The Transmission of Non-Banking Liquidity Shocks to the Banking Sector

Sarmiento Paipilla, Miguel

Publication date:
2024

Document Version
Early version, also known as pre-print

Link to publication in Tilburg University Research Portal

Citation for published version (APA):
Sarmiento Paipilla, M. (2024). *The Transmission of Non-Banking Liquidity Shocks to the Banking Sector*. (CentER Discussion Paper; Vol. 2024-011). CentER, Center for Economic Research.

CentER

Discussion Paper

No. 2024-011

THE TRANSMISSION OF NON-BANKING LIQUIDITY SHOCKS TO THE BANKING SECTOR

By

Miquel Sarmiento

22 April 2024

ISSN 0924-7815
ISSN 2213-9532

Tilburg University

The Transmission of Non-Banking Liquidity Shocks to the Banking Sector*

Miguel Sarmiento[a,b]

Abstract

The increasingly interdependence between non-banking financial institution (NBFIs) and the banking sector conditions the provision of liquidity in the financial markets. This paper evaluates how the market stress associated to the bankruptcy of one of the most interconnected NBFIs in an emerging market economy affected the availability of unsecured interbank funding. We show that the market stress conducted to a reallocation of deposits from money market mutual funds (MMMF) within the banking sector that affected the liquidity provision in the unsecured interbank market. Banks with ex-ante high concentration of deposits from the MMMF sector significantly increased loan spreads and reduced the supply of unsecured funds in the interbank market. Lending relationships and central bank liquidity contributed to partially alleviate the liquidity shock. Overall, we identify that the concentration of uninsured deposits from MMMFs increases the transmission of non-banking liquidity shocks to the banking sector.

Keywords: Interbank markets; Lending relationships; MMMF; NBFI; Deposits Channel; Banks; Financial Stability.

JEL Codes: L14, G12, G2, E58

*This paper is an extension of my PhD dissertation. I am grateful to Harry Huizinga, Olivier De Jonghe, Fabio Castiglionesi, Hans Degryse, Sylvester Eijffinger, and Wolf Wagner, for their valuable suggestions and fruitful discussions during this research. This research has benefited from comments and suggestions of participants at the XXI Banco de la República Research Seminar, and the 2nd Regional Conference on Payment Systems and Financial Infrastructures organized by CEMLA and Banco de la República. This paper was awarded with the First Place of the 2023 Central Bank Award Rodrigo Gómez granted by the Center of Latin-American Monetary Studies (CEMLA). I would like to thank, Jesús Sierra-Jimenez (discussant), Wilmar Cabrera (discussant), Juan Esteban Carranza, Clara Machado, Javier Miguélez, Maria Fernanda Menéses, Daniela Rodríguez, Camilo Sánchez, Hernán Rincón, and Jair Ojeda for their helpful comments, discussions, and cooperation with data requirements. Views and errors are my own and do not represent the views of the Banco de la República or its Board of Directors. E-mail: nsarmipabanrep.gov.co; Carrera 7 14-78, Floor 4, Bogotá DC. Colombia.

[a]Banco de la República

[b]European Banking Center, E-mail: nsarmipa@banrep.gov.co

1 Introduction

The increasingly interdependence between non-banking financial institution (NBFIs) and the banking sector affects the provision of liquidity in the financial markets (Aramonte et al., 2022; Agarwal et al., 2017; IMF, 2023). During the Covid-19 liquidity shock observed in March 2020, money market mutual funds (MMMFs) exhibited the largest outflows of funds since the great financial crisis of 2008-09 forcing central banks to grant liquidity to these institutions to reducing the contagion between NBFIs and banks, and to preserve the financial stability (Afonso et al., 2022; Afonso et al., 2014; Boyarchenko et al., 2022; Breckenfelder and Hoerova, 2023; Falato et al., 2021; Müller et al., 2024). Therefore, containing the interdependence between NBFIs with the banking sector to reduce the spillovers across financial markets is one of the main concerns among financial regulators and central banks (FSB, 2021; FSB, 2022; Bagattini et al., 2023).

In this paper, we identify a novel deposits channel that traces how liquidity shocks from MMMFs are transmitted to the banking sector and the effects on the provision of unsecured interbank funding. We evaluate the market stress associated with the collapse of the largest Brokerage Firm in Colombia (Interbolsa) and one of the most interconnected NBFI in the financial system (León et al., 2011). Interbolsa was one of the 14 money market makers of the public debt market and one of the key players in the secured money market and the stock exchange market [1]). The failure of this too-interconnected-to-fail NBFI caused a contagion effect across the MMMFs because of the strong interaction in secured money markets. This forced the central bank to grant access to MMMFs and other NBFIs to the expansionary open market operations by using an ample range of elegible collaterals (i.e., private debt, municipal public debt bills, and certificates of deposits (CDs)) (Banco de la

