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The Impact of Exogenous Liquidity Shocks on Banks Funding Costs: Microevidence from the Unsecured Interbank Market

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Abstract

This paper examines the impact of exogenous liquidity shocks in the unsecured interbank market. We evaluate the effects of idiosyncratic liquidity shocks—arising from deposits outflow at the bank level—and of the aggregate liquidity shock related to the U.S. tapering observed between May and September of 2013. We find that both liquidity shocks are associated with higher interbank loan prices, albeit the magnitude of the overprice and the impact on the access to interbank liquidity differ depending on the borrower-specific characteristics. More capitalized and liquid banks tend to pay less for liquidity—concurrent with evidence on market discipline—but also can absorb better the impact of exogenous liquidity shocks, suggesting benefits from capital and liquidity ratios. Our results suggest that lending relationships can alleviate funding costs during idiosyncratic liquidity shocks, while central bank liquidity contributes to smooth the impact of aggregate liquidity shocks. Results have implications for both financial stability and monetary policy transmission.

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

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

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1. Introduction

The unsecured interbank funds market is mainly used by financial institutions to hedge short-term liquidity against idiosyncratic liquidity shocks arising from the behavior of retail depositors (Freixas et al., 2000). Because there is no collateral pledged to the loan, participants in this market have powerful incentives to monitor each other and to maintain stable lending relationships to properly gain access when they face liquidity shocks (Rochet and Tirole, 1996). In normal times, the interbank market tends to be a stable source of short-term funding for banks allowing them to cover idiosyncratic liquidity shocks (Afonso et al., 2014). However, during aggregate liquidity shocks—as observed during the global financial crisis (GFC) of 2008—interbank market liquidity can quickly evaporate due to concerns over counterparty and liquidity risk of its participants (Brunnermeier and Pedersen, 2009; Angelini, et al., 2011; Acharya and Merrouche, 2013). This forced central banks to implement alternative liquidity facilities to alleviate liquidity tensions in the interbank market (Christensen et al., 2009; Allen et al., 2009; Freixas et al., 2011; Abbassi and Linzert, 2012). However, the unconventional monetary policies implemented in the U.S.—such as the quantitative easing (QE)—and Eurozone to alleviate domestic liquidity tensions have increased global liquidity, leading to capital inflows and easing the financial conditions in emerging markets (Mohanty, 2014; Tillmann, 2016; Anaya et al., 2017). Between May and September, 2013, Fed officials informed the market of the possibility of tapering its securities purchases [1] —i.e. the tapper tantrum—an unexpected announcement that had negative impact on financial markets in emerging economies, leading to capital outflows, exchange rate depreciation and increased funding costs (Eichengreen and Gupta, 2015; Bowman et al., 2015; Aizenman et al, 2016).

In this paper, we identify how exogenous liquidity shocks affect borrowing banks in the interbank market. We are particularly interested in understanding these related questions: i) How the availability and pricing of liquidity in the interbank market is affected by exogenous liquidity shocks? ii) Do banks respond differently to an idiosyncratic liquidity shock compared to an aggregate liquidity

[1] In early May 2013, Fed officials first began to talk of the possibility of tapering its securities purchases (gradually reducing them from $85 billion monthly to a lower level until its potential termination depending on the US economy conditions). However, in May 22, 2013, the Chairman Ben Bernanke raised the possibility of tapering in his testimony to the Congress, confirming the higher probability to initiate a tapering soon (Bernanke, 2013). The uncertainty related to the QE termination remained until September 17, 2013, when new data on the condition of the US economy led Fed officials to make statements that moderated prior expectations of tapering (Eichengreen and Gupta, 2015).

shock? iii) Can lending relationships and central bank liquidity mitigate the impact of exogenous liquidity shocks?

Our analytical framework is close to recent studies evaluating the behavior of banks under tight liquidity conditions in interbank markets (Angelini, et al., 2011; Acharya and Merrouche, 2013; Afonso et al., 2014; Bednarek et al., 2015; Braüning and Fecht, 2016). Unlike these studies—that center their analysis on the liquidity shock related to the GFC of 2008 in advanced economies—we focus on the role of market discipline, lending relationships and central bank liquidity in mitigating the impact of idiosyncratic and aggregate liquidity shocks on the interbank market in an emerging economy. We also contribute to this branch of literature by incorporating alternative measures of counterparty and liquidity risk—including bank's stability, banks' liquidity position and liquidity ratios—and by examining the role of secured funding from the central bank and form the money market in mitigating the impact of exogenous liquidity shocks in the interbank market.

Our main contribution consists in to evaluate two different types of liquidity shocks. First, because we can observe deposits outflow at the bank level, we use it as an approximation of idiosyncratic liquidity shocks (i.e. bank-specific shocks) that affect both prices and access to the interbank market (Freixas et al., 2000; Aschraft, et al., 2011). Second, we use the U.S. tapering—observed between May and September, 2013—as an aggregate exogenous liquidity shock and evaluate its impact on the interbank market. While most of the literature evaluating the U.S. tapering has focused on its impact using aggregate data at the country level (i.e. exchange rates, capital flows, equity, bonds, CDS, etc.)[2], we use microdata from the interbank market to identity its effect on the availability (and price) of short-term liquidity in an emerging market. Both shocks have in common that they are exogenous and that they affect the supply of liquidity to the banks. To our knowledge, the impact of idiosyncratic liquidity shocks—related to deposits outflow—and aggregate liquidity shocks—associated to the effects of the U.S. tapering—on interbank markets in emerging economies remains unexplored in the literature.

Our analysis uses a rich data set supplied by the CB of Colombia and the Financial Superintendence of Colombia (FSC). First, we use micro-level data on unsecured loans among the 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

[2] See for instance: Rai and Suchanek (2014); Eichengreen and Gupta (2015); Bowman et al., (2015); Aizenman et. al., (2016);Fratzscher, et. al., (2018).

to December 2014. The data set also has information of overnight-secured loans in the money market at the bank level. Unique to this paper, we employ observed data on overnight interbank loans instead of approximations of the interest rates and volumes extracted from large-value payment systems.[3] Second, we employ daily liquidity reports including CB' repo operations, deposits, reserve balances, cash holdings, liquid assets, and required reserves of banking institutions, which makes it possible to properly gauge the liquidity position of banks over time. Third, we match these data with bank-specific characteristics of size, risk, capitalization and liquidity using monthly balance sheet reports. The detailed information at the borrower-lender loan level and about lender and borrower specific-characteristics allow us to include a large set of fixed effects in the specifications to control for unobserved heterogeneity, isolate aggregate changes in liquidity, and disentangle supply from demand effects.

Our results contribute to the literature devoted to understand the behavior of the participants in the interbank market and provide new evidence on the effects of exogenous liquidity shocks in this market. First, we find that both exogenous liquidity shocks are associated to higher liquidity prices and that the overpriced and its impact on the access to interbank liquidity varies with bank-specific characteristics. We observe that, on the one hand, riskier banks pay higher prices and have less access to the market based on the existence of market discipline (Furfine, 2001; King, 2008) and that; on the other hand, these effects are stronger during exogenous liquidity shocks. In addition, large banks are found to pay less for liquidity and have more access to interbank funds—compared to small banks—which concurs with the behavior of surplus banks that exert market power in interbank markets (Allen et al., 1989; Acharya et al, 2012) and with evidence on implicit government guarantees (Angelini et al., 2011).

Second, we show that although banks facing idiosyncratic liquidity shocks pay higher prices, they are able to obtain funds in the interbank market to cover their liquidity needs by relying more on lending relationships (see, Cocco et al., 2009; Afonso et al., 2014; Braüning and Fecht, 2016). We observe that liquid banks—either banks with more stable reserves or higher collateral—can absorb better the impact of idiosyncratic liquidity shocks, highlighting the benefits from liquidity ratios on funding

[3] Thus, we can directly observe the characteristics of the interbank loans (i.e., rates, volumes, maturities and counterparties) as they are registered by the participants on a daily basis and reported to the FSC. Therefore, we avoid the disadvantages 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).

costs.[4] We also find that small banks are more prone to idiosyncratic liquidity shocks, and in turn suffer more in finding liquidity when they face higher credit and liquidity risk (Fetch et al., 2011).

Third, we identify that the U.S. tapering—our aggregate liquidity shock—was associated to increased loan prices in the interbank market and higher volatility in the availability of short-term liquidity. Moreover, less liquid and capitalized banks exhibited higher funding prices and less market access during that period. This result provides micro evidence on the negative impact of the U.S. tapering on funding costs in emerging markets filling the gap in the recent literature focused only on country level financial and macro data (Eichengreen and Gupta, 2015; Bowman et al., 2015; Aizenman et. al., 2016). Our findings also shed light on the transmission of the U.S. monetary policy to lending conditions in emerging economies (Dias et al, 2017; Morais et al, 2017), which concurs with the spillovers of the global financial cycle (Bruno and Shin, 2015; Rey, 2016).

Fourth, we observe that, unlike idiosyncratic liquidity shocks, lending relationships had lees effect on banks' access to the interbank market during the U.S. tapering, suggesting that hard information seems to dominate soft information during aggregate liquidity shocks (Bednarek et al., 2015). We find that, in turn, the higher central bank liquidity—which increased by 25% during this period—contributed to mitigate the impact of the U.S. tapering on the interbank market by allowing banks to obtain short-term funding at a large scale. This result not only provides evidence on the crucial role of central banks in alleviating liquidity tensions in the interbank market (Christensen et al., 2009; Allen et al., 2009; Freixas et al., 2011; Abbassi and Linzert, 2012), but also suggests that holding high quality collateral in the banks' portfolios contributes to hedging liquidity risk under aggregate liquidity shocks.

Lastly, our results highlight some benefits from the recent banking regulation. We observe that increased counterparty and liquidity risk is associated with reduced lending activity in the interbank market (Beltran et al., 2015); evidencing the crucial nexus between counterparty and liquidity risk in unsecured markets (Heider et al., 2015). This result implies that capital and liquidity regulatory requirements can contribute to enhance financial stability (Berger and Bowman, 2013; Pierret, 2015; Calomiris et al., 2015; Bonner and Eijffinger, 2016).

[4] Bonner and Eijffinger (2016) show that banks close to their short-term regulatory liquidity requirement pay and charge higher interest rates in the Dutch unsecured interbank market.

The remainder of this paper is organized as follows. Section 2 provides the background of the Colombian interbank market and shows initial evidence of the impact of exogenous liquidity shocks on the interbank market. Section 3 presents the methodology, and the variables employed in the models' estimation. Section 4 discusses the results. Section 5 presents robustness checks and extensions of the baseline models. Finally, section 6 concludes.

2. The interbank market

The Colombian interbank funds market is an unsecured market for liquidity in which participants impose counterparty limits among themselves based on their credit risk assessments[5]. This behavior 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 that banks can trade in this market. During the period 2011-2014, approximately 75% of interbank loans were agreed upon at an overnight maturity, demonstrating that it is a short-time market for liquidity. The participants in the interbank market are banking institutions divided into the following categories: commercial banks, financial companies specializing in retail loans and corporate loans for small and medium firms, and financial corporations that operate as investment banks. During the evaluated period, 53 banking institutions participated in the interbank market. Despite the differences in their banking business, these credit institutions usually exchange liquidity among themselves, although large commercial banks tend to be the most active participants, playing the role of super-spreaders of central bank liquidity throughout the interbank market (see León, et al., 2018). As a result, the interbank market rate tends to be close to the CB rate due to it is the target rate for the monetary policy implementation (**Figure 1A**).

2.1. Idiosyncratic liquidity shocks and the interbank market

We are interested in understanding the influence of exogenous liquidity shocks on the interbank market. We first evaluate whether borrowing banks suffering deposits outflow (our measure of idiosyncratic liquidity shocks) obtain interbank liquidity at different prices. In **Table 1,** we classify all interbank loans granted during 2011-2014 that involve a borrower bank suffering an idiosyncratic liquidity shock (i.e. a deposits outflow) compared to loans in which the borrower does not exhibit

[5] The credit risk regulation establishes a lending concentration limit of 10% among banks, meaning that a bank is not allowed to have more than 10% of the total lending with a single counterpart.

such liquidity shock.[6] We observe that loans associated to idiosyncratic liquidity shocks are priced at higher spreads, albeit those loans do not entail grater cross-sectional standard deviations of borrowing rates compared to loans with no liquidity shocks involved. We also observe a higher volume of granted loans, and more lending and borrowing banks, concurrent with the regular activity of the interbank market under idiosyncratic liquidity shocks (Afonso et al., 2014).

In **Table 2** we present mean comparison tests of idiosyncratic liquidity shocks and interbank market activity distinguishing between small and large banks. This allows to explore whether idiosyncratic liquidity shocks may affect differently banks depending of their size. In panel A, we evaluate the frequency and magnitude of idiosyncratic liquidity shocks derived from the behavior of depositors by computing the rate of change in deposits, and the deposits outflow (change and number of days) for participating banks of the interbank market. We classify large (small) banks as those with assets value higher (lower) than the 66th (33th) percentile of the assets distribution during the evaluated period. We observe that large banks tend to have a higher growth of deposits (0.056) compared to small banks (0.011), and that small banks exhibit negative liquidity shocks more frequent than large banks. During the evaluated period, small banks registered a negative rate of growth of deposits for 423 days of the 982 effective days, while large banks exhibit negative liquidity shocks on 327 days, i.e., 43% and 33%, respectively. This seems to be reflected in the distribution of the idiosyncratic liquidity shocks for small and large banks (**Figure 1, panel a**). In **Table 2** (panel B), we observe that on average, small banks pay 3.0 bps *over* the CB rate for an interbank loan while large banks pay 1.5 bps *under* the CB rate. Indeed, we find a different distribution of borrowing rates between large and small banks (**Figure 1, panel b**). We identify ample differences between small and large banks in terms of the amount of funds that they exchange in the interbank market. On average, small banks borrow COP$1.39 billion and lend COP$7.61 billion per day, while large banks borrow COP$16.23 billion and lend COP$7.15 billion. That is, small banks borrow almost ten times less liquidity in the interbank market than large banks, but both lend relatively similar quantities. The implication is that large banks behave as net borrowers in the interbank market while small banks behave more as net lenders (as documented by Allen et al., 1989; Furfine (2001) for the U.S. federal funds market). These findings confirm that small banks are more vulnerable to adverse liquidity shocks and that finding liquidity can be more expensive for those banks compared to large banks (as documented by Fecht et al., 2011).

[6] In particular, we select all interbank loans of the borrower bank that had a negative rate of change of deposits in t-1 and, 0 otherwise.

2.2. Aggregate liquidity shocks and the interbank market

In addition to the prolonged lower interest rates in the U.S., the QE program significantly increased capital flows into emerging markets in search of higher returns (Mohanty, 2014). However, between May and September 2013, the announcements from the Fed officials on the possibility of reducing the purchase of assets (i.e. the U.S. tapering) affected negatively financial markets in emerging economies[7] (Eichengreen and Gupta, 2015; Bowman et al., 2015; Fratzscher, et. al, 2018). The announcements of the Fed officials were understood by the market as a signal on the gradual termination of the QE program and to the beginning of the U.S. monetary policy normalization (Aizenman et al., 2016), leading to exchange rate depreciation, capital outflows and increased funding costs in emerging markets[8]. The U.S. tapering was an aggregate liquidity shock that significantly affected expectations on short-term liquidity, raising concerns among financial authorities in Colombia (see, Banco de la República, 2013a; Banco de la República, 2013b)[9]. The Colombian government bonds' yields exhibited a rapid increase during the U.S. tapering. The 5-year government' yields (TES) increased from 4.77% in late April to 5.97% at the end of May (i.e. an increase of 120 bps right after the first announcement of the U.S. tapering) and by the end of June, the TES rates achieved 6.84% (i.e. 87 bps more after the second Fed's announcement), following similar trend than the 10-years U.S. Treasury bills (**Figure 3A**).

