*Liq_position*) borrow less interbank funds and also are less likely to borrow from the interbank market. Note that in Model (1) we find that those banks pay higher prices in the interbank market. These results can indicate that those banks may exhibit higher liquidity risk and herby they are willing to pay more for their short-term funding. Results from the interaction term of *small x risky loans* confirm that small banks are more affected as their credit risk increases. The estimated coefficients (total effect) indicate that smaller banks can borrow 1.9% less funds and have 18.6% less probability to access the interbank market compared with larger banks. The interaction of *small x liq position* only has statistical significance on the volume albeit with a low effect (-0.2%). Overall, these results bring additional support to our previous findings on the higher sensitivity of small banks when they exhibit increased credit and liquidity risk.

Results on the effect of market conditions on the interbank demand of funds in the interbank market are robust to the inclusion of different covariates of risk. We find that more imbalanced liquidity positions across banks are associated with lower volume and with a lower access to the interbank market, which is consistent with our baseline specifications and with evidence of liquidity hoarding for precautionary motives (Acharya and Merrouche, 2013). Higher liquidity by the central bank increases the volume of borrowed funds and the likelihood of a bank to access the interbank market as well. Interestingly, during periods of monetary policy tightening the volume of borrowed funds increases albeit with a low effect; while banks are more likely to borrow in the interbank market. These results hereby confirm that central bank's liquidity tends to increase market activity and that during periods of monetary policy contraction the interbank market liquidity does not declines.

Finally, results from our additional variables in the selection equation confirm that banks with stable counterparts (higher BPI) and with a net borrower position (*net_borrow*) have more probability to borrow funds in the interbank market (Column II). The associated probabilities are 28.0% and 18.2%, respectively. This suggests a key influence of lending relationships in determining the banks' access to interbank markets.

9. Final remarks

In this paper we identify bank-specific-characteristics and market conditions that contribute to determine prices and demand for liquidity in the interbank market as wells as the banks' access to this market. Our analytical framework is based on a Heckman model that allows both to account for the potential selection bias in the sample of borrowing banks and to identify the drivers of a bank to borrow in the interbank market. We find that riskier banks pay higher prices and borrow less liquidity according with the existence of market discipline. This result is explained by the role of peer monitoring among banks and price discovery (Rochet and Tirole, 1996). We find that more liquid banks pay less for interbank funds and can borrow more funds in the market. This finding can support literature on strategic behavior of liquidity-surplus banks, based on banks with excess liquidity may exert market power on deficit banks (Acharya et al., 2012). We also show that interbank market funding-dependent banks tend to pay higher prices and to borrow more liquidity in this market, which could entails more risk as banks that rely more on non-core funding are found to engage on more risk increasing bank fragility (Demirgüç-Kunt and Huizinga, 2010).

We document that the borrowing concentration of banks and the bank's net position in the interbank market are key determinants of the likelihood of a bank to demand liquidity in the interbank market. Thus, we provide evidence on the crucial role of lending relationships and interbank funding-dependence in determining the behavior of banks in interbank markets. Besides, we show that small banks suffer more (i.e. pay higher prices and can borrow less funds) as a result of further deterioration in their loans portfolio and when their liquidity positions are more imbalanced as well. This result can be associated with evidence suggesting that small banks are more affected by liquidity squeezes (Fecht et al, 2011). One chief implication of this finding is that small banks have to hold more collateral to access the secured market in order to cover their liquidity needs, especially in times of higher uncertainty on the availability of liquidity.

Furthermore, we find that more capitalized and liquid banks tend to pay less for their funds and to have higher access to the interbank market. Thus, on the one hand, we provide evidence that under the market discipline view higher capitalization is associated with lower risk taking and herby lower funding costs. On the other hand, we argue that banks with a higher ratio of liquid assets can be in a better position to obtain liquidity from the money market. It is because of in the case of higher prices in the unsecured interbank market those banks can use their assets as collateral in the secured market to cover their short-time liquidity needs avoiding the higher prices of the unsecured funding. Overall, these results support the importance of capital and liquidity regulatory requirements to enhance financial stability and market discipline.