We are interested in identifying how participants of the interbank market reacted to this aggregate liquidity shock. In **Figure 2**, we observe that the interbank market exhibited higher rates and greater volatility during the U.S. tapering. During the first week of the U.S. tapering announcement (between May 22 and May 30, 2013) the interbank rate exhibited a rapid increase—from 3.12% to 3.26% (i.e. 14 bps or 4.5%)—reaching a level above to the CB rate, and the highest level since the last change of the CB policy rate (i.e. the period between March 27 and May 21, 2013). In the following weeks, the interbank rate exhibited greater volatility, and by the last week of July it again reached a level above

[7] The uncertainty related to the QE termination began in May, 22, 2013 with the Bernanke's speech to the U.S. Congress (Bernanke, 2013) and remained until September, 17, 2013 when the Fed moderated prior expectations of tapering (Eichengreen and Gupta, 2015).

[8] The impact of this aggregate liquidity shock concurs with the spillovers effects from the U.S. conventional and unconventional monetary policies on emerging markets (see, Rey, 2016; Morais, et al., 2017; Dias et al., 2017). Bruno and Shin (2015) show that a contractionary shock to U.S. monetary policy leads to a decrease in cross-border banking capital flows and a decline in the international banks' leverage.

[9] The minutes of the Central Bank of Colombia in May and June mentioned the concerns of the Board members on the financial markets volatility in advanced and emerging markets. In the minutes of June, the Board specifically mentioned that the U.S. tapering has increased the volatility in the international financial markets, which was reflected in a rise in interest rates on Colombian government and private bonds (Banco de la República, 2013b).

the CB rate, followed by a significant decline in the volume of loans from COP 1,000 million to COP 200 million (**Figure 2**, right axis). During the rest of the U.S. tapering period (i.e. until September 17, 2013), the interbank rate remained above the CB rate, and the volume of loans exhibited greater variation. **Figure 3** and **Figure 4** confirm the greater volatility in both interbank market rates and loan volume during the U.S. tapering period—compared to the periods before and after this aggregate liquidity shock—indicating that participants of the interbank market faced higher funding costs and greater uncertainty in accessing the market during the U.S. tapering period.

In **Table 3,** we present the results of a mean comparison test that allows to identifying whether banks behave differently in the interbank market during the U.S. tapering period. We compare interbank market conditions during the U.S. tapering period and the previous period since the last change of the CB policy rate. We find that during the U.S. tapering the mean loan volume was 13% lower compared to the volume observed the period before. Spite of the interbank rate remained below the CB rate, we observe significantly higher loan spreads and greater volatility of borrowing rates compared to the period before the U.S. tapering. We also identify that during the U.S. tapering there was an increase in the number of borrowing banks and a decline in the number of lending banks. This suggests that the announcement of the U.S. Fed officials related to the possibility to reduce the purchases of assets forced surplus banks to hoard liquidity and in turn, deficit banks had to borrow funds at higher rates. In addition, the wider dispersion across individual borrowing rates during the US tapering period may reflect concerns over counterparty risk across banks, which can be related to uncertainty over the availability of short-term liquidity, which force banks to hoard liquidity for precautionary reasons (see, Diamond and Rajan, 2011; Acharya and Skeie, 2011; Ashcraft et al., 2011; Acharya and Merrouche, 2013).

Since May 2013, the CB kept its policy rate unchanged and increased the liquidity supply through the daily repo operations (**Figure 1A**), mainly in response to the weak economic growth and the higher uncertainty in financial markets (Banco de la República, 2013b). Indeed, between March 26 and May 21, 2013 (before the U.S. tapering) the median daily repo auction was 3.6 billion COP, while during the U.S. tapering it reached 4.5 billion COP (i.e. an increase of 25% in the short-term liquidity granted by the CB) (**Figure 4, panel a**). The higher volatility in the interbank market was also reflected in a greater volatility of the banks' reserves holdings accompanied by a slightly increase in the system's excess of reserves (**Figure 4, panel b**), which can suggest evidence of liquidity hoarding. Nevertheless, the greater liquidity granted by the CB seems to mitigate the transmission of the U.S.

tapering to the deposits market as the rate of growth of deposits remained relatively stable and in similar levels to the ones observed during the entire period 2011-2014 (**Figure 2A**).

3. The empirical model

The proposed approach relies on the drivers of liquidity demand developed by Heider et al., (2015), in which the decision to borrow—but not the decision to lend—in an unsecured market depends on the banks' own risk, and the market conditions. Thus, our model relates bank-specific characteristics of borrowing banks and market conditions to the prices and availability of funds negotiated in the interbank market. We employ a Heckman-type model to correct for the selection bias in the sample of borrowing banks, which further allows the drivers of bank access to interbank market liquidity to be identified. To achieve identification, we employ a large set of fixed effects that allows to control for unobserved heterogeneity and to disentangle supply from demand effects, as well.

More concretely, because we only observe the interest rate of an interbank loan when it is granted, we need to account for the possibility of a sample selection on unobservable conditions. Thus, we employ a Heckman-type selection model to account for the potential selection bias (Heckman, 1979). This model is proposed because if the bank's decision to participate in the interbank market is non-random, then the estimated coefficients will be inconsistent (Acharya and Merrouche, 2013; Braüning and Fecht, 2016). The model combines a selection mechanism for participating in the interbank market with a regression model.

The selection equation is as follows:

$$z^*_{ijt} = \gamma' w_{ijt} + \mu_{ijt.} \qquad (1)$$

The regression model is:

$$p_{ijt} = \beta' X_{ijt} + \varepsilon_{ijt} \qquad (2)$$

In (1), z^*_{ijt} is not observed; the variable is observed as:

$$z_{ijt} \begin{cases} 1 \quad if\ z^*_{ijt} > 0 \text{ with Prob}_{(z_{ijt}=1)} = \Phi(\gamma' w_{ijt}) \\ 0 \quad o.w. \quad \text{with Prob}_{(z_{ijt}=0)} = 1 - \Phi(\gamma' w_{ijt}) \end{cases} \qquad (3)$$

In the regression model (2), the latent variable p_{ijt} (i.e. the price of the loan) is observed only if $z_{ijt} = 1$, which in our case, indicates that the bank *i* borrows liquidity form bank *j* in the interbank market at time *t*; where X_{ijt} is a vector of variables (i.e. bank-specific characteristics and market conditions) that determine p_{ijt}. The bank's decision to borrowing liquidity is modeled by the selection equation (1), under the mechanism denoted in (3), where w_{ijt} is a set of variables assumed to determine whether z_{ijt} is observed, and ϕ is the standardized normal cumulative distribution function. Therefore, in the selected sample, we have the following:

$$E\,[p_{ijt} \mid z_{ijt} = 1] = \beta' X_{ijt} + \rho\, \sigma_{\varepsilon}\, \lambda\, (\gamma' w_{ijt}) \qquad (4)$$

In (4), λ is the inverse Mills ratio. In addition, $(\mu_{ijt}, \varepsilon_{ijt})$ are assumed to be bivariate normal, with $\mu_{ijt} \sim N(0, 1)$; $\varepsilon_{ijt} \sim N(0, \sigma_{\varepsilon})$ and $corr(\mu_{ijt}, \varepsilon_{ijt}) = \rho$. Thus, if $\rho \neq 0$, then standard ordinary least squares (OLS) models applied to (2) will yield biased results. To overcome this problem, we employ a two-step Heckman-type selection model which provides consistent parameter estimates of the second-stage parameters.[10] Under this approach, we first estimate a standard Probit model using equations (1) and (3), then correct for the possible selection bias by including the inverse Mills ratio in the price equations (2) and (4), which are estimated by OLS. Note that in (4), w_{ijt}, is a vector that contains the same set of variables than X_{ijt}, plus an additional variable that validates the Heckman's exclusion restriction.[11]

We are particularly interested in identifying whether exogenous liquidity shocks can exacerbate concerns over counterparty and liquidity risk, affecting the price and availability of liquidity in interbank markets. Thus, we perform two exercises including the interaction terms of our measures of idiosyncratic and aggregate liquidity shocks with the set of variables in X_{ijt} (and w_{ijt}), which capturing the bank-specific characteristics of the borrower *i*, and market conditions observed at *t*. More specifically, the influence of the idiosyncratic liquidity shock in (4) is identified as:

[10] In order to have borrowing and non-borrowing banks in *t*, we match the bank-specific-characteristics of *all* the banks operating at time *t* with the interbank loan data. Thus, in our matched data, we have banks that are active in the financial system but are not borrowing funds from the interbank market (z=0), compared to banks that are both active and borrowing from the interbank market (z=1) (Braüning and Fecht, 2016).

[11] The Heckman model centers on a valid exclusion restriction: the selection equation should contain at least one variable that is not in the outcome equation. Thus, in (1), we employ an additional variable that conditions the likelihood that a bank will borrow from the interbank market and that is part of w_{ijt}, namely, excess reserves. The rationale is that banks with low (or negative) values in this ratio exhibit a deficit of reserves, and in turn, they are more willing to borrow in the interbank market to fulfill the reserve requirement (as in Braüning and Fecht, 2016).

$$\beta' X_{ijt} (\gamma' w_{ijt}) = \beta_1 * Liquidity\_Shock_{it} + \beta_2 * Liquidity\_Shock_{it} \times Borrower\_Characteristics_{it} + \beta_3 * Liquidity\_Shock_{it} \times Market\ Conditions_t + FE_{ijt} \quad (5)$$

In a similar form, the impact of the aggregate liquidity shock related to the U.S. tapering can be identified as:

$$\beta' X_{ijt} (\gamma' w_{ijt}) = \beta 1 * US\ Tapering_t + \beta 2 * US\ Tapering_t \times Borrower\_Characteristics_{it} + \beta 3 * US\ Tapering_t \times Market\ Conditions_t + FE_{ijt.} \quad (6)$$

Where, $Borrower\_Characteristics_{it}$ includes bank size, counterparty risk measures (i.e. credit risk, capital ratio and z-score), liquidity risk and measures of lending relationships. $Market\ Conditions_t$ is composed of a measure of market liquidity risk and the CB's supply of liquidity. These variables are explained in the data section. In (5), $Liquidity\_Shock_{it}$ denotes an idiosyncratic liquidity shock faced by the borrower bank *i* at time *t* (i.e. deposits outflow), while in (6), $US.\ tapering_t$ corresponds to our aggregate liquidity shock observed during the period *t* in which the Fed announced to the market the possibility of reducing its purchase of assets (between May 22 and September 17, 2013).[12] We saturate the model with a large set of fixed effects (FE_{ijt}) that allow us to control for unobserved heterogeneity and to disentangle supply from demand effects. In particular, we include borrower fixed effects, to control for unobservable bank characteristics of borrowing banks, borrower*lender fixed effects, to account for borrower-lender variation in credit that may affect borrower's participation and loan pricing in the interbank market. We also include lender*time fixed effects to control for variation in supply by lenders in a particular period. Thus, variation in demand of liquidity of a bank from this lender in that period will reflect demand factors as the common supply effect is controlled for. Lastly, we include daily fixed effect to isolating aggregate changes in liquidity.

3.1. Variables

We employ a unique data set composed by the universe of overnight-unsecured bilateral loans among the financial institutions participating in the Colombian interbank market. We match the interbank loans with banks' daily liquidity reports (including access to CB repo operations) and banks' balance sheet information to compute bank specific-characteristics related to liquidity, credit risk, size, and

[12] Because we do not observe a significant variation in the deposits outflow during the US tapering period (Figure A2), we can treat both exogenous liquidity shocks (independently) and compare the results from equation (5) and (6).

capitalization. Thus, we construct a daily panel composed of 25,910 unsecured overnight loans granted among 53 financial institutions between January 2011 and December 2014. Summary statistics and definitions of the set of variables employed in the model are presented in **Table 3A** in the appendix.

Our baseline dependent variable in (1) is the match of a borrower bank with a lender bank (i.e. loan), which in case of a successful match ($z_{ijt} = 1$) indicates that the bank *i* borrows liquidity form bank *j* in the interbank market at time *t.* In (2), our dependent variable is the price of liquidity (p_{ijt}), which is defined as the spread in bps between the volume-weighted average interest rate paid by bank *i* to bank *j* over all its overnight unsecured loans during the day (*t*) and the CB rate in *t*. We use the spread to the CB rate because all interbank market participants have access to the regular liquidity of the CB.[13] Thus, p_{it} gauges how costly the liquidity is compared to the CB liquidity.

The main goal of the proposed model is to identify the impact of exogenous liquidity shocks on the price and availability of interbank funds. We employ two alternative liquidity shocks that differ in their nature. First, we use the bank's deposits outflow as our measure of idiosyncratic liquidity shocks, based on that banks suffer from liquidity shocks associated with unexpected withdrawals by their depositors that condition their liquidity (Frexias, et al., 2000; Ashcraft et. al. 2011). Thus, if the bank suffers a deposits outflow in *t-1*, it may force the bank to borrow in *t* from the interbank market and (depending on the bank's characteristics and market conditions) it may entail a greater borrowing cost. In particular, we define the borrower's $\textit{liquidity shock}_{it}$ as a dummy variable equal 1 if the rate of change of the deposits of bank *i* is negative in *t-1* and, 0 otherwise.

Second, we employ the U.S. tapering as an aggregate liquidity shock that may affect the prices of interbank funds as it affected financial conditions in emerging markets (see, Eichengreen and Gupta, 2015; Bowman et al., 2015). As reported in **Figure 2**, **Figure 3** and **Table 3,** this announcement was associated with higher volatility in both the price and the availability of interbank funds. We define $\textit{US tapering}_t$ as a dummy variable equal to 1 during the period *t* in which the Fed announced to the market the possibility of reducing its purchase of assets: between May 22 and September 17, 2013, and 0, during the period immediately before (since the last change of the CB policy rate), that is, between March 23 and May 21, 2013.

[13] All interbank market participants are credit institutions with regular access to central bank liquidity that includes intraday and daily liquidity auctions and overnight liquidity facilities.

As we are particularly interested in identifying the role of counterparty risk in explaining the liquidity prices in the interbank market, we employ alternative measures aimed at capturing counterparty risk of a bank.[14] Initially, we include the ratio of non-performing loans over total loans (*npl*) and the capital ratio (*car*), defined as capital equity (Tier I and Tier II) over risk-weighted assets.[15] We expect that banks with a higher credit risk in their loan portfolios and lower capital ratios pay more for liquidity, given that their creditors tend to charge higher prices to less healthy banks (see Furfine, 2001; King, 2008; Gorton and Metrick, 2012).[16] We compute the bank's *z-score*, which gauges the risk-taking of a bank.[17] This indicator is defined as the sum of the mean rate of the return on assets (ROA) of a bank *i* (μ_{roa}) and the mean equity-to-assets ratio (*car*) divided by the standard deviation of the ROA σ_{roa}; that is, $z\text{-}score_{it} = (\mu_{roa} + car_{it} / \sigma_{roa})$. It tells us the number of *roa* standard deviations that a bank's ROA must decrease to surpass equity. Thus, a lower z-score indicates a higher probability that a bank will become insolvent, which we expect to be reflected in higher loan prices, suggesting evidence of market discipline.[18] The interaction between our measures of exogenous liquidity shocks and the set of borrower's counterparty risk measures further allows to identifying whether banks approaching insolvency or facing higher credit risk tend to pay more for their liquidity during exogenous liquidity shocks.

We employ several measures of liquidity to gauge the impact of liquidity risk on the price of interbank funds. First, as the liquidity position of banks is affected by the reserve requirements, we expect that banks short on reserves may face liquidity squeezes when approaching the fulfillment date of their reserve requirements, forcing them to borrow funds from the interbank market (Fecht et al., 2011). Thus, to account for the liquidity position of a bank in terms of its reserves holdings, we include a measure of the bank's excess reserves ($excess\_reserves_{it}$). This variable is defined as the bank's reserve holdings less the amount that a bank needs to hold on a daily basis for the balance of the reserve

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[14] Market discipline considers that if a bank is taking too much risk and its creditors can identify this behavior, then they will request a higher return (i.e., risk premium) that will be reflected in the market prices (Berger, 1991; Flannery, 2001). Evidence on market discipline in financial markets can be found in Sironi (2003); Flannery (2010); Demirgüç-Kunt and Huizinga (2013) and Gurara, et. al., (2018).

[15] Colombian regulation establishes that the 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.

[16] This is based on the role of peer monitoring given that banks usually have information on the riskiness of their peers and can observe their behavior from different markets (Rochet and Tirole, 1996)

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

[18] 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 we combine these with the current *t* values of the equity ratio (car_{it}). Sarmiento et al., (2017) find that banks that consistently pay high borrowing rates in the interbank market exhibit low z-score values, demonstrating their higher riskiness.

maintenance period to exactly fulfill the reserve requirements, divided by the average daily required reserves during the month. Thus, banks with low (or negative) values in this ratio exhibit a deficit of reserves, and in turn, they are more willing to borrow in the interbank market to fulfill the reserve requirement. This variable is included only in the selection model to account for the Heckman exclusion restriction (Braüning and Fecht, 2016).

Second, we argue 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 liquidity risk of a bank *i* at time *t* ($Liquidity\_risk_{it}$), defined as the standard deviation of the daily change in the reserve holdings of the bank during the last 30 days, normalized by the reserve requirements (as in Braüning and Fecht, 2016). In order to evaluate the effect of the bank's structural liquidity on the price and availability of interbank funding, in alternative specifications we employ the ratio of liquid assets to total assets ($Liquidity\_ratio_{it}$). We consider that banks with lower liquidity can be more affected by exogenous liquidity shocks forcing them to borrow funds at higher prices to cover their liquidity needs. We evaluate this prediction by employing a set of interactions between the measures of liquidity risk and our exogenous liquidity shocks.

As we observe in **Table 2**, bank size seems to play an important role in liquidity pricing. We control for this effect by including the natural log of the value of a bank's assets ($size_{it}$). We are also interested in testing whether, compared to large banks, small banks are more penalized by their creditors when they face higher liquidity risk and counterparty risk. To account for these effects, we include two interaction terms $small*liq\_risk_{it}$ and $small*npl_{it}$, where small is a dummy variable equal to one if the bank's assets are below the 33^{th} percentile of the assets distribution in the sample and zero otherwise. In addition to this, we interact our exogenous liquidity shocks with the latter set of variables to check whether the concerns over counterparty risk and liquidity risk increased when small banks suffer exogenous liquidity shocks.

Lending relationships play a key role in determining the access of banks to the interbank market. Banks with stable lending relationships benefit from greater access to the interbank market, which contributes to hedging liquidity risk (Cocco et al., 2009; Affinito, 2013; Afonso et al., 2014; Braüning and Fecht, 2016). To account for this effect, we employ tow alternative measures: relationship lending (RL_{ijt}) and the borrowing preference index (BPI_{ijt}). The *RL* gauges the frequency of interactions between two banks in the interbank market (Furfine, 1999) and is computed by the logarithm of one plus the number of days a bank *i* has lent to bank *j* over a certain time of period *T* as: RL_{ijt}= log (1+

$\sum_{t \epsilon T} I(y_{ijt} > 0)$). We expect that banks that keep stable lending relationships have more access to the interbank market and can benefit from lower prices. The BPI_{ijt} is computed as the amount of funds borrowed by bank *i* from bank *j* at time *t* (q_{ijt}) over period *T* relative to the overall amount borrowed by bank *i* over the same period *T* as: $BPI_{ijt} = \sum_{t \epsilon T} y_{ijt'} / \sum_j \sum_{t' \epsilon T} y_{ijt'}$.[19] Hence, if a bank has higher concentration of counterparties providing liquidity (high *BPI*), it is more likely that it accesses the market on a regular basis to cover its liquidity needs. We consider that a higher frequency and concentration of lending relations may contribute to absorb the impact of idiosyncratic liquidity shocks (as in Afonso, et al., 2014). However, in case of an aggregate liquidity shock, the dependence on a small set of counterparties may lead to higher prices, as all the interbank market participants are being affected by the same liquidity shock (Bernarek, et al., 2015). We check these predictions, by using the interaction of our exogenous liquidity shocks with the lending relationships measures.

Market conditions play a key role in determining the access of banks to the interbank market. In our specification, we include several variables to account for the effects of market conditions. First, we include our measure of liquidity risk; however, it is computed across all banks *j* at time *t*, which corresponds to the standard deviation of the normalized excess reserves among banks, namely, $Market\ Liq\_risk_t$. The intuition here is that in the presence of liquidity imbalances across banks, the liquidity demand tends to increase because more banks need funds, which, in turn, would affect both the prices and volumes in the interbank market. Second, as noted above, all interbank market participants have access to the liquidity of the CB. Thus, we expect that increases in the liquidity supply by the CB might increase the activity of the interbank market and exert downward pressure on interbank prices (León et al., 2018). We account for this effect by including the log of the total liquidity supply of the CB at time *t* ($CB\_Liq\_Supply_t$).[20] We are also interested in testing whether the access to secured money markets alleviates funding costs in the interbank market based on the premise that using collateral reduce borrowing costs (Allen et al., 1989), and on the benefits from diversification across money markets (León and Sarmiento, 2016). To do this, we employ a dummy variable equal to 1 if the bank *i* borrows funds in the secured money market in time *t*, and zero otherwise ($Borrowing\ secured_{it}$). Then, we include the interactions of our exogenous liquidity shocks with the set of market conditions to check whether these shocks exacerbate concerns on market liquidity conditions. In **Figure 4**, we observe that during the U.S. tapering the CB significantly

[19] We set the variable to zero if the denominator is zero, which means that the banks did not borrow at all.
[20] 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 bps over the central bank rate.

increased the liquidity supply, while the volatility of reserve holdings raised suggesting the presence of liquidity imbalances across banks.

4. Results

4.1. Evaluating the impact of idiosyncratic liquidity shocks in the interbank market

In this section, we present results on the effect of idiosyncratic liquidity shocks in accessing and pricing interbank funds. In **Table 4 (panel a)**, columns (1) to (6), we present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market (z_{it} =1). In **Table 4 (panel b)**, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). Columns (3) to (6) and (9) to (12) incorporate the effects of our idiosyncratic liquidity shock (deposits outflow) in accessing and pricing funds in the interbank market, respectively. All models have borrower, borrower*lender and time fixed effects to control for unobservable effects of the borrower, borrower-lender availability of credit, and aggregate changes in liquidity, respectively. In columns (6) and (12) we check the robustness of our baseline results under a more demanding specification that includes lender*time fixed effects in order to control for variation in supply by lenders in a particular period and thus to capture variation in demand of liquidity (as the common supply effect is controlled for). In addition, we cluster robust standard errors at the borrower bank level.

4.1.1. Accessing the interbank market during idiosyncratic liquidity shocks

The specification in **Table 4** column (1) includes our set of counterparty risk measures along with the variables of lending relationships and the supply of CB liquidity. This specification allows to identify the impact of counterparty risk of the borrower bank on the access to the interbank market liquidity by controlling for lending relationships and market conditions. Results indicate that banks with higher capital ratios are more likely to borrow liquidity from the interbank market. Interestingly, banks with a higher share of non-performing loans are less likely to borrow from the interbank market. A 1% increase in the share of non-performing loans is associated with 9.1% less probability to borrow from the interbank market. These results confirm that riskier banks have less access to the interbank market (King, 2008, Furfine, 2001). The estimated coefficient of size indicates that the larger the bank, the higher the likelihood that it will borrow from the interbank market. This coincides with our findings in **Table 2**, confirming that large banks have incentives to be net borrowers in the interbank market, which can be associated the existence of too-big-to-fail implicit guarantees (Angelini et al., 2011; Davies and Tracey, 2014; Sarmiento and Galán, 2017). We also observe that banks are more likely to obtain funding from a credit bank with whom they had stablished lending relationships compared to a spot lender (Cocco et al., 2009).

In column (2), we include the liquidity position at the bank level (liquidity risk) and across banks (market liquidity risk) to gain further insights into the role of liquidity risk in accessing to the interbank market. We find that banks with a greater liquidity needs are more likely to borrow funds from the interbank market while the opposite is true for banks with excess reserves. The estimated coefficient of *excess reserves*—our additional variable in the selection model—suggests that banks holding large reserves are 11.8% less likely to borrow from the interbank market, while banks facing a higher liquidity risk are 6.3% more likely to borrow liquidity. This result indicates that banks short on reserves or with higher uncertainty over their liquidity needs are more prone to borrowing funds from the interbank market. In addition, we identify that the probability of borrowing liquidity from the interbank market falls 2.7% when liquidity positions across banks are more imbalanced, suggesting lower activity under higher uncertainty over liquidity conditions among banks, which can be associated to precautionary motives (Diamond and Rajan, 2011; Acharya and Skeie, 2011).

In column (3) we include our idiosyncratic liquidity shock (deposits outflow) and interaction terms with bank-specific-characteristics and market conditions. We find that banks facing deposits outflow are 18.1% more likely to borrow liquidity from the interbank market. Interestingly, the estimated coefficient of RL suggests that banks affected by this liquidity shock are 16.3% more likely to get funding from a credit bank with whom they had stablished lending relationships in the past 30 days, compared to a spot lender. This result confirms the role of lending relationships in overcoming liquidity shocks (Cocco et al., 2009; Braüning and Fetch, 2016). We also observe that—under idiosyncratic liquidity shocks—more capitalized banks are more likely to get funding from the interbank market. In addition, higher CB liquidity supply also contributes to overcome the idiosyncratic liquidity shocks faced by borrowing banks in the interbank market. This result was expected as all interbank market participants have access to the discount window facility, which is mainly used to overcome bank-specific liquidity shocks.

In column (4), we extend the model by including the interactions of liquidity shocks with our measures of liquidity risk. We observe that greater market liquidity risk significantly reduces the probability of a bank to borrow from the interbank market, suggesting that higher uncertainty over the availability of liquidity may induce liquidity hoarding affecting more those banks with higher liquidity needs.

In column (5), we test whether small banks are more affected in accessing the interbank market when facing higher credit and liquidity risk. We find that small banks are more vulnerable to changes in their credit risk because their probability of borrowing funds decreases more than the probability for large banks. The total estimated coefficients indicate that small banks have a 13.0% lower probability of borrowing funds while for large banks this probability is 8.2%. These results suggest that when credit risk increases, small banks have less access to interbank liquidity than large banks. We also find that the probability of accessing the interbank market for a small bank facing a higher liquidity risk does not significantly differ from that for a large bank in the same situation. However, we do observe that under idiosyncratic liquidity shocks, a small bank has 24.4% less probability of borrowing liquidity compared to a large bank (compare 9.6% vs 12.7%). Lastly, in column (6), we identify that our results are robust to the use of lender*time fixed effects, which suggests that we are capturing how the idiosyncratic liquidity shocks affect the demand for liquidity in the interbank market.

4.1.2. Idiosyncratic liquidity shocks and the price of liquidity

After identifying the drivers of a bank to borrow from the interbank market, we estimate the pricing models. Results are presented in **Table 4** (**panel b**). The specification in column (7) includes the bank size and the measures of counterparty risk along with the variables of lending relationships and supply of CB liquidity. The results indicate that the price of liquidity decreases with increase in bank size, 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). This result is also consistent with the hypothesis that large banks enjoy lower funding costs in financial markets (Bertay, et al., 2013). We also find that more capitalized banks pay less for liquidity. The estimated coefficient indicates that a 1% increase in the capital ratio (*car*) is associated with a discount on the price of interbank funds of 7 bps. Holding a higher credit risk in the bank's portfolio is associated with higher liquidity prices in the interbank market. This result shows that in the interbank market, riskier banks seem to be charged a risk premium (Furfine, 2001). Banks with stable counterparties are associated with a significant lower spread, confirming the importance of lending relationships in interbank markets (see Cocco, et al., 2009; Craig et al., 2015; Braüning and Fetch, 2016). The estimated coefficient of RL has an economic and significant impact: a bank pair that interacted on any given day in the past month will agree on an interest rate that is about 4 bps lower than the spread agreed on a bank pair that did not trade during the prior month.[21] In addition, we observe the higher CB liquidity is associated to lower prices in the interbank market, indicating that CB liquidity can exert downward pressure on market interest rates (Christensen et al., 2009; Allen et al., 2009)

In column (8), we include variables that gauge the liquidity position both at the bank level and across banks to gain further insights into the role of liquidity risk in liquidity pricing. We find that higher volatility of the reserve holdings of borrowing banks is associated with higher loan prices. This effect is captured by our measure of *Liq_risk*, which is significant, although with a relatively small effect. Hence, banks with higher uncertainty over their liquidity needs are associated with higher liquidity prices (Fecht et al., 2011). Liquidity imbalances across banks are associated with higher prices as well. The estimated coefficient of *Market Liq_risk* is positive and highly significant. Note that the estimated coefficient of *Market Liq_risk* (0.065) is considerably larger than that observed at the bank level (0.031). This difference suggests that the price of liquidity in the interbank market is more sensitive to changes in the market liquidity conditions.

In column (9), we include our measure of idiosyncratic liquidity shocks (*Liq. Shock*) and interaction terms with bank-specific-characteristics and market conditions. We find that a deposits outflow force banks to borrow at significant higher prices. On average, a bank facing a deposits outflow in *t-1* pays 5.13 bps more on an interbank loan in *t*, compared to a day in which it has no deposits outflow. Second, we identify that this liquidity shock seems to have more impact over small and riskier borrowers. The estimated coefficient of the interaction term *Liquidity_shock*size* suggests that large banks pay a lower spread even when they are affected by a deposits outflow. The rationale of this effect can be related to the behavior of smaller banks whose prefer lending to larger banks even at lower rates due to too-big-to-fail considerations (Angelini et al., 2011). Indeed, large banks behave more as net borrowers while small banks as net lender in the interbank market (**Table 2**). Deposits outflow does not affect more the prices of interbank funds for less capitalized banks, but they do increase prices for borrowers with higher credit risk exposition. The estimated coefficient of *Liquidity_shock*npl* indicates that, if a borrower faces a deposits outflow, an increase of 1% in the borrower's share of non-performing loans adds 1.2 bps of spread (an additional 22.2%) compared to a day in which the borrower has no deposits outflow. This finding is consistent with the view that liquidity risk and counterparty risk are intrinsically linked (Heider et al., 2015). Third, we find that lending

[21] The effect is computed as -1.181 x (log(31) – log (1)=-4.05.

relationships alleviate borrowing costs for banks suffering idiosyncratic liquidity shocks.[22] During a deposits outflow, banks that rely more on lending relationships—compared to spot borrowers—can obtain a lower spread of about 5.4 bps for interbank funds.[23]

In column (10), we include the interaction terms of our idiosyncratic liquidity shock with measures of liquidity risk. Borrowers facing greater liquidity risk have a significant higher spread associated to deposits outflow. The estimated coefficient of the interaction term *Liq_Shock*Liq_risk* indicates that if a borrower bank faces a deposits outflow, one standard deviation of the ratio between the daily change in the reserve holdings of the bank (during the last 30 days) and the reserve requirements, leads to a premium of 0.7 bps (i.e. 14.3% more compared to the same effect during a day without deposits outflow). During deposits outflow, borrowers' funding costs are more affected by liquidity imbalances across banks as well. The estimated coefficient of the interaction term *Liq_Shock *Market_Liq_risk* suggests that, when the borrower faces a deposits outflow, one standard deviation in the market liquidity risk adds a premium of 1.1 bps, that is 17.4% more compared to a day in which the borrower has no deposits outflow. These results indicate that idiosyncratic liquidity shocks force banks to pay more for their interbank funds when they face greater liquidity risk.