We identify that market conditions have an important effect on the behavior of banks in the interbank market. We document that when liquidity positions across banks are more imbalanced the prices of interbank funds increase and the demand for funds declines. We relate this result with evidence of short-time liquidity squeezes and liquidity hoarding for precautionary motives. Besides, increases in the central bank liquidity supply are associated with a downward pressure in interbank rates and increased market activity. Thus, we provide evidence on the role of the central bank in alleviating potential liquidity tensions in the interbank market. Further, we find that during periods of monetary policy tightening banks do not exhibit liquidity constrains in the market but they do face higher prices, in accordance with the pass-through from the central bank' rate to the interbank market rates.

In sum, we document that the interbank funds market is an essential source of liquidity for its participants, especially when they face uncertainty on their liquidity needs. However, this market is found to be "too sensible" to liquidity shocks and to concerns on the counterparty risk of its participants. Usually, central banks monitor this market to assess the transmission of the monetary policy but it is also important to examine the behavior of its participants to identify potential disruptions in the allocation of liquidity due to concerns on credit and liquidity risk among them.

Lastly, this analysis can be extended in several ways. A relevant venue is to analyze the behavior of banks in the secured market to identify whether the collateral improves liquidity access, especially for small banks. Another interesting extension is to evaluate the impact of liquidity requirements (as the LCR proposed in Basel III) on both prices and demand for liquidity. We find preliminary evidence suggesting that banks short in liquidity (lower ratio of liquid asset to total assets) pay more for interbank funding, which provide support to the benefits of reserve requirements and liquidity ratios to mitigate the liquidity shocks faced by banks. However, employing the LCR can highlight direct implications for regulatory proposes under the current Basel III environment (BIS, 2016).

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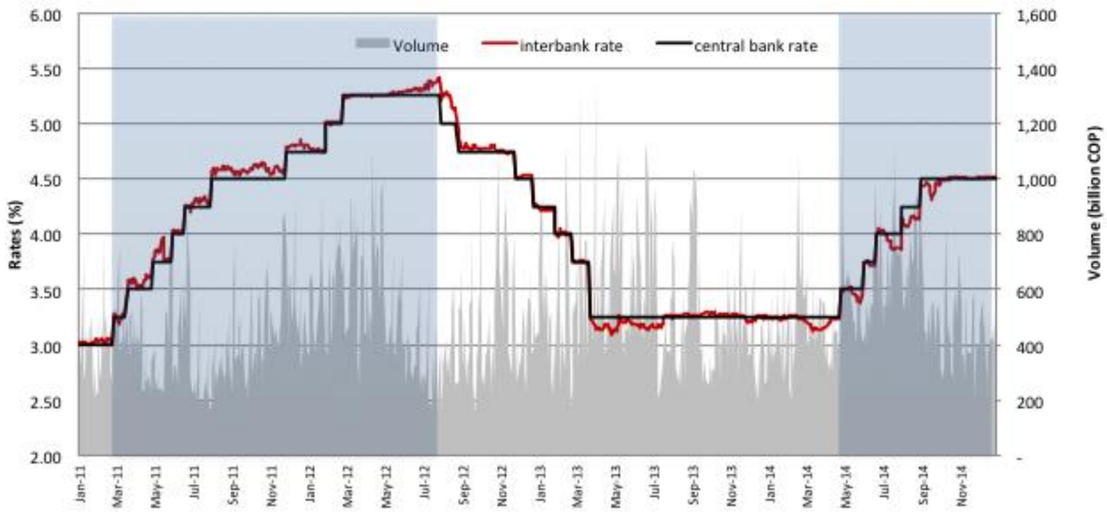
Figure 1. Interbank market rate, central bank rate, and daily volume of interbank funds



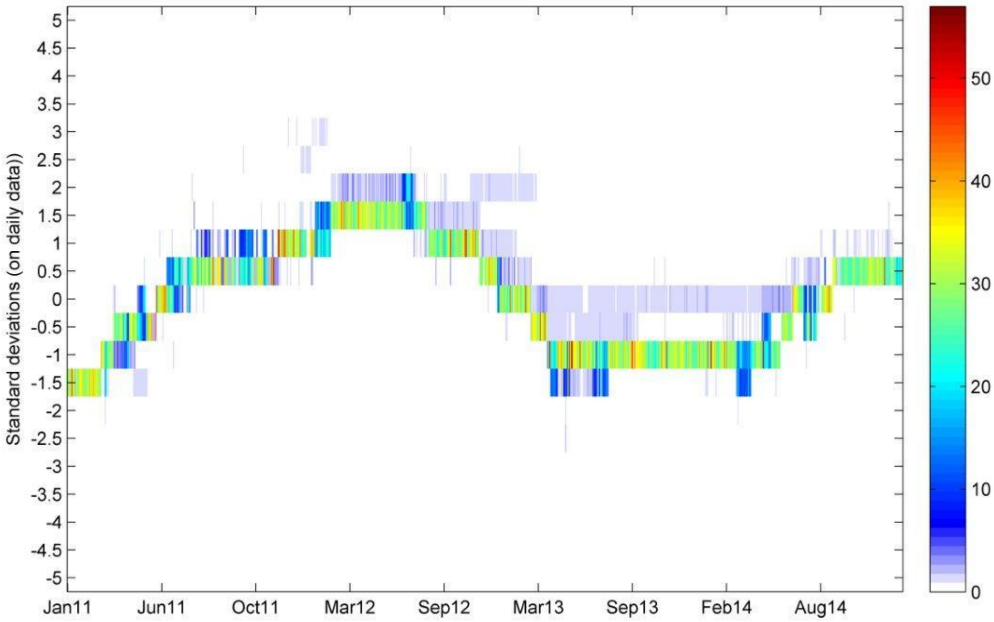
This figure depicts the overnight interbank market rate and central bank rate in percentage (%). Average daily amount traded in the interbank market in billions of COP (Right axis). Shared region corresponds to the monetary policy tightening period: 02-2011 to 07-2012 and 04-2014 to 12-2014.

Table 1. Summary statistics of the interbank market rates and volume

Full period: 2011-2014					Period I: 02/2011 - 07/2012				Period II: 04/2014 - 12/2014			
Stat.	TIB (%)	CB (%)	TIB - CB (bps)	Volume (billions COP)	TIB (%)	CB (%)	TIB - CB (bps)	Volume (billions COP)	TIB (%)	CB (%)	TIB - CB (bps)	Volume (billions COP)
Mean	4,07	4,06	1,0	493	4,61	4,56	4,66	464	4,14	4,18	-3,97	559
Std. Dev.	0,75	0,72	3,0	202	0,61	0,61	-0,55	192	0,38	0,37	0,93	180
Min	3,01	3,00	1,0	156	3,19	3,25	-6,00	160	3,38	3,50	-12,00	206
Max	5,42	5,25	17,0	1,348	5,42	5,25	17,00	1134	4,52	4,50	2,00	1288

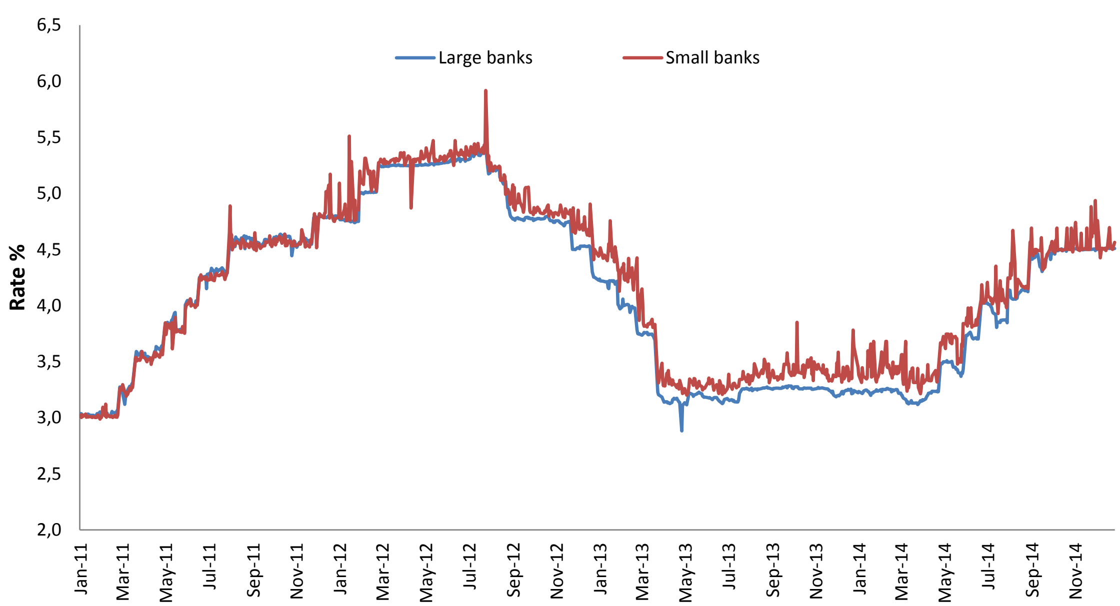
This table shows the volume-weighted average rates for overnight loans of the unsecured interbank market (TIB) and the central bank repo rate (CB). Differences between TIB and CB rates are in basis points (bps). The average daily volume negotiated is in billions of COP and corresponds only to overnight maturity loans.