In column (11), we test whether small banks are more penalized by their creditors in the presence of higher credit risk and liquidity risk, and also we check if idiosyncratic liquidity shocks can affect more these banks. The estimated coefficient of interaction of *small*npl* is statistically significant and has an important economic effect. The total effect of *npl* on the price of liquidity for small banks is 0.084, which implies that small banks are more sensitive to changes in their credit risk than large banks.[24] Thus, further deterioration in the quality of loans of small banks would have a greater effect on their funding costs in the interbank market. A 1% increase in the ratio of non-performing loans to total loans for small banks is associated with overpricing of 8.4 bps. Small banks are also more affected by uncertainty over their liquidity needs. The estimated coefficient of the interaction term *small*liq_risk* is positive and significant. Although the coefficient has a lower level (0.008), the total effect of liquidity risk on small banks is 9.7% higher than that observed for large banks.[25] We also identify that

[22] Afonso et al., (2014) show that borrowers in the US Fed funds market pay lower prices and borrow more from their concentrated lenders and that—when there are exogenous shocks to liquidity supply—concentrated lenders insulate borrowers from the shocks without charging significantly higher interest rates

[23] The effect is computed as [-1.167 x (log(31) – log (1)] + [-0.411 x (log(31) – log (1)]=-5.418.

[24] That is, $\beta_{npl} + \beta_{small \times npl} = 0.061 + 0.023 = 0.084$.

[25] The total effect of liquidity risk for small banks is computed as follows: $\beta_{liq\_risk} + \beta_{small \times liq\_risk} = 0.031 + 0.008 = 0.039$. Note that compared to the benchmark group (i.e., large banks), the interaction adds an impact of 9.7% to the effect of liquidity risk.

idiosyncratic liquidity shocks have more effect over small banks. When small banks have deposits outflow, they pay 2.39% more for interbank loans compared to large banks, and if an small bank has higher liquidity risk, the overprice is 3% more compared to a large bank. This result is consistent with the view that small banks are more affected by liquidity squeezes (Nyborg and Strebulaev, 2004; Fecht, et al., 2011). Our results are robust to the inclusion of lender*time fixed effects, indicating that we are able to capture the effect of idiosyncratic liquidity shocks on the demand for liquidity in the interbank market (column 12).

4.2. Evaluating the impact of aggregate liquidity shocks in the interbank market

In this section, we present results on the impact of our aggregate liquidity shock—related to the U.S. tapering—in accessing and pricing interbank funds. In **Table 5 (panel a)**, columns (1) to (6), we present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market ($z_{it}=1$). Panel b, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). As in our previous model, all the specifications have borrower, borrower*lender and time fixed effects to control for unobservable effects of the borrower, borrower-lender availability of credit, and aggregate changes in liquidity, respectively. In columns (6) and (12) we check the robustness of our baseline results under a more demanding specification that includes lender*time fixed effects to control for variation in supply by lenders in a particular period and thus to capture variation in demand of liquidity. In addition, we cluster robust standard errors at the borrower bank level.

4.2.1. The access to interbank liquidity during the U.S. tapering

Results in columns (1) and (2) of **Table 5** confirm the findings from our baseline specifications: riskier banks have less access to the interbank market, and those that rely more on lending relationships are more likely to borrow funds. In column (3) we include our aggregate liquidity shock (*U.S. tapering*$_t$) and interaction terms with bank-specific-characteristics and market conditions. We find that during the U.S. tapering the banks were 5.2% more likely to borrow from the interbank market compared to the period before. Note that this probability is considerably lower compared to the one we observe under idiosyncratic liquidity shocks in **Table 4** (18.1%), suggesting lower market activity compared to idiosyncratic liquidity shocks. Banks size and credit risk have no significant effect on the probability to access the interbank market, while the effect of higher capitalization becomes more relevant. The estimated coefficient suggest that an increase of 1% in the bank's capital ratio is associated with an increase of 8.2% in the probability of a bank to borrow funds in the interbank market. This result may indicate that the U.S. tapering posed more concerns on banks' solvency rather than to their credit risk exposure; and also that large banks faced similar constrains in accessing interbank funds compared to small banks. We also identify that during the U.S tapering, banks that borrowed more from their frequent counterparties had similar access to the interbank market compared to borrowing from spot lenders. This result contrasts to the one we observe under idiosyncratic liquidity shocks, and may suggest that aggregate liquidity shocks do forces liquidity hoarding in the interbank market (Acharya and Merrouche, 2013).

In column (4), we identify that banks with higher liquidity risk were less likely to obtain funds during the U.S. tapering, compared to the period before. Note that the opposite effect was found under idiosyncratic liquidity shocks, which may indicate that aggregate liquidity shocks affect more the availability of liquidity compared to idiosyncratic liquidity shocks. During the U.S. tapering, more imbalanced liquidity positions across banks (i.e. higher market liquidity risk) significantly reduce the probability of a bank to borrow from the interbank market. In **Figure 4** (panel a) we observe a higher volatility in the banks' reserves holdings around the U.S. tapering period, indicating higher uncertainty over the liquidity conditions during this period. Then, in column (5), we find that small banks are more affected by aggregate liquidity shocks compared to large banks, especially when those banks are less liquid. The probability to borrow funds of a small bank during the U.S. tapering was 8.7% lower compared to the one for a large bank. In addition, an increase in the liquidity risk for small banks further deteriorates the access to the interbank market in 0.02%, which is 18.2% higher compared to large banks. Column (6) confirms that our results are robust to the use of lender*time fixed effects indicating that model is able to identify how the U.S tapering affected the demand for liquidity in the interbank market.

4.2.2. Liquidity pricing during the U.S. tapering

Results from the pricing models are presented in **Table 5** (Panel B), columns (7) to (12). The estimated coefficients from the baseline specifications confirm our previous findings on the role of counterparty and liquidity risk in the liquidity pricing in interbank markets. In column (7) we observe that riskier banks are charged with higher prices and that larger banks have cheaper funding from the interbank market, while more liquid banks are associated to lower prices (column 8). In addition, we confirm that lending relations and central bank liquidity alleviate funding costs in the interbank market.

In column (9), we observe that the U.S. tapering was associated to significant higher prices in the interbank market. On average, banks paid 3 bps more on an interbank loan, compared to the period before the U.S tapering. The overprice is 61% higher than the mean spread during the full period (1.85 bps), albeit lower that the one a bank pay during an idiosyncratic liquidity shock (5.13 bps). Unlike the idiosyncratic liquidity shocks, we observe that the U.S. tapering affected more the prices of interbank funds for less capitalized banks—as well as their access to the market (column 3)—. This indicates that more capitalized banks were able to absorb better the impact of the U.S. tapering, consistent with the role of capital in enhancing the performance of banks during times of increased uncertainty (Berger and Bowman, 2013). In spite of the probability to get funds from frequent counterparts during the U.S. tapering was no statistically different from the one to borrow from spot lenders, results suggest that lending relationships significantly alleviate borrowing costs during aggregate liquidity shocks (Braüning and Fetch, 2016).[26] Banks that rely more on lending relationships—compared to spot borrowers—obtained a lower spread of about 4.5 bps for their interbank funds.[27] In addition, higher CB liquidity was associated to lower prices in the interbank market, indicating that CB liquidity can exert downward pressure on market interest rates during aggregate liquidity shocks. This result—in conjunction with the effect of the CB liquidity in the access to interbank market—may indicate that the higher liquidity granted by the CB during the U.S. tapering (which reached 25%, **Figure 4**, pane b) contributed to alleviate funding costs in the interbank market and to enhance the access to interbank liquidity (see, Abbassi and Linzert, 2012). This finding is consistent with the evidence of León and Sarmiento (2016), for whom the connective structure of the repo network of the CB can mitigate liquidity tensions in the money market.

In column (10), we find that banks facing higher liquidity risk were charged with a spread of 1.1 bps during the U.S. tapering period, compared to the period before. This effect is similar to the one we observe under idiosyncratic liquidity shocks. Interestingly, more imbalanced liquidity positions across banks were associated to an overprice of 2.2 bps, that is an increase of 36.1% compared to the period before the U.S. tapering—and twice the effect associated to the bank-specific liquidity risk—.

[26] Braüning and Fecht (2016) find that, during the GFC, relationship lenders in the German interbank market provided cheaper loans to their closest borrowers, confirming that lending relationships help banks to reduce search frictions, even for opaque borrowers.

[27] The effect is computed as [-1.075 x (log(31) – log (1)] + [-0.225 x (log(31) – log (1)]=-4.46

These results indicate that when banks face greater liquidity risk (individual or across banks), aggregate liquidity shocks force them to pay more for their interbank funding. However, the role of size seems to matter. In column (11), we observe that small banks were more affected by uncertainty over their liquidity needs during the U.S. tapering. The total effect of liquidity risk on small banks was 28.6% higher than that observed for large banks.[28] During the U.S. tapering, small banks paid 4.5% more for interbank loans compared to large banks, and under higher liquidity risk, small banks pay 6.1% more compared to large banks. The baseline results remain intact to the inclusion of lender*time fixed effects, suggesting that the proposed model captures the effect of the U.S. tapering on the demand for liquidity in the interbank market (column 12).

5. Robustness

We perform additional exercises to test the robustness of our model by using alternative bank-specific-characteristics, lending relationships and market access measures. First, we test whether the results hold under alternative measures of counterparty and liquidity risk. In particular, we employ the bank's z-score instead of the capital ratio, and employ the ratio of liquid assets to total assets ($liquidity\_ratio_{it}$) as an alternative measure of the liquidity position of the borrower bank.[29] Second, we use a measure of borrowing concentration instead of the frequency of interactions, by employing the BPI_{ijt} instead of RL_{ijt}. This allows to test whether higher concentration of counterparties providing liquidity (high *BPI*) increases the probability of a bank in accessing the interbank market to cover its liquidity needs. Third, we test whether the access to secured money markets alleviate funding costs in the interbank market as the use of collateral may reduce borrowing costs (Allen et al., 1989). We employ a dummy variable equal to 1 if the bank *i* borrows funds in the secured money market in time *t*, and zero otherwise ($Borrowing\ secured_{it}$). In addition to check the robustness of our baseline results, this exercise allows assessing the role of banks' stability, liquidity ratios, secured funding and lending concentration in mitigating the impact of idiosyncratic and aggregate liquidity over banks' funding in the interbank market.

[28] The total effect of liquidity risk for small banks is computed as follows: $\beta_{liq\_risk} + \beta_{small\ x\ liq\_risk} = 0.042 + 0.012 = 0.054$. Note that compared to the benchmark group (i.e., large banks), the interaction adds an impact of 28.6% to the effect of liquidity risk.

[29] Liquid assets include cash holdings, negotiable and available to sell public and private debt instruments and pledged collateral in repurchase agreement operations.

5.1. Idiosyncratic liquidity shocks, bank' stability, secured funding and lending concentration

The results on the impact of idiosyncratic liquidity shocks in the interbank market using alternative covariates of risk, liquidity, secured funding and lending relationships are presented in **Table 6**. Overall, the estimated parameters of the alternative covariates capturing counterparty and liquidity risk yield results similar to those that we obtained in our baseline models. However, they exhibit lower levels but remain significant compared to the estimated coefficients in our baseline specifications. Regarding the z-score, we find that a lower probability of insolvency is associated with more access to the interbank market and lower spread (columns 1 and 6). The estimated coefficient in column (7) suggests that an increase of one standard deviation in the bank's z-score is associated with a decrease in the price of liquidity of 3.2 bps. In addition, we identify that under idiosyncratic liquidity shocks, higher bank's z-score is associated to lower prices (column 9). Thus, banks engaging in less risk-taking are found to pay less for liquidity, confirming our evidence on market discipline.

Banks with a higher ratio of liquid assets are associated with lower prices (column 7), albeit it has no significant impact on the probability to borrow from the interbank market (column 2). However—under idiosyncratic liquidity shocks—, more liquid banks have higher access to interbank market and benefit from lower prices (columns 4 and 10), suggesting that more liquid banks are in a better position to obtain liquidity from the money market (Craig et. al, 2015). The rationale is that if prices in the unsecured interbank market are high, then they can use their liquid assets in the secured market to cover their liquidity needs, lowering their funding costs. This intuition is supported by our findings using the indicator variable on the banks' access to the secured money market. We identify that borrowing liquidity in secured markets significantly reduces borrowing costs in the interbank market during idiosyncratic liquidity shocks. This result implies, on the one hand, that collateral can reduce asymmetric information problems (Allen et al., 1989); and on the other hand, that liquid banks (banks with higher collateral) can absorb better the impact of idiosyncratic liquidity shocks[30]. Thus, our results provide further support to the benefits of liquidity ratios in mitigating liquidity shocks, and then in preserving financial stability.

Higher concentration of lending relations (high BPI) is associated to more access to the interbank market (column 1) and lower prices (column 7). In addition, banks with more concentrated

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[30] Bonner and Eijffinger (2016) find that German banks with higher liquidity ratios pay lower prices for their interbank funds. Similarly, Pierret (2015) shows that liquid banks benefit from lower funding costs and a lower insolvency risk

counterparties are found to pay lees for liquidity during idiosyncratic liquidity shocks compared to those borrowing from spot lenders (column 9). This result confirms our previous finding using RL, and provides further evidence on the role of lending relationships in mitigating liquidity shocks (Afonso, et al., 2014).

5.2. Aggregate liquidity shocks, bank' stability, secured funding and lending concentration

Results on the impact of the aggregate liquidity shock in the interbank market using alternative covariates of risk and lending relationships are presented in **Table 7**. We observe similar results to those that we obtained in our baseline models in **Table 5**. Regarding the alternative covariates of risk, we identify that during the U.S. tapering, more stable banks are associated to a higher probability to access the interbank market (column 3), and to lower liquidity prices (column 9). More liquid banks are associated to lower interbank loan prices (column 10). We find that higher concentration of counterparties is associated to more access to the interbank market (column 1) and lower prices (column 7). However, during the U.S. tapering, banks that borrow from a small set of counterparties did not obtain significant lower prices (column 9), albeit they did benefit from higher access to the interbank market (column 3). This may evidence liquidity hoarding, based on the fact that all the interbank market participants are being affected by the same liquidity shock. Indeed, during the U.S. tapering, the estimated coefficient of our measure of market liquidity risk was twice the one we observe in the specification with idiosyncratic liquidity shocks (compare -0.017 vs. -0.035). This result implies that during aggregate liquidity shocks, more imbalanced liquidity positions across banks significantly reduced the ability of a bank to borrow funds from the interbank market. Note also that the effect of the CB liquidity remains statistically significant and that the point estimate increases during the U.S. tapering—in line with our previous findings reported in **Table 6**—and supporting the role of CB in alleviating liquidity tensions in the interbank market

Banks with access to the secured market are more likely to borrow from the interbank market, and had more access to the market during the U.S. tapering (column 3). However,—unlike the idiosyncratic liquidity shocks—the higher access to secured market does not significantly reduced borrowing costs; neither contributed to absorb the liquidity shock associated to the U.S. tapering. The lack of significance of secured borrowing in the price models can be associated to the fact that the main collateral used in secured markets is the government bill (TES), which price was severely affected during the U.S. tapering period (see **Figure 3A**, panel b). This lead to increasing funding costs in the secured money market (Banco de la República, 2013). Overall, our results confirm that during aggregate liquidity shocks, in addition to CB liquidity, the role of hard information (solvency and liquidity ratios) seems to be more important in the liquidity pricing than soft information (i.e. lending relationships).