Figure 2. Dispersion of individual interbank interest rates (%)



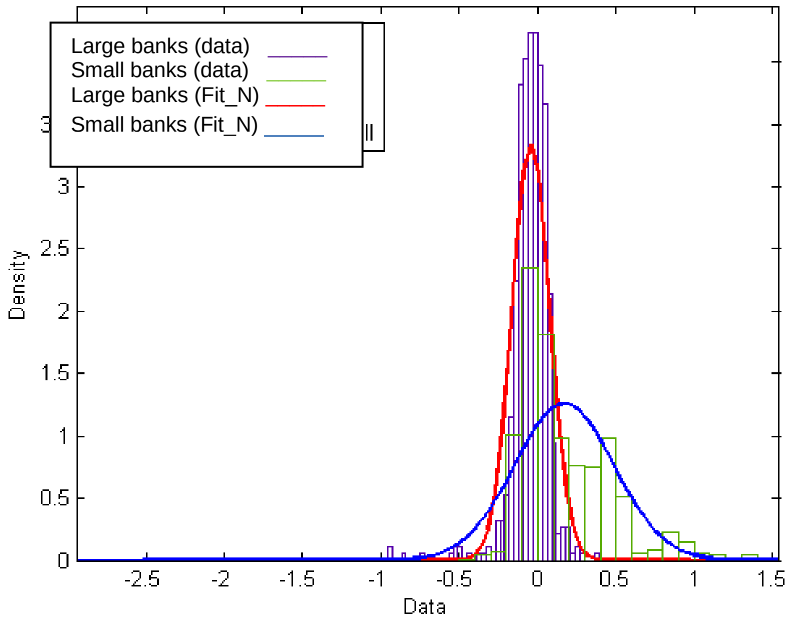
This figure shows the standardized dispersion of overnight interbank interest rates for the period 2011-2014. It compares the deviations of the observed rates of bilateral unsecured loans standardized with the standard deviation estimated on the entire period. The intensity (i.e. color) corresponds to the number of observed loans.

Figure 3. The price of liquidity in the interbank market and the bank size



This figure presents the volume weighted average interest rate (in percentage) that banks pay for overnight-unsecured loans in the interbank market during the period 2011-2014. Large (small) banks are those with assets value larger (lower) than the 66th (33th) percentile of the assets distribution during the period.

Figure 4. Distribution of borrowing rates by banks' size



This figure presents the distribution of the interest rates of overnight-unsecured loans in the interbank market during the period 2011-2014. Large (small) banks are those with assets value larger (lower) than the 66th (33th) percentile of the assets distribution during the period.

Table 2. Bank size, bank-specific-characteristics and interbank market activity

Bank-characteristics (Panel a)	Small banks	Large banks	Difference between large and small banks	p-value of test eq. Means
spread (bps)	3,00	-1,50	-4,50	0,000
Total assets (billion COP)	2.748	13.935	11.187	0,000
z-score (percent)	0,33	0,61	0,28	0,000
capital ratio (percent)	18,20	21,52	3,30	0,015
Non-performing loans (percent)	4,03	3,45	-0,60	0,012
Excess reserves (percent)	6,14	8,68	2,54	0,087
Liquidity risk (percent)	12,56	9,32	-3,24	0,061
Interbank market activity (Panel b)				
Total amount borrowed (billion COP)	41,8	488,3	446,6	0,000
Total amount lent (billion COP)	228,4	214,4	-14	0,000
Net position	186,6	-273,9	-460,6	0,000

This table reports average values of selected bank-specific-characteristics long with the activity of banks in the interbank market, distinguishing between small and large banks. Large (small) banks are those with assets value larger (lower) than the 66th (33th) percentile of the assets distribution during the period. Spread is the difference between the interest rate paid by a bank and the central bank rate measured in basis points (bps). Total assets in billion COP. Z-score is an inverse measure of the probability of insolvency defined as z-score= μ_{roa} + car_t /σ_{roa}. The ratio of non-performing loans over total loans (percent). Liquidity ratio is liquid assets over total assets (percent). Capital ratio is Tier I and Tier II capital equity over total assets (percent). Total amount borrowed and total amount lent in the interbank market per month in billion COP. Net position is the difference between the total amount lent and the total amount borrowed during a month in billion COP.