6. Final remarks

This paper evaluates the impact of exogenous liquidity shocks on the behavior of banks participating in the interbank market. We study the impact of idiosyncratic liquidity shocks—associated to deposits outflow at the bank level—and of the aggregate liquidity shock derived from the US tapering—observed between May and September, 2013—on the pricing and availability of interbank liquidity. We find that this market is "too sensitive" to exogenous liquidity shocks. Our results indicate that both liquidity shocks are associated with higher interbank loan prices, albeit the magnitude of the overprice and the impact on the access to interbank liquidity differ depending on the borrower-specific characteristics. One implication of our results is that higher capital and liquidity buffers can reduce short-term funding costs, and increase access to interbank market liquidity, allowing banks to absorb better the impact of exogenous liquidity shocks. Thus, recent regulation—under the umbrella of Basel II and III—can contribute to mitigate the impact of exogenous liquidity shocks over short-term funding.

We also identify that during aggregate liquidity shocks, the role of the central bank in alleviating liquidity strains throughout the interbank market becomes more relevant—as hard information seems to dominate soft information—while the benefits of lending relationships are significantly more important when banks face idiosyncratic liquidity shocks. Therefore, our results point out that understanding the impact of exogenous liquidity shocks on the interbank market is crucial for identifying potential disruptions in the allocation of liquidity that could affect not only short-term funding, but also bank lending and monetary policy transmission.

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Table 1. The impact of idiosyncratic liquidity shocks on the interbank market.

Interbank market conditions	Liquidity shock = 0	Liquidity shock =1	Difference	t-Statistic
No of loans	35,56	41,24	-5,68	-6,35***
Total volume of loans	532.240	603.340	-71.100	-7,23***
Average amount of loans	11.635	14.723	-30.88	-8,25***
Average spread of loans	0,03	0,07	-0,04	-4,21***
Spread to CB rate	0,05	0,07	-0,02	-1,05
St. Dev of spreads of loans	0,05	0,06	-0,01	-1,17
No. of lending banks	22,12	23,45	-1,33	-1,25
No. of borrowing banks	17,71	21,35	-3,64	-5,02***

Note: This table presents mean comparison test for daily variables of the interbank market. Liquidity shock =1 corresponds to all interbank loans that involve a borrower bank suffering an idiosyncratic liquidity shock (i.e. a deposits outflow). Liquidity shock=0 is composed by the remaining loans in which the borrower does not face this liquidity shock. The test employs all loans observed between January 1, 2011 and December 30, 2014.*** p>0.01

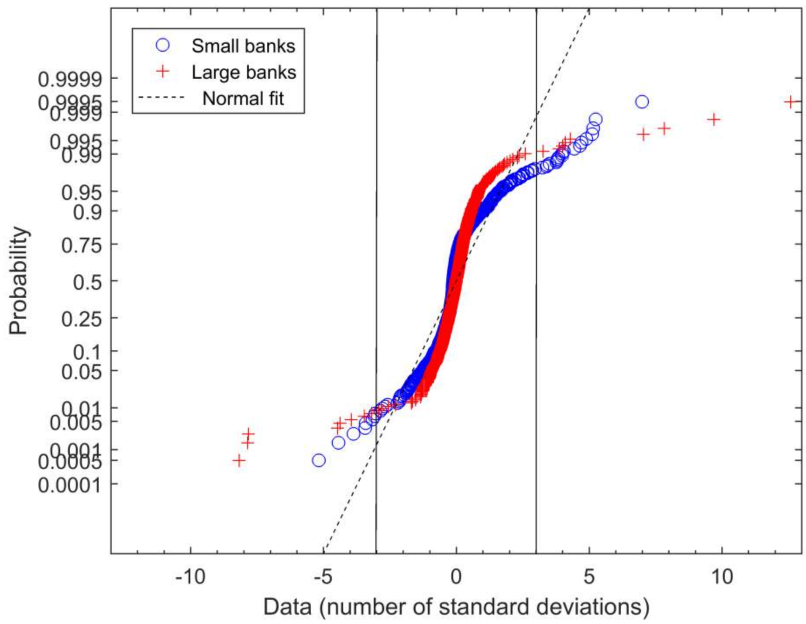
Table 2. Banks' size, idiosyncratic liquidity shocks and interbank market activity

Idiosyncratic liquidity shocks (Panel a)	Small banks	Large banks	Difference between large and small banks	t-Statistic
Change in deposits (percent)	0,011	0,056	0,045	6,33***
Deposits outflow (percent)	-0,137	-0,084	0,053	7,71***
Deposits outflow (No of days)	423	327	-96	-7,52***
Interbank market activity (*Panel b*)				
Spread (bps)	3,00	-1,50	-4,50	-5,87***
Total amount borrowed (billion COP)	1,39	16,28	14,89	10,26***
Total amount lent (billion COP)	7,61	7,15	-0,47	5,25***
Net position	6,22	-9,13	-15,35	-8,26***

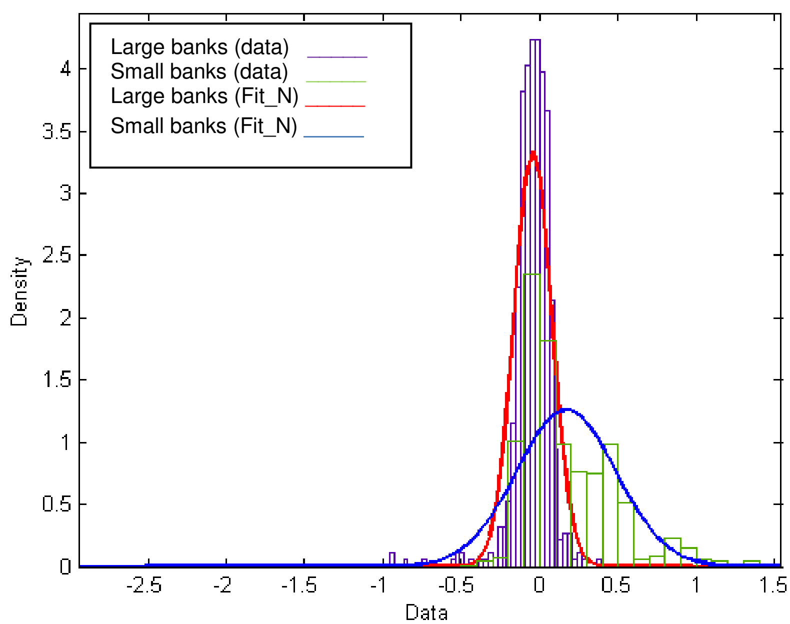
Note: This table presents mean comparison tests for selected variables of participating banks in the interbank market. Large (small) banks are those with assets value larger (lower) than the 66th (33th) percentile of the assets distribution during the period. In Panel A change in deposits is the daily mean change in the deposits of the bank (in percent). Deposits outflow is the mean value of the negative rate of change in deposits (percent), and the number of days a bank has a negative rate of change of deposits. Panel B has measures of interbank market activity. Spread is the difference between the interest rate paid by a bank in the interbank market and the CB rate measured in basis points (bps). Total amount borrowed and total amount lent in the interbank market per day in billion COP. Net position is the difference between the total amount lent and the total amount borrowed during a day in billion COP.

Figure 1. Idiosyncratic liquidity shocks, banks' size, and borrowing costs

Panel (a) Distribution of idiosyncratic liquidity shocks by banks' size

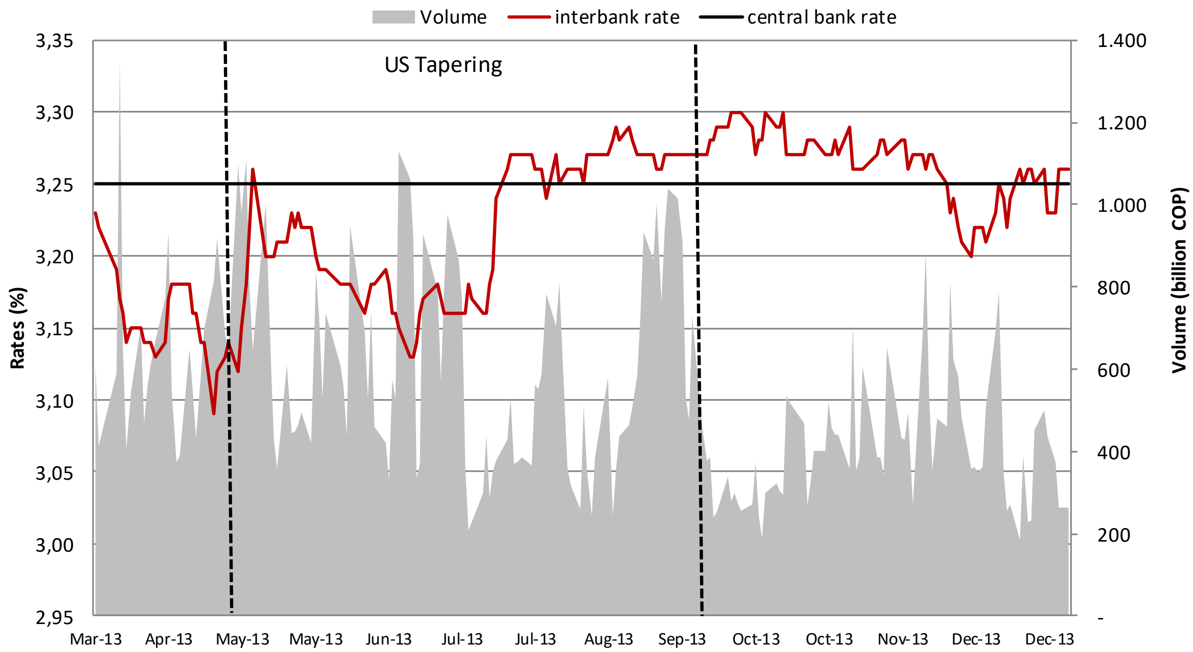


Panel (b) Distribution of borrowing rates by banks' size



Note: Panel (a) presents the distribution of the rate of change of deposits by type of bank during the period 2011-2014 assuming normal distributions. Panel (b) presents the distribution of the interest rates of overnight-unsecured loans in the interbank market during the period 2011-2014. In both figures large (small) banks are those with assets value larger (lower) than the 66th (33th) percentile of the assets distribution during the period.

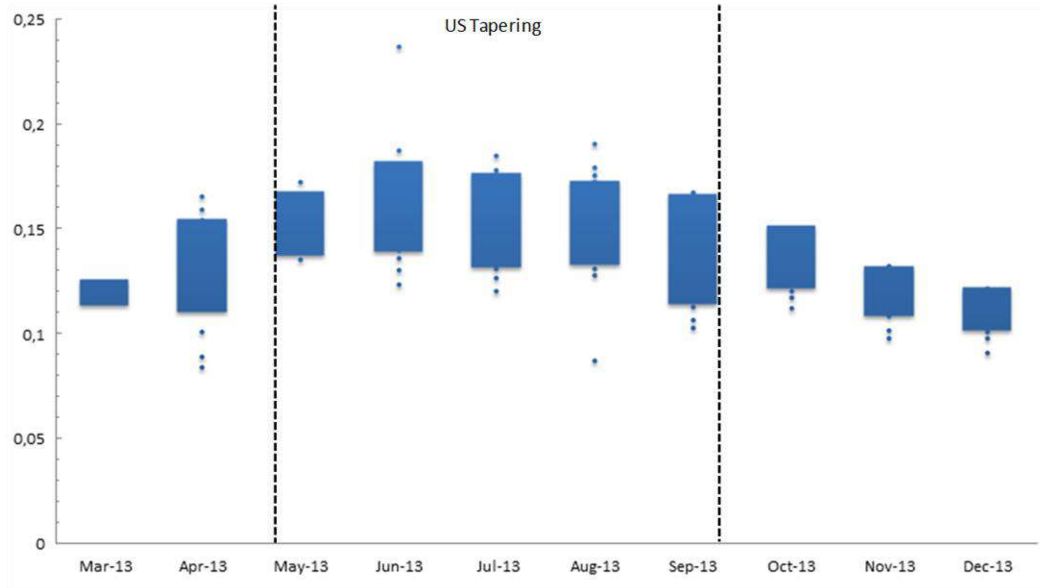
Figure 2. The impact of the U.S. tapering in the Colombian interbank market



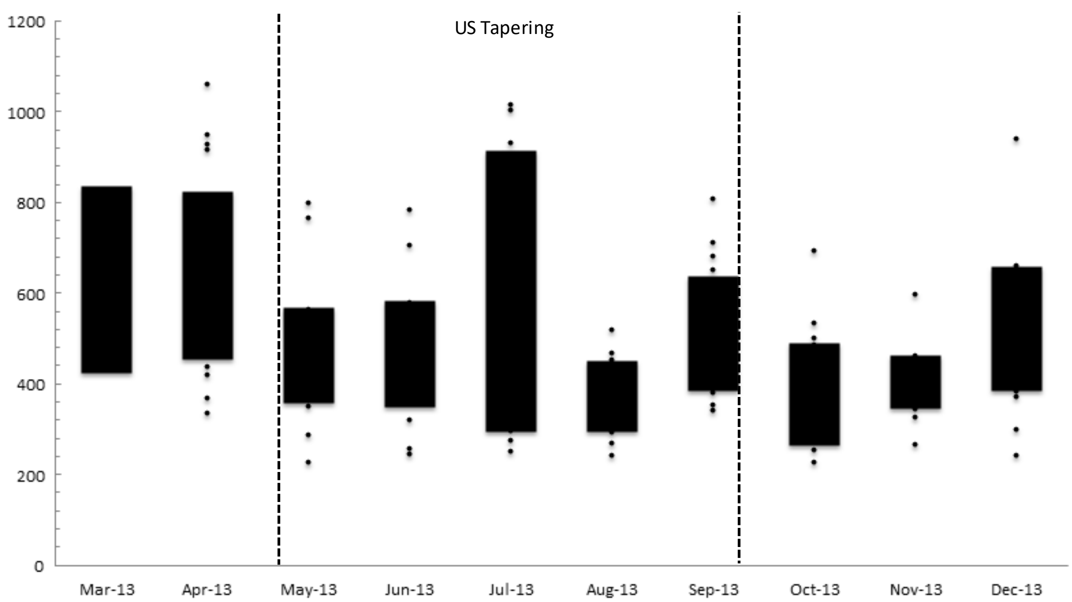
Note: This figure depicts the overnight interbank market rate (red line) and central bank rate (black line) in percentage (%) during the period March 26 and December 30, 2013. Average daily amount traded in the interbank market in billion COP (Right axis). Dotted lines correspond to the U.S. tapering period: May 22 to September 17, 2013.