Table 3. Summary statistics and definitions of the variables employed in the model

Variable	Definition	Mean	Std. Dev.	Min	Max	Obs
	Dependent variables (Panel A)					
p_{it} *(spread)*	The difference in basis point (bps) between the volume-weighted average interest rate (i_{it}) paid for a bank i of all its overnight unsecured loans during the last 30 days t and the central bank rate in t (r_{cbt}), standardized by the interbank rate volatility in t (σi_{it}).	1,50	35,20	-132,21	179,51	1138
q_{it} *(ln)*	The log of the quantity borrowed by each bank in the interbank market during the month.	6,92	5,85	0,00	16,67	1138
	Counterparty risk variables (bank level) (Panel B)					
$zscore_{it}$	Sum of mean roa plus capital ratio in period t (car_t) over the standard deviation of roa (z-score= $\mu roa + car_t / \sigma roa$) computed on a rolling window of 12 months for the ROA and monthly for CAR. (in %)	0,45	0,48	-0,16	3,45	1138
npl_{it}	Ratio of nonperforming loans (loans past due more than 90 days) over total loans (end of month) (in %)	0,04	0,02	0,00	0,20	1138
car_{it}	Capital equity (Tier I and Tier II) over risk-weighted assets (end of month) (in %)	0,19	0,17	-2,93	0,95	1138
roa_{it}	Return on assets measure as profits over assets (end of month) (in %)	0,01	0,04	-1,09	0,17	1138
$size_{it}$	Log of total assets (end of month)	14,68	1,92	9,08	18,42	1138
risky loans $_{it}$	Ratio of risky loans over total loans. Risky loans are based on internal loan ratings performed by banks (in %).	0,06	0,04	0,00	0,32	1138
$borrow\_car_{it}$	Total amount borrowed in the interbank market during the last 30 days over capital equity (in %).	0,22	0,57	-0,36	6,05	1138
	Liquidity risk variables (bank level) (Panel C)					
$liq\_position_{it}$	Liquidity position computed as total assets over liquid assets (end of month) (in %)	0,19	0,16	0,01	0,96	1138
$excess\_res_{it}$	Reserve holding less the amount a bank needs to hold on a daily basis for the balance of the reserve maintenance period in order to exactly fulfill reserve requirements, divided by the average daily required reserves	9,56	30,80	-1,18	261,27	1138
liq_risk_{it}	Liquidity risk is measured as the standard deviation of daily change in reserve holdings during the last 30 days divided by reserve requirements	0,12	6,20	-78,59	173,92	1138
	Market conditions variables (Panel D)					
$log\_liq\_s_{jt}$	Log of the total liquidity supply of the central bank	29,36	0,48	27,81	30,35	1138
CB rate_inc $_{jt}$	Dummy variable equal to one during the period in which the central increases the policy rate (from 02/11 to 07/12; and from 04/14 to 12/14)	4,06	0,72	3,00	5,25	1138
$Market\_liq\_risk_{jt}$	Standard deviation of excess reserves across all banks j at time t.	0,08	3,40	-14,87	26,31	1138
	Additional variables of the selection equation (Panel E)					
BPI_{it-1}	Borrowing preference index (BPI) computed as the amount of funds borrowed by the bank i from a bank k at time t (qkit) over a period T relative to the overall amount borrowed by bank i over the same period T	0,47	0,50	0,00	0,65	1892
net_borrow_{it-1}	Net borrower position of a bank. Dummy variable equal to one if the amount borrowed by the bank in the interbank market was larger than the amount lent in the previous period	0,36	0,48	0,00	1,00	1892

Table 4. Comparison of bank-specific-characteristics between non-borrowing and borrowing banks in the interbank market

Variable	Non borrowing banks (Panel A)					Borrowing banks (Panel B)				
	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.
$zscore_{it}$	0,41	0,32	-0,23	3,28	754	0,45	0,48	-0,16	3,45	1138
npl_{it}	0,04	0,03	0	0,23	754	0,04	0,02	0,00	0,20	1138
car_{it}	0,17	0,14	-3,12	0,57	754	0,19	0,17	-2,93	0,95	1138
roa_{it}	0,01	0,05	-2,09	0,11	754	0,01	0,04	-1,09	0,17	1138
$size_{it}$	11,81	2,21	9,06	14,79	754	14,68	1,92	9,08	18,42	1138
$liq\_position_{it}$	0,11	0,19	0,01	0,26	754	0,19	0,16	0,01	0,96	1138
$excess\_reserves_{it}$	11,2	22,71	-1,02	121,32	754	9,56	30,80	-1,18	261,27	1138
liq_risk_{it}	0,14	8,2	-83,24	134,27	754	0,12	6,20	-78,59	173,92	1138

This table reports compares counterparty and liquidity risk variables for non-borrowing banks (Panel A) vs. borrowing banks (Panel B) in the interbank market. They are computed over the full sample period 2011-2014. *Z-score* is the Sum of mean roa plus capital ratio in period t (cart) over the standard deviation of roa (z-score= µroa + cart /σroa) computed on a rolling window of 12 months for the ROA and monthly for CAR. (in %). *Npl* is the ratio of nonperforming loans (loans past due more than 90 days) over total loans (end of month) (in %). *Car* is the capital equity (Tier I and Tier II) over risk-weighted assets (end of month) (in %). *ROA* is return on assets measure as profits over assets (end of month) (in %). Size is the log of total assets (end of month). *Liq_position* is liquidity position computed as total assets over liquid assets (end of month) (in %). *Excess_reserves* is reserve holding less the amount a bank needs to hold on a daily basis for the balance of the reserve maintenance period in order to exactly fulfill reserve requirements, divided by the average daily required reserves. *Liq_risk* is liquidity risk measured as the standard deviation of daily change in reserve holdings during the last 30 days divided by reserve requirements.

Table 5. Determinants of the price of liquidity in interbank markets

This table presents ML parameter estimates of the Heckman regression model that corrects for sample selection bias based on the selection Eq. (Table 7, Model 1). Each column is a separate model. The dependent variable is the spread in bps between the volume-weighted average interest rate and the central bank rate standardized by the interbank market rate volatility in basis points (bps). Model (2) adds liquidity risk measures both at the bank level and across banks. Model (3) includes interaction terms to test if small banks are more penalized by their creditors in presence of higher credit and liquidity risk. All specifications include individual-fixed effects. t-statistics are in parentheses and correspond to the null hypothesis that the parameter is zero. The model in (7) is run on the full sample of borrowing and non-borrowing banks and is estimated by maximum likelihood. They are computed based on robust standard errors estimates clustered at the bank level. [a], [b], and [c] denote significance level at 1%, 5% and 10%, respectively.

Variables	Model (1) (bps)	Model (2) (bsp)	Model (3) (bps)
$Z\text{-score}_{it}$ (percent)	-0,169[a]	-0,152[a]	-0,148[a]
	(-3,19)	(-3,98)	(-4,10)
Npl_{it} (percent)	0,115[a]	0,105[a]	0,102[a]
	(3,15)	(3,92)	(4,03)
Car_{it} (percent)	-0,234[a]	-0,184	-0,270
	(-2,98)	(-3,13)	(-4,29)
$Size_{it}$ [Log of assets (mln)]	-0,190[a]	-0,161[a]	-0,141[a]
	(-4,18)	(-4,95)	(-5,14)
Small x npl_{it} (percent)			0,076[a]
			(3,10)
$Excess\_reserves_{it}$ (percent)		-0,009	-0,011
		(-1,61)	(-1,19)
Liq_risk_{it} (percent)		0,023[b]	0,042[a]
		(2,34)	(3,19)
Small x Liq_risk_{it} (percent)			0,009[b]
			(2,13)
Market Liq_risk_{jt} (percent)		0,075[a]	0,071[a]
		(4,35)	(3,96)
Liq_supply [ln (mln)]	-0,026[a]	-0,052[a]	-0,038[a]
	(-6,92)	(-6,58)	(-6,25)
CB $rate\_inc_{jt}$	0,017[a]	0,014[a]	0,006[a]
	(5,18)	(5,35)	(5,39)
Constant	-5,264	-4,685	-4,263
	(-6,23)	(-5,92)	(-5,62)
Observations	1138	1138	1138

Table 6. Determinants of the liquidity demand in interbank markets

This table presents ML parameter estimates of the Heckman regression model that corrects for sample selection bias based on the selection Eq. (Table 7, Model 2). Each column is a separate model. The dependent variable is the natural log of the quantity of funds borrowed by the bank in the interbank market (Ln q_{it}). Model (2) adds liquidity risk measures both at the bank level and across banks. Model (3) includes interaction terms to test if small banks are more penalized by their creditors in presence of higher credit and liquidity risk. All specifications include individual-fixed effects. t-statistics are in parentheses and correspond to the null hypothesis that the parameter is zero. They are computed based on robust standard errors estimates clustered at the bank level. [a], [b], and [c] denote significance level at 1%, 5% and 10%, respectively.