Figure 3. Interbank market volatility during the U.S. tapering

Panel (a) Volatility of the interbank market rates



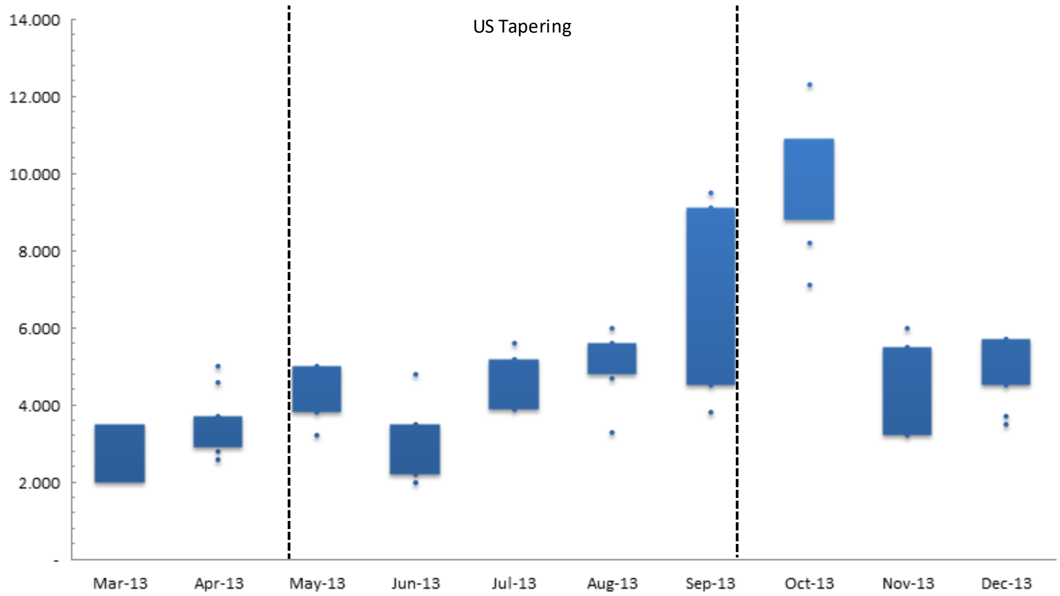
Panel (b) Loan volume in the interbank market



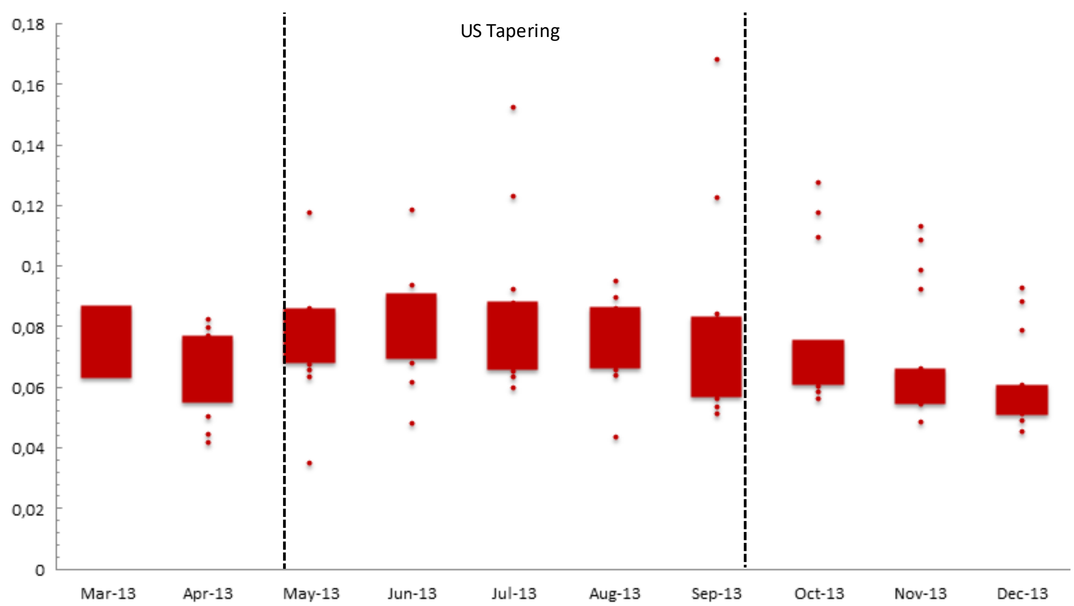
Note: Panel (a) depicts the standard deviation of the overnight interbank market rate in percentage points. Panel (b) presents the daily volume of interbank loans (billion COP). Data is from the period March 26 and December 30, 2013. Dotted lines correspond to the U.S. tapering period: May 22 to September 17, 2013.

Figure 4. Market liquidity and the U.S. tapering

Panel (a) Central bank liquidity supply



Panel (b) Volatility of banks' reserve holdings



Note: Panel (a) shows the CB liquidity supply (i.e. size of the REPO auction on a daily basis in billion COP). Panel (b) depicts our measure of market liquidity risk defined as the standard deviation of the normalized excess reserves across banks (per day) in percentage points. Data is from the period March 26 and December 30, 2013. Dotted lines correspond to the U.S. tapering period: May 22 to September 17, 2013.

Table 3. The impact of the U.S. tapering in the Colombian interbank market.

Interbank market conditions	U.S Tapering =0	U.S Tapering =1	Difference	t-Statistic
No of loans	40,23	37,25	-2,98	5,23***
Total volume of loans	666,57	579,55	(87,02)	-7,04***
Average amount of loans	12.356	10.503	(1.853)	-7,81***
Average spread of loans	0,04	0,07	0,03	3,85***
Spread to CB rate	-0,03	0,02	0,05	3,56***
Std of spreads of loans	0,04	0,14	0,10	6,89***
No. of lending banks	21,47	20,12	-1,35	-1,53
No. of borrowing banks	16,46	19,76	3,30	-4,78***

Note: This table presents mean comparison test for daily variables of the interbank market. U.S Tapering =1 corresponds to the loans granted during May 22 and September 17, 2013, while U.S Tapering =0 covers the loans granted between March 27 and May 21, 2013. Amount in COP million and spread is the difference (in percentage points) to the CB rate.

Table 4. The impact of idiosyncratic liquidity shocks in the interbank market

Variables	Panel A: Probability to access the market: P (zit =1)						Panel B: Pricing Models: Spread it					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Liquidity $Shock_{it}$			0,181	0,164	0,127	0,113			5,135	5,233	5,148	4,802
			(5,87)***	(5,62)***	(5,84)***	(5,21)***			(5,30)***	(5,26)***	(5,87)***	(6,23)***
$Size_{it}$ [Log of assets (mln)]	0,130	0,139	0,121	0,137	0,120	0,122	-0,110	-0,108	-0,112	-0,115	-0,118	-0,126
	(4,06)***	(4,02)***	(3,76)***	(4,01)***	(3,52)***	(3,43)***	(-3,12)***	(-3,23)***	(-2,81)**	(-2,78)**	(-3,10)***	(-3,35)***
Capital $ratio_{it}$ (percent)	0,051	0,064	0,052	0,057	0,054	0,051	-0,069	-0,071	-0,064	-0,072	-0,058	-0,042
	(3,21)***	(3,11)***	(3,02)***	(3,45)***	(3,48)***	(3,32)***	(-1,79)*	(2,46)**	(2,31)**	(2,50)**	(2,21)**	(2,05)**
Npl_{it} (percent)	-0,091	-0,082	-0,095	-0,078	-0,082	-0,077	0,052	0,051	0,054	0,057	0,061	0,072
	(-1,86)**	(-1,81)**	(-1,76)*	(-2,01)**	(-2,18)**	(-1,43)	(2,46)**	(2,59)**	(2,61)**	(2,18)**	(2,16)**	(2,31)**
$Liquidity\_risk_{it}$ (percent)		0,063	0,061	0,072	0,064	0,071		0,031	0,037	0,049	0,031	0,023
		(2,19)**	(2,11)**	(2,04)**	(2,18)**	(2,23)**		(3,19)***	(3,25)***	(4,01)***	(3,19)***	(3,46)***
Market Liq_risk_t (percent)		-0,027	-0,038	-0,013	-0,026	-0,018		0,065	0,071	0,063	0,075	0,062
		(-1,87)**	(-1,82)**	(-1,74)*	(-1,81)*	(-1,81)*		(3,87)***	(3,91)***	(3,28)***	(2,25)**	(2,51)**
Liquidity $Shock_{it}$ * $Size_{it}$ [Log of assets (mln)]			0,005	0,007					-0,019	-0,015		
			(1,67)*	(1,42)					(-1,91)*	(-1,98)*		
Liquidity $Shock_{it}$ * Capital $ratio_{it}$ (percent)			0,061	0,057					-0,004	-0,006		
			(2,47)**	(2,41)**					(-1,19)	(-1,22)		
Liquidity $Shock_{it}$ * Npl_{it} (percent)			-0,016	-0,018	-0,011	-0,006			0,012	0,009	0,007	0,011
			(-1,19)	(-1,22)	(-1,14)	(-1,17)			(2,19)**	(2,38)**	(2,35)**	(2,71)**
Liquidity $Shock_{it}$ * $Liquidity\_risk_{it}$ (percent)				-0,011	-0,008	-0,013				0,007	0,011	0,015
				(-1,08)	(-1,02)	(-1,15)				(3,14)***	(3,78)***	(3,34)***
Liquidity $Shock_{it}$ * Market Liq_risk_t (percent)				-0,008	-0,009	-0,011				0,011	0,009	0,007
				(-1,95)**	(-2,09)**	(-2,23)**				(2,96)***	(2,72)**	(1,84)*
$Small_{it}$ * npl_{it} (percent)					-0,048	-0,051					0,023	0,027
					(-2,59)**	(-2,34)**					(2,61)**	(2,58)**
$Small_{it}$ * $Liquidity\_risk_{it}$ (percent)					0,004	0,002					0,008	0,006
					(1,45)	(1,22)					(2,32)**	(2,71)**
Liquidity $Shock_{it}$ * $Small_{it}$					-0,031	-0,042					0,123	0,117
					(-4,01)***	(-3,29)***					(2,79)***	(3,02)***
Liquidity $Shock_{it}$ * $Small_{it}$ * npl_{it} (percent)					-0,016	-0,008					0,076	0,062
					(-1,31)	(-1,25)					(1,06)	(1,17)
Liquidity $Shock_{it}$ * $Small_{it}$ * $Liquidity\_risk_{it}$ (percent)					-0,003	-0,006					0,031	0,027
					(-1,20)	(-1,24)					(2,06)**	(2,35)**
RL_{ijt}	0,481	0,515	0,496	0,474	0,423	0,507	-1,181	-1,192	-1,167	-1,175	-1,177	-1,185
	(7,59)***	(6,21)***	(7,04)***	(6,85)***	(6,72)***	(5,23)***	(-5,59)***	(-5,10)***	(-4,38)***	(-4,15)***	(-3,02)***	(-3,59)***
Liquidity $Shock_{it}$ * RL_{ijt}			0,081	0,011	0,014	0,019			-0,411	-0,456	-0,482	-0,503
			(2,59)***	(2,84)***	(3,19)***	(3,47)***			(-3,84)***	(-3,15)***	(-2,94)***	(-3,26)***
CB Liq_supply_t [ln (mln)]	0,012	0,015	0,022	0,013	0,011	0,009	-0,038	-0,027	-0,021	-0,024	-0,028	-0,031
	(1,28)	(1,25)	(1,18)	(1,04)	(1,41)	(1,29)	(-1,72)*	(-1,84)*	(-2,03)**	(-2,17)**	(-2,31)**	(-1,73)*
Liquidity $Shock_{it}$ * CB Liq_supply_t [ln (mln)]			0,004	0,005	0,003	0,001			-0,008	-0,004	-0,004	-0,002
			(1,25)	(1,31)	(1,18)	(1,02)			(-1,25)	(-1,75)	(-0,92)	(-1,03)
Inv_Mills $ratio_{it}$							-4,254	-3,741	-4,073	-5,046	-3,279	-3,745
							(-4,17)***	(-4,51)***	(-4,28)***	(-3,94)***	(-3,77)***	(-4,08)***
$Excess\_reserves_{it}$ (percent)	-0,118	-0,129	-0,134	-0,122	-0,120	-0,137						
	(-5,06)***	(-5,47)***	(-4,77)***	(-5,12)***	(-5,78)***	(-4,89)***						
Observations	813150	813150	813150	813150	813150	813150	27105	27105	27105	27105	27105	27105
Borrower FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Borrower*Lender FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lender*Time FE	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents OLS parameter estimates of the Heckman two-stage procedure that corrects for sample selection bias. Panel A, columns (1) to (6), present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market (z_{it} =1). Panel B, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). Columns (3) to (6) and (9) to (12) incorporate the effects of our idiosyncratic liquidity shock (deposits outflow) in accessing and pricing funds in the interbank market, respectively. All models have borrower, borrower*lender and time fixed effects to control for unobservable effects at the borrower, borrower-lender and time levels. Columns (6) and (12) include lender*time fixed effects. We cluster robust standard errors at the borrower bank level. Robust t-statistics in parentheses. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