Variables	Model (1)	Model (2)	Model (3)
$Z\text{-score}_{it}$ (percent)	0,034[b]	0,031[b]	0,048[b]
	(2,19)	(2,40)	(2,51)
Npl_{it} (percent)	-0,068[a]	-0,081[a]	-0,077[a]
	(-3,29)	(-3,98)	(-3,03)
Car_{it} (percent)	0,128[b]	0,159[b]	0,170[b]
	(2,40)	(2,53)	(2,32)
$Size_{it}$ [Log of assets (mln)]	0,025[a]	0,030[a]	0,048[a]
	(3,18)	(3,13)	(3,04)
Small x npl_{it} (percent)			-0,025[b]
			(2,51)
$Excess\_reserves_{it}$ (percent)		-0,007[a]	-0,009[a]
		(-3,41)	(-3,82)
Liq_risk_{it} (percent)		0,023[c]	0,019[b]
		(1,74)	(2,19)
Small x Liq_risk_{it} (percent)			0,005[a]
			(3,09)
Market Liq_risk_{jt} (percent)		-0,037[b]	-0,044[b]
		(-2,57)	(-2,34)
Liq_supply [ln (mln)]	0,016[a]	0,015[a]	0,019[a]
	(4,23)	(5,67)	(5,14)
CB $rate\_inc_{jt}$	0,005[b]	0,004[b]	0,006[c]
	(2,18)	(2,46)	(1,78)
Constant	-7,326[a]	-6,520[a]	-5,934[a]
	(-7,22)	(-6,86)	(-6,52)
Observations	1138	1138	1138

Table 7. Results of the selection models for the price and demand specifications

This table presents ML parameter estimates of the Heckman selection model that corrects for sample selection bias (Panel A). The dependent variable is the probability to borrow liquidity from the interbank market (in %). The set of variables of the selection model are the same that we included in the regression models plus the two additional variables that are included lagged one period, namely *BPI* and *net_borrow*. Model (1) corresponds to the selection Eq. when we employ the price of liquidity as a dependent variable; while Model (2) is the selection Eq. in which we use the quantity of borrowed funds as a dependent variable. Both selection models are run on the full set of borrowing and non-borrowing banks in order to account for the selection bias. Both specifications include individual-fixed effects. t-statistics are in parentheses and correspond to the null hypothesis that the parameter is zero. They are computed based on robust standard errors estimates clustered at the bank level. Parameters of the selection equation are presented in Panel B. Standard errors are in [brackets]. [a], [b], and [c] denote significance level at 1%, 5% and 10%, respectively.

Variables	Model (1)	Model (2)
Panel A		
$Z\text{-score}_{it}$ (percent)	0,063[b]	0,072[b]
	(1,98)	(2,03)
Npl_{it} (percent)	-0,181[a]	-0,172[a]
	(-2,59)	(-2,81)
Car_{it} (percent)	0,067[a]	0,047[a]
	(3,26)	(3,87)
$Size_{it}$ [Log of assets (mln)]	0,260[a]	0,218[b]
	(2,61)	(2,49)
Small x npl_{it} (percent)	-0,085[b]	-0,046[a]
	(-2,40)	(-2,72)
$Excess\_reserves_{it}$ (percent)	-0,018	-0,013[b]
	(-1,04)	(-2,19)
Liq_risk_{it} (percent)	0,042[c]	0,062
	(1,79)	(1,12)
Small x Liq_risk_{it} (percent)	0,002	0,006
	(1,13)	(1,08)
Market Liq_risk_{jt} (percent)	-0,012[b]	-0,015[c]
	(-2,40)	(-1,77)
Liq_supply [ln (mln)]	0,029[a]	0,037[a]
	(4,02)	(3,82)
CB $rate\_inc_{jt}$	0,014[c]	0,018
	(1,75)	(1,57)
BPI_{it-1}	0,277[a]	0,204[a]
	(7,23)	(11,14)
Net_borrow_{it-1}	0,140[a]	0,124[a]
	(6,39)	(7,14)
Constant	-8,478[a]	-7,715[a]
	(-5,48)	(-5,20)