Table 5. The impact of the U.S. tapering in the interbank market

Variables	Panel A: Probability to access the market: P (zit =1)						Panel B: Pricing Models: Spread it					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
US tapering$_t$			0,052	0,044	0,046	0,051			3,021	3,452	3,026	3,034
			(3,51)***	(3,25)***	(3,78)***	(3,90)***			(4,21)***	(4,82)***	(4,18)***	(4,36)***
Size$_{it}$ [Log of assets (mln)]	0,091	0,108	0,103	0,114	0,184	0,172	-0,095	-0,087	-0,092	-0,071	-0,098	-0,076
	(3,24)***	(3,12)***	(2,98)***	(3,01)***	(3,18)***	(3,27)***	(-3,04)***	(-2,88)***	(-2,91)**	(-2,83)**	(-2,68)**	(-3,03)**
Capital ratio$_{it}$ (percent)	0,048	0,051	0,047	0,044	0,049	0,053	-0,065	-0,079	-0,071	-0,078	-0,063	-0,073
	(3,15)***	(3,18)***	(3,06)***	(2,87)***	(2,93)***	(3,18)***	(-2,65)**	(2,71)**	(3,14)***	(3,28)***	(3,18)***	(3,26)***
Npl$_{it}$ (percent)	-0,084	-0,087	-0,072	-0,079	-0,086	-0,074	0,058	0,061	0,047	0,051	0,054	0,049
	(-2,14)**	(-2,21)**	(-2,16)**	(-2,24)**	(-2,10)**	(-1,93)**	(2,27)**	(2,61)**	(2,77)**	(2,80)**	(2,56)**	(2,02)**
Liquidity_risk$_{it}$ (percent)		0,053	0,035	0,037	0,028	0,041		0,028	0,033	0,038	0,042	0,037
		(2,54)**	(2,17)**	(2,19)**	(2,08)**	(2,73)**		(3,06)***	(3,10)***	(3,21)***	(2,87)***	(3,20)***
Market Liq_risk$_t$ (percent)		-0,039	-0,047	-0,051	-0,042	-0,039		0,055	0,058	0,061	0,059	0,063
		(-2,13)**	(-2,74)**	(-2,96)***	(-3,12)***	(-3,58)***		(2,42)**	(2,85)**	(2,73)**	(2,25)**	(2,37)**
US tapering$_t$ * Size$_{it}$ [Log of assets (mln)]			0,012	0,017					-0,019	-0,015		
			(1,24)	(1,16)					(-1,91)*	(-1,98)*		
US tapering$_t$ * Capital ratio$_{it}$ (percent)			0,082	0,085					-0,015	-0,017		
			(3,30)***	(3,33)***					(-3,04)***	(-2,97)***		
US tapering$_t$ * Npl$_{it}$ (percent)			-0,012	-0,011	-0,008	-0,013			0,016	0,022	0,026	0,018
			(-1,04)	(-1,10)	(-1,15)	(-1,20)			(1,24)	(1,40)	(1,02)	(1,21)
US tapering$_t$ * Liquidity_risk$_{it}$ (percent)				-0,015	-0,011	-0,008				0,011	0,014	0,012
				(-3,02)***	(-2,90)**	(-3,21)**				(2,14)*	(1,78)*	(2,28)**
US tapering$_t$ * Market Liq_risk$_t$ (percent)				-0,013	-0,015	-0,011				0,022	0,019	0,015
				(-2,75)**	(-2,81)**	(-2,73)**				(3,22)***	(3,17)***	(3,48)***
Small$_{it}$ * npl$_{it}$ (percent)					-0,031	-0,027					0,019	0,013
					(-1,69)*	(-1,32)					(1,04)	(1,02)
Small$_{it}$ * Liquidity_risk$_{it}$ (percent)					-0,007	-0,005					0,012	0,008
					(3,51)***	(3,23)***					(3,63)***	(3,51)***
US tapering$_t$ * Small$_{it}$					-0,004	-0,006					0,136	0,128
					(-2,01)**	(-2,54)**					(1,95)*	(2,24)**
US tapering$_t$ * Small$_{it}$ * npl$_{it}$ (percent)					-0,009	-0,012					0,013	0,015
					(-1,31)	(-1,18)					(1,18)	(1,23)
US tapering$_t$ * Small$_{it}$ * Liquidity_risk$_{it}$ (percent)					-0,002	-0,001					0,007	0,005
					(-3,20)***	(-2,73)**					(2,28)**	(2,71)**
RL$_{ijt}$	0,413	0,402	0,443	0,471	0,372	0,394	-1,123	-1,054	-1,075	-1,026	-1,427	-1,235
	(7,20)***	(7,54)***	(8,10)***	(8,43)***	(8,27)***	(7,25)***	(-5,94)***	(-5,75)***	(-5,07)***	(-4,83)***	(-4,39)***	(-5,07)***
US tapering$_t$ * RL$_{ijt}$			0,014	0,008	0,019	0,011			-0,225	-0,268	-0,212	-0,248
			(1,05)	(0,97)	(0,90)	(1,04)			(-3,92)***	(-3,74)***	(-3,63)***	(-3,37)***
CB_Liq_supply$_t$ [ln (mln)]	0,014	0,011	0,017	0,019	0,013	0,018	-0,057	-0,061	-0,053	-0,058	-0,062	-0,059
	(1,48)	(1,50)	(0,98)	(1,03)	(1,17)	(1,02)	(-3,73)***	(-3,80)***	(-3,86)***	(-3,70)***	(-3,31)***	(-3,91)***
US tapering$_t$ * CB_Liq_supply$_t$ [ln (mln)]			0,009	0,011	0,007	0,009			-0,011	-0,017	-0,009	-0,013
			(2,15)**	(2,30)**	(2,16)**	(2,72)***			(-4,21)***	(-3,51)***	(-3,97)***	(-4,78)***
Inv_Mills ratio$_{it}$							-3,478	-3,657	-3,986	-3,253	-3,547	-3,205
							(-3,17)***	(-2,50)**	(-2,34)**	(-2,56)***	(-2,17)**	(-3,24)***
Excess_reserves$_{it}$ (percent)	-0,101	-0,112	-0,121	-0,130	-0,118	-0,112						
	(-4,91)***	(-4,82)***	(-4,29)***	(-4,14)***	(-4,32)***	(-4,09)***						
Observations	102060	102060	102060	102060	102060	102060	3402	3402	3402	3402	3402	3402
Borrower FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Borrower-Lender FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lender*Time FE	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents OLS parameter estimates of the Heckman two-stage procedure that corrects for sample selection bias. Panel A, columns (1) to (6), present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market (z_{it} =1). Panel B, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). Columns (3) to (6) and (9) to (12) incorporate the effects of our aggregate liquidity shock (US tapering) in accessing and pricing funds in the interbank market, respectively. All models have borrower, borrower*lender and time fixed effects to control for unobservable effects at the borrower, borrower-lender and time levels. Columns (6) and (12) include lender*time fixed effects. We cluster robust standard errors at the borrower bank level. Robust t-statistics in parentheses. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

Table 6. Idiosyncratic liquidity shocks, bank's stability, secured funding and lending concentration

Variables	Panel A: Probability to access the market: P (zit =1)						Panel B: Pricing Models: Spread it					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Liq. $Shock_{it}$			0,169	0,161	0,129	0,138			4,854	4,431	4,758	4,322
			(4,58)***	(4,21)***	(4,37)***	(4,09)***			(5,19)***	(5,03)***	(5,74)***	(5,12)***
$Size_{it}$ [Log of assets (mln)]	0,131	0,124	0,127	0,131	0,124	0,145	-0,146	-0,127	-0,108	-0,133	-0,146	-0,132
	(3,25)***	(3,78)***	(3,84)***	(3,26)***	(3,02)***	(3,17)***	(-3,62)***	(-3,47)***	(-3,09)**	(-3,21)**	(-3,46)***	(-3,28)***
z-$score_{it}$ (percent)	0,062	0,054	0,058	0,061	0,072	0,068	-0,032	-0,028	-0,019	-0,023	-0,015	-0,021
	(2,71)**	(2,45)**	(2,14)**	(2,59)**	(1,68)*	(1,83)*	(-2,25)**	(2,13)**	(2,26)**	(2,74)***	(3,01)***	(2,97)***
Npl_{it} (percent)	-0,091	-0,086	-0,082	-0,074	-0,087	-0,077	0,047	0,055	0,062	0,053	0,049	0,041
	(-2,10)**	(-1,91)**	(-1,79)*	(-2,25)**	(-2,35)**	(-2,26)**	(2,18)**	(2,33)**	(2,08)**	(2,29)**	(2,22)**	(2,64)**
Liquidity_$ratio_{it}$ (percent)		0,049	0,069	0,072	0,064	0,053		-0,026	-0,031	-0,019	-0,027	-0,023
		(1,15)	(1,06)	(1,24)	(1,35)	(1,12)		(-2,17)**	(-2,29)**	(-2,46)**	(-1,78)*	(-2,03)**
Market Liq_$risk_t$ (percent)		-0,013	-0,017	-0,023	-0,029	-0,018		0,058	0,063	0,054	0,059	0,065
		(-2,05)**	(-1,96)**	(-2,21)**	(-1,71)*	(-2,19)**		(3,01)***	(3,24)***	(3,15)***	(2,45)**	(2,38)**
Liq. $Shock_{it}$ * $Size_{it}$ [Log of assets (mln)]			0,013	0,009					-0,015	-0,011		
			(1,26)	(1,42)					(-1,73)*	(-1,90)*		
Liq. $Shock_{it}$ * z-$score_{it}$ (percent)			0,011	0,024					-0,007	-0,009		
			(1,40)	(1,19)					(-2,04)**	(-2,25)**		
Liq. $Shock_{it}$ * Npl_{it} (percent)			-0,014	-0,018	-0,013	-0,011			0,008	0,005	0,009	0,007
			(-1,12)	(-1,26)	(-1,32)	(-1,21)			(1,84)*	(1,73)*	(2,04)**	(2,18)**
Liq. $Shock_{it}$ * Liquidity_$ratio_{it}$ (percent)				0,013	0,009	0,007				-0,004	-0,007	-0,005
				(2,71)**	(2,24)**	(2,36)**				(-2,40)**	(-2,26)**	(-2,37)**
Liq. $Shock_{it}$ * Market Liq_$risk_t$ (percent)				-0,006	-0,004	-0,003				0,011	0,009	0,012
				(-2,35)**	(-2,49)**	(-2,52)**				(2,06)*	(1,92)*	(1,81)*
BPI_{ijt}	0,356	0,351	0,319	0,394	0,343	0,356	-1,026	-1,058	-1,112	-1,076	-1,084	-1,046
	(4,96)***	(5,15)***	(5,74)***	(6,55)***	(5,24)***	(5,38)***	(-3,90)***	(-4,06)***	(-4,25)***	(-3,56)***	(-3,91)***	(-4,12)***
Liq. $Shock_{it}$ * BPI_{ijt}			0,061	0,032	0,029	0,031			-0,206	-0,241	-0,308	-0,273
			(3,51)***	(3,44)***	(4,93)***	(4,42)***			(-3,25)***	(-3,07)***	(-2,27)**	(-2,41)**
Borrowing $secured_{it}$	0,012	0,018	0,013	0,027	0,023	0,031	-0,017	-0,011	-0,019	-0,022	-0,013	-0,018
	(1,21)	(1,07)	(1,78)*	(1,34)	(1,38)	(1,24)	(-1,25)	(-1,14)	(-0,96)	(-1,10)	(-1,27)	(-1,03)
Liq. $Shock_{it}$ * Borrowing $secured_{it}$			0,004	0,007	0,002	0,004			-0,003	-0,005	-0,004	-0,002
			(1,75)*	(1,94)*	(1,38)	(1,23)			(-2,20)**	(-2,75)***	(-1,97)*	(-2,19)**
CB_Liq_$supply_t$ [ln (mln)]	0,015	0,011	0,019	0,017	0,008	0,011	-0,024	-0,031	-0,029	-0,027	-0,019	-0,024
	(1,30)	(1,14)	(1,22)	(1,09)	(1,38)	(1,22)	(-2,47)**	(-2,26)**	(-2,19)**	(-2,89)***	(-2,70)***	(-3,08)***
Liq. $Shock_{it}$ * CB Liq_$supply_t$ [ln (mln)]			0,007	0,008	0,002	0,001			-0,011	-0,008	-0,013	-0,015
			(1,07)	(1,22)	(1,16)	(1,24)			(-1,15)	(-1,26)	(-1,07)	(-1,21)
Inv_Mills $ratio_{it}$							-6,135	-5,846	-5,024	-4,967	-4,146	-5,123
							(-3,75)***	(-3,97)***	(-4,02)***	(-4,41)***	(-3,52)***	(-4,24)***
Excess_$reserves_{it}$ (percent)	-0,205	-0,237	-0,216	-0,245	-0,178	-0,240						
	(-6,21)***	(-5,36)***	(-5,54)***	(-5,83)***	(-6,25)***	(-5,87)***						
Observations	813150	813150	813150	813150	813150	813150	27105	27105	27105	27105	27105	27105
Borrower FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Borrower-Lender FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lender*Time FE	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents OLS parameter estimates of the Heckman two-stage procedure that corrects for sample selection bias. Panel A, columns (1) to (6), present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market (z_{it} =1). Panel B, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). Columns (3) to (6) and (9) to (12) incorporate the effects of our idiosyncratic liquidity shock (deposits outflow) in accessing and pricing funds in the interbank market, respectively. All models have borrower, borrower*lender and time fixed effects to control for unobservable effects at the borrower, borrower-lender and time levels. Columns (6) and (12) include lender*time fixed effects. We cluster robust standard errors at the borrower bank level. Robust t-statistics in parentheses. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

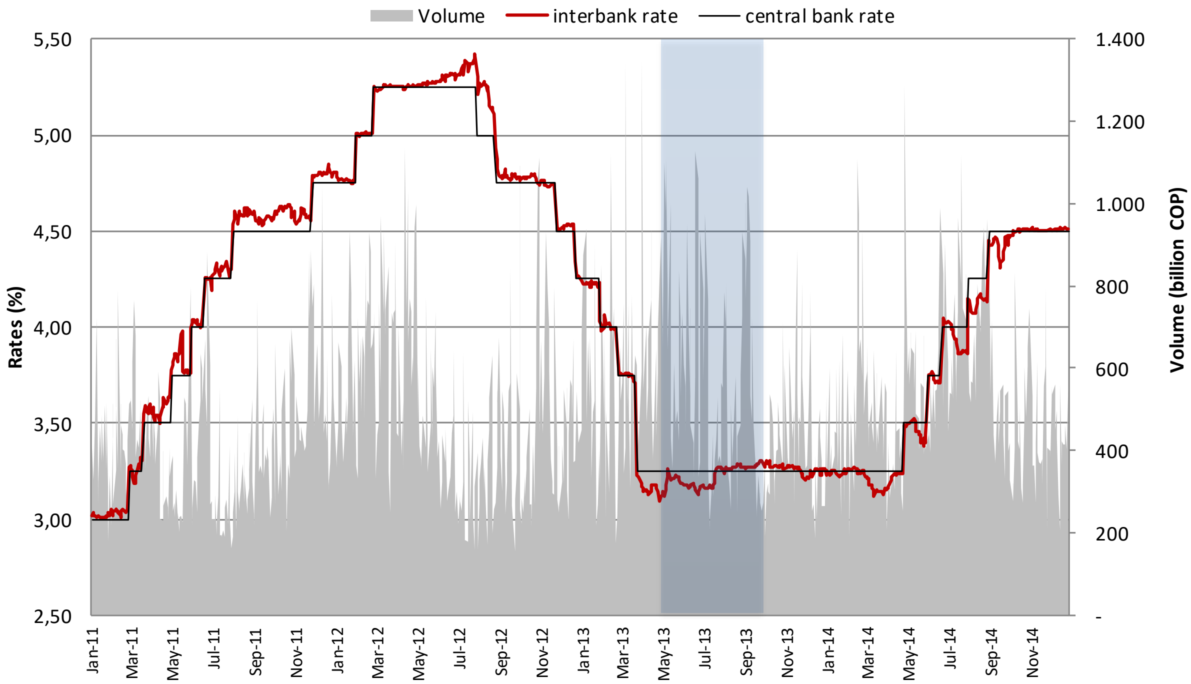
Table 7. Aggregate liquidity shocks, bank's stability, secured funding and lending concentration

Variables	Panel A: Probability to access the market: P (zit =1)						Panel B: Pricing Models: Spread it					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
US tapering$_t$			0,063	0,052	0,049	0,054			3,104	3,319	2,843	2,652
			(3,28)***	(3,61)***	(3,46)***	(3,23)***			(5,14)***	(5,36)***	(5,91)***	(5,70)***
Size$_{it}$ [Log of assets (mln)]	0,086	0,097	0,101	0,107	0,125	0,118	-0,079	-0,086	-0,094	-0,073	-0,069	-0,072
	(3,45)***	(3,29)***	(3,08)***	(3,16)***	(3,27)***	(3,19)***	(-3,41)***	(-3,07)***	(-2,87)**	(-2,94)**	(-3,18)**	(-3,36)**
z-score$_{it}$ (percent)	0,051	0,043	0,040	0,058	0,061	0,048	-0,065	-0,079	-0,071	-0,078	-0,063	-0,058
	(2,26)**	(2,34)**	(2,18)**	(2,16)**	(2,02)**	(2,38)**	(-2,65)**	(2,71)**	(2,14)**	(2,28)**	(1,73)*	(2,07)**
Npl$_{it}$ (percent)	-0,077	-0,081	-0,075	-0,073	-0,082	-0,079	0,055	0,057	0,039	0,046	0,051	0,045
	(-2,26)**	(-2,18)**	(-2,34)**	(-2,20)**	(-2,17)**	(-1,84)*	(2,31)**	(2,41)**	(2,30)**	(2,61)**	(2,47)**	(2,31)**
Liquidity_ratio$_{it}$ (percent)		0,042	0,046	0,041	0,037	0,022		-0,018	-0,012	-0,019	-0,008	-0,013
		(1,26)	(1,18)	(1,37)	(1,07)	(1,12)		(-2,06)**	(-2,19)**	(-1,90)*	(-2,15)**	(-1,78)*
Market Liq_risk$_t$ (percent)		-0,032	-0,041	-0,055	-0,047	-0,051		0,046	0,051	0,049	0,057	0,063
		(-2,28)**	(-2,69)**	(-2,76)**	(-2,58)**	(-3,26)**		(3,28)***	(3,41)***	(3,64)***	(3,07)***	(3,48)***
US tapering$_t$ * Size$_{it}$ [Log of assets (mln)]			0,016	0,022					-0,015	-0,018		
			(1,04)	(1,12)					(-1,74)*	(-1,49)		
US tapering$_t$ * z-score$_{it}$ (percent)			0,017	0,008					-0,015	-0,017		
			(2,77)**	(2,21)**					(-2,04)**	(-1,94)*		
US tapering$_t$ * Npl$_{it}$ (percent)			-0,018	-0,014	-0,011	-0,007			0,019	0,024	0,021	0,018
			(-1,10)	(-1,14)	(-1,22)	(-0,92)			(2,30)**	(2,19)**	(2,27)**	(1,75)*
US tapering$_t$ * Liquidity_ratio$_{it}$ (percent)				-0,012	-0,017	-0,011				-0,007	-0,009	-0,011
				(-1,02)	(-1,18)	(-1,23)				(-2,44)**	(-2,31)**	(-1,82)*
US tapering$_t$ * Market Liq_risk$_t$ (percent)				-0,017	-0,011	-0,014				0,019	0,014	0,021
				(-2,95)***	(-3,17)***	(-3,59)***				(2,94)***	(3,08)***	(3,21)***
BPI$_{ijt}$	0,509	0,474	0,387	0,362	0,324	0,372	-1,123	-1,054	-1,075	-1,026	-1,427	-1,234
	(6,90)***	(7,33)***	(7,03)***	(6,40)***	(7,22)***	(6,56)***	(-3,97)***	(-4,02)***	(-4,21)***	(-3,46)***	(-3,30)***	(-3,11)***
US tapering$_t$ * BPI$_{ijt}$			0,011	0,009	0,013	0,015			-0,051	-0,063	-0,077	-0,061
			(1,86)*	(2,14)*	(2,22)**	(2,43)**			(-1,50)	(-1,39)	(-1,27)	(-1,22)
Borrowing secured$_{it}$	0,017	0,012	0,013	0,027	0,023	0,019	-0,013	-0,012	-0,018	-0,011	-0,012	-0,009
	(1,12)	(1,04)	(1,16)	(1,47)	(0,94)	(1,15)	(-0,95)	(-0,84)	(-0,77)	(-0,91)	(-1,03)	(-0,81)
US tapering$_t$ * Borrowing secured$_{it}$			0,004	0,007	0,002	0,006			-0,006	-0,004	-0,007	-0,003
			(1,98)**	(2,07)**	(2,28)**	(2,35)**			(-1,20)	(-1,45)	(-1,17)	(-0,91)
CB_Liq_supply$_t$ [ln (mln)]	0,011	0,018	0,012	0,009	0,015	0,021	-0,062	-0,057	-0,049	-0,054	-0,051	-0,049
	(1,23)	(1,08)	(0,91)	(0,87)	(1,20)	(1,03)	(-3,21)***	(-3,42)***	(-3,24)***	(-3,51)***	(-3,30)***	(-3,47)***
US tapering$_t$ * CB_Liq_supply$_t$ [ln (mln)]			0,009	0,011	0,007	0,005			-0,019	-0,025	-0,017	-0,021
			(2,15)**	(2,30)**	(2,16)**	(1,91)*			(-5,06)***	(-4,68)***	(-4,92)***	(-3,72)***
Inv_Mills ratio$_{it}$							-2,856	-3,162	-3,436	-2,741	-3,059	-2,783
							(-3,28)***	(-3,19)**	(-2,46)**	(-3,08)***	(-3,31)***	(-3,55)***
Excess_reserves$_{it}$ (percent)	-0,114	-0,109	-0,118	-0,123	-0,106	-0,112						
	(-4,02)***	(-4,23)***	(-3,74)***	(-3,81)***	(-3,65)***	(-3,71)***						
Observations	102060	102060	102060	102060	102060	102060	3402	3402	3402	3402	3402	3402
Borrower FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Borrower-Lender FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lender*Time FE	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents OLS parameter estimates of the Heckman two-stage procedure that corrects for sample selection bias. Panel A, columns (1) to (6), present the results of the selection models, where the dependent variable is the probability of a bank to borrow from the interbank market (z_{it} =1). Panel B, columns (7) to (12) correspond to the second stage estimates of the interest rate models in which the spread to the CB rate (in bps) is employed as a dependent variable (i.e. the price of liquidity (p_{it})). Columns (3) to (6) and (9) to (12) incorporate the effects of our aggregate liquidity shock (US tapering) in accessing and pricing funds in the interbank market, respectively. All models have borrower, borrower*lender and time fixed effects to control for unobservable effects at the borrower, borrower-lender and time levels. Columns (6) and (12) include lender*time fixed effects. We cluster robust standard errors at the borrower bank level. Robust t-statistics in parentheses. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

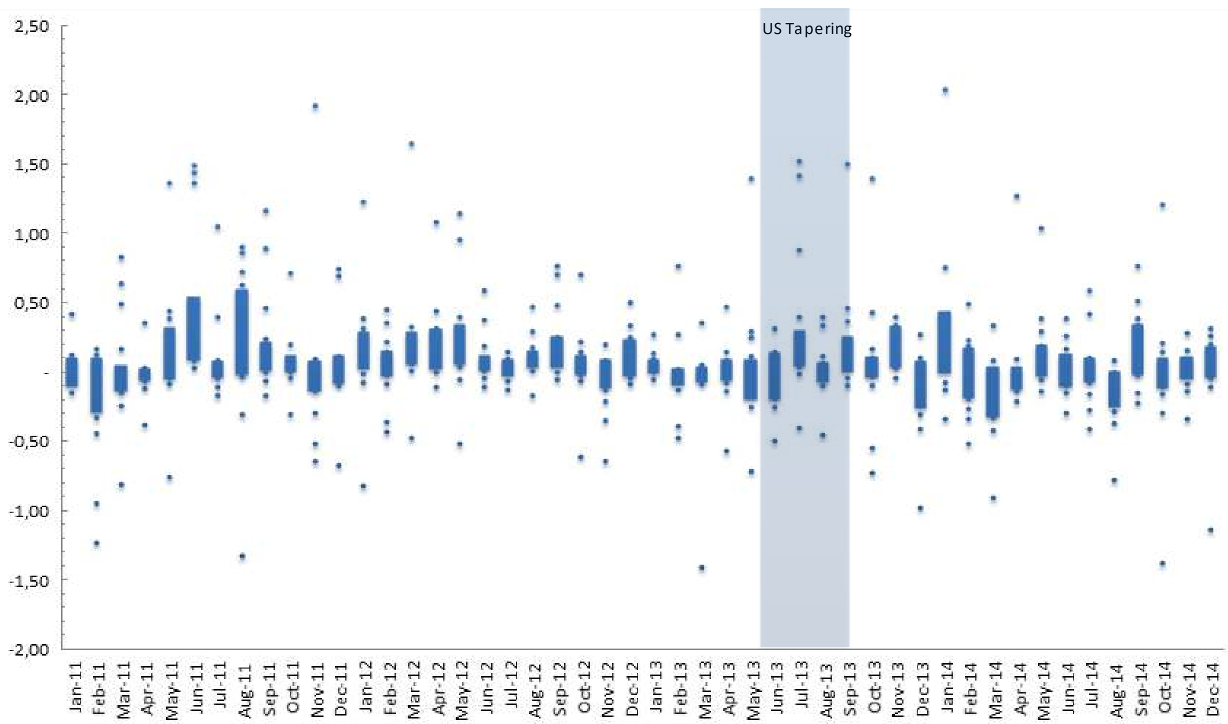
Appendix

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



Note: This figure depicts the overnight interbank market rate and central bank rate in percentage (%) during the period 2011-2014. Average daily amount traded in the interbank market in billions of COP (Right axis). Shared region corresponds to the U.S. tapering period: May-22-2013 to Sep-17-2013.

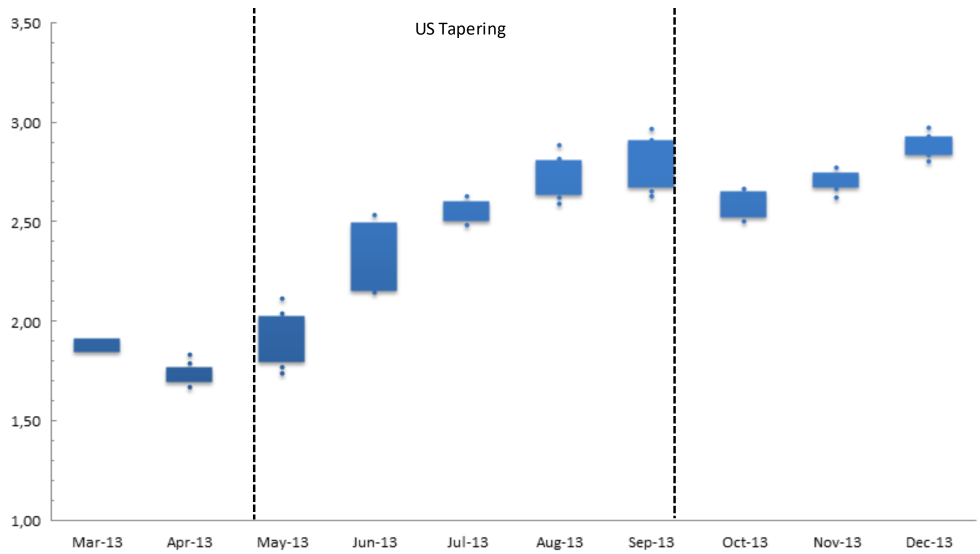
Figure 2A. Distribution of the rate of growth of bank deposits at the bank level



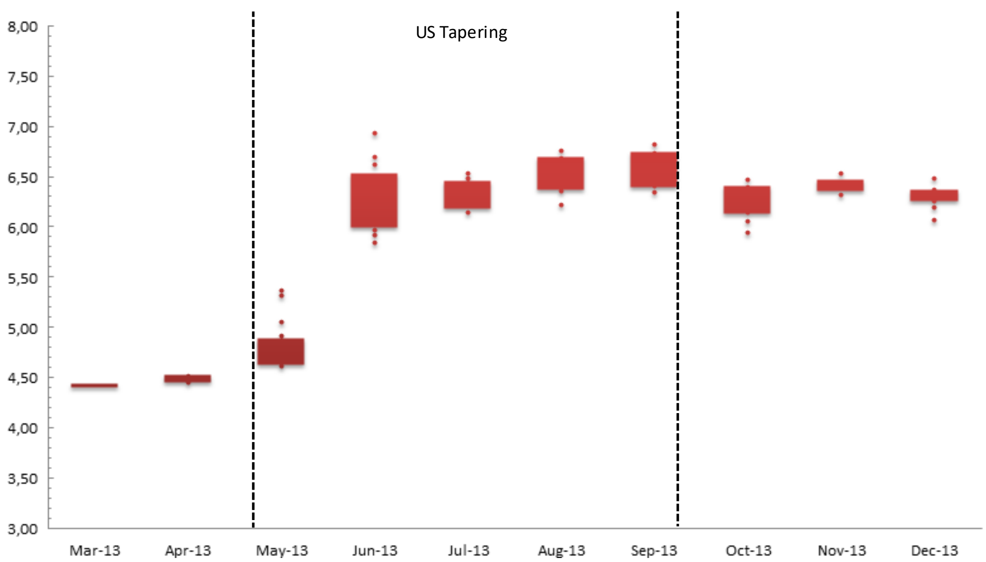
Note: This figure presents the median rate of growth of the deposits at the bank level (per month) between January 1, 2011 and December 30, 2014. Shared region corresponds to the U.S. tapering period: May-22-2013 to Sep-17-2013.

Figure 3A. Government bills in U.S. and Colombia during the U.S. tapering

Panel (a) 10-years U.S. Treasury bills (yields, %)



Panel (b) 5-years Colombian bills (TES) (yields, %)



Note: Panel (a) depicts the 10-years Treasury bills (yields, in %). Panel (b) shows the 5-years Colombian bills (TES) (yields, in %). Data is from the period March 26 and December 30, 2013. Dotted lines correspond to the U.S. tapering period: May 22 to September 17, 2013.

Table 1A. Summary statistics and definitions of the variables employed in the model

Variable	Definition	Mean	Std. Dev.	Min	Max	Obs.
p_{it} *(spread)*	The difference in basis points (bps) between the volume-weighted average interest rate (r_{it}) paid for a bank *i* of all its overnight unsecured loans during the day *t* and the central bank rate in *t* (r_{cbt}).	1,85	47,50	(148,32)	195,36	27105
$Loan_{ijt}$	Indicator variable equal 1 if the bank *i* borrows liquidity form bank *j* in the interbank market at time *t*.	0,73	0.27	0	1	813150
US tapering$_t$	Dummy variable equal to 1 during the period *t* in which the Fed announced to the market the possibility of reducing its purchase of assets: between May 22 and September 17, 2013, and 0 during the period immediately before (since the last change of the CB policy rate) i.e. March 23 and May 21, 2013.	0.28	0,16	0	1	3402
$Liq.Shock_{it}$	Dummy variable equal 1 if the rate of change of the deposits of bank *i* is negative in *t-1* and, 0 otherwise.	0,43	0,75	0	1	27105
$size_{it}$	Log of total assets (million COP, end of month)	14,68	1,92	9,08	18,42	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
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
$zscore_{it}$	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 %)	4,51	4,82	(1,60)	7,55	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	17,06	39,21	(11,47)	293,24	27105
$liquidity\_risk_{it}$	Liquidity risk is measured as the standard deviation of daily change in reserve holdings during the last 30 days divided by reserve requirements	0,19	9,31	(82,57)	183,43	67950

liquidity_ratio$_{it}$	Liquidity position computed as liquid assets over total assets (end of month) (%)	0,52	0,62	0,38	0,87	1138
Market_liq_risk$_{jt}$	Standard deviation of the normalized excess reserves among all banks j during the period t.	0,08	3,40	(14,87)	26,31	67950
RL$_{ijt}$	RL gauges the frequency of interactions between two banks in the interbank market and is computed by the logarithm of one plus the number of days a bank *i* has lent to bank *j* over a certain time of period *T* as: $RL_{ijt} = \log(1+ \sum_{t \in T} I(y\_ijt>0))$, with T = 30 days.	0,25	0,54	0,00	1,75	813150
BPI$_{it-1}$	Borrowing preference index (BPI) computed as the amount of funds borrowed by the bank *i* from a bank j at time t over a period *T* relative to the overall amount borrowed by bank *i* from all banks *j* over the same period *T* (with T = 30 days)	0,05	0,11	0,00	0,42	813150
Borrowing secured$_{it}$	Dummy variable equal 1 if the bank i borrows funds in the secured money market in time t, and zero otherwise.	0,16	0,38	0,00	1,00	27105
CB_Liq_Supply$_{t}$	Log of the total liquidity supply of the central bank at time t (in billion COP)	29,36	0,48	27,81	30,35	1138