Panel B		
Log pseudolikelihood	-6137,6	-6021,1
Prob > chi2	0,016	0,008
rho	-0,076[a]	-0,068[a]
	[0,021]	[0,016]
sigma	2,745[a]	2,105[a]
	[0,721]	[0,612]
lambda	-0,209[a]	-0,143[b]
	[0,054]	[0,061]
Observations	1892	1892

Table 8. Results of regression and selection models under alternative measures of risk

This table presents ML parameter estimates of the regression and selection models run on our sample of borrowing and non-borrowing banks. In Model (1) the dependent variable is the price of liquidity in bps, while in Model (2) it is the log of the volume of funds borrowed by the bank (in millions of COP). In both models Column (I) refer to the regression model and Column (II) to the selection equation. The set of variables of the selection model are the same that in the regression model plus the two additional variables that are included lagged one period, namely *BPI* and *net_borrow*. All specifications include individual-fixed effects. t-statistics are in parentheses and correspond to the null hypothesis that the parameter is zero. They are computed based on robust standard errors estimates clustered at the bank level. Parameters of the selection equation are presented in Panel B. Standard errors are in [brackets]. [a], [b], and [c] denote significance level at 1%, 5% and 10%, respectively.

	Model (1)		Model (2)	
Variables	(I) Price (bps)	(II) Prob. %	(I) Ln (q)	(II) Prob. %
Panel A				
ROA_{it} (percent)	-0,085[a]	0,023[b]	0,034[c]	0,045[b]
	(-3,10)	(2,50)	(1,88)	(2,84)
Risky $loans_{it}$ (percent)	0,120[a]	-0,172[a]	-0,053[b]	-0,155
	(4,12)	(3,62)	(-2,11)	(-0,88)
$Borrow\_Car_{it}$ (percent)	0,081[a]	0,059[a]	0,011[a]	0,021[b]
	(2,97)	(3,01)	(3,74)	(2,31)
$Size_{it}$ [Log of assets (mln)]	-0,151[a]	0,296[a]	0,071[a]	0,232[a]
	(-3,73)	(3,41)	(3,23)	(3,11)
Small x risky $loans_{it}$ (percent)	0,048[c]	-0,042[a]	-0,019[c]	-0,031[b]
	(1,69)	(-2,75)	(-1,79)	(-2,47)
$Excess\_reserves_{it}$ (percent)	-0,019	-0,001	-0,012[a]	-0,015[b]
	(1,08)	(0,68)	(-3,05)	(-2,24)
$Liq\_position_{it}$ (percent)	0,152[b]	-0,092[a]	-0,014[b]	-0,050[b]
	(2,15)	(-3,03)	(-2,22)	(-2,51)
Small x $Liq\_position_{it}$ (percent)	0,012[b]	0,008[b]	-0,002[a]	0,004
	(1,97)	(1,92)	(-2,87)	(0,75)
Market Liq_risk_{jt} (percent)	0,054[a]	-0,015[b]	-0,025[b]	-0,009[c]
	(4,10)	(-2,24)	(-2,61)	(-1,77)
Liq_supply [ln (mln)]	-0,081[a]	0,036[a]	0,015[a]	0,012[a]
	(5,27)	(3,82)	(4,51)	(2,86)
CB $rate\_inc_{jt}$	0,010[a]	0,011[b]	0,008[a]	0,004[b]
	(4,13)	(2,09)	(4,23)	(2,57)
BPI_{it-1}		0,231[a]		0,280[a]
		(8,21)		(8,87)
Net_borrow_{it-1}		0,164[a]		0,182[a]
		(7,02)		(6,12)
Constant		-9,115[a]		-6,072[a]
		(-4,72)		(-4,96)

Panel B

Log pseudolikelihood		-6874,2		-6145,5
Prob > chi2		0,008		0,011
rho		-0,054		-0,073
		[0,030]		[0,022]
sigma		2,946		2,105
		[0,845]		[0,612]
lambda		-0,159		-0,143
		[0,043]		[0,061]
Observations	1138	1892	1138	1892