[1]On November 1st of 2012, Interbolsa defaulted on a credit operation with a counterparty and the next day it was liquidated by the Financial Supervisor. The investigation revealed that Interbolsa engaged on excessive risk taking by supporting operations in the repo market using stocks of a low-rated non-financial listed firm. This event negatively affected the stock exchange market leading to a decline of 20 percent the following days

República, 2012a). The policy response contributed to alleviate liquidity tensions in the secured money market (Banco de la República, 2012b). However, as banks are the main depository institutions of MMMFs, the redemptions by investors reduced the availability of short-term liquidity by these funds forced them to reduce their deposits in the banking sector, mainly CDs issued by banks. We observe that the reallocation of liquidity within the banking sector was accompanied by a significant increase in the spreads on unsecured interbank loans and lower interbank market activity.

We exploit the different exposition of banks to deposits from MMMFs to evaluating the transmission of the liquidity shock caused by the collapse of Interbolsa on the availability of short-term liquidity in the unsecured interbank market. To our knowledge, this is the first paper that evaluates how liquidity shocks from MMMFs affected the unsecured interbank market via the deposits channel.

We focus on the effects of the market stress faced by MMMFs on the unsecured interbank market given that it is mainly used by banks 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). Evidence shows that, 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; Sarmiento, 2022). However, during aggregate liquidity shocks the interbank market liquidity tend to decline due to concerns over counterparty and liquidity risk of its participants and can reduce the availability of short-term liquidity and also the provision of credit to the real economy—as observed during the global financial crisis (GFC) of 2008 (Brunnermeier and Pedersen, 2009; Angelini et al., 2011; Acharya and Merrouche, 2013; Iyer et al., 2014; Gofman, 2017; Craig and Ma, 2022)—. Using micro-data from both the deposits market and the unsecured interbank market matched with bank-specific characteristics, we evaluate how this deposits channel operated during the market stress faced by MMMFs following the collapse of a too-interconnected-to-fail NBFI.

In particular, we analyze the changes in the supply of credit in the unsecured interbank market during the market stress period. The Colombian unsecured interbank market is a short-term (overnight liquidity market) in which only banks exchange liquidity (i.e., BFs, MMMF or other NBFIs do not participate in the unsecured interbank market). Thus, we identify how the intensity of this deposits channel affected the provision of interbank liquidity by banks with high exposition to deposits from MMMFs. We evaluate how the frequency and intensity of the lender-borrower relationship in the unsecured interbank market contributed to mitigate the liquidity shock faced by exposed banks to deposits from MMMFs. We also analyze whether the liquidity from the central bank alleviated the liquidity tensions in the unsecured interbank market during the turmoil period. Thus, we provide novel evidence on how liquidity shocks from the MMMF sector affect the unsecured interbank market via the deposits channel.

Our empirical strategy combines the approach in Braüning and Fecht (2017) to study the unsecured interbank market with the estimation process in Jiménez et al. (2012, 2014) to evaluate the transmission of shocks in credit markets. We use the differential exposition of banks to deposits from MMMFs as an instrument to identify how liquidity shocks from these NBFIs can be transmitted to the banking sector. The detailed dataset on bank-to-depositors-deposits level matched with bank-to-bank unsecured loan level data and with bank-specific characteristic of liquidity, credit risk, capitalization, among others, allows to identify how the exposition of banks to deposits from MMMFs during the market stress affected their behavior *as lenders of funds* in the unsecured interbank market. Furthermore, the rich dataset allows to include a large set of fixed effects at the borrower, lender, borrower*lender, and time level to control for unobserved heterogeneity and aggregated changes in liquidity. To disentangle supply from demand effects, we also include borrower*time fixed effects, and hence we identify changes in the composition of the supply of unsecured funds. This unique dataset provides an ideal setting to test the transmission of liquidity shocks from the MMMF sector to the banking sector via the deposits channel, a less explored channel in the banking literature.

We find four main results. First, we find that during the market stress associated to the collapse of a top NBFI, banks with ex-ante high concentration of deposits with the MMMF sector exhibited lower probability to lend unsecured funds in the interbank market, charged significantly higher prices on unsecured loans and reduced their supply of unsecured finds. This finding reveals a novel deposits-channel that links banks' deposits concentration with the MMMF sector with the availability and price of short-term liquidity in the banking sector. More concretely, banks with ex-ante MMMFs in the top 10 of its depositors exhibited a reduction in the probability to lend funds in the interbank market from 11.8 to 4.3 percent during the market stress, while the price charged on interbank funds significantly increased from a discount of 6,5 bps to a spread of 14 bps over the central bank policy rate. Moreover, we find that during the market stress, banks with ex-ante high concentration of deposits with the MMMF sector significantly reduced their supply of unsecured funds to participants of the interbank market in around 17 percentage points (pp).

Second, we find that the liquidity shock in the unsecured interbank was partially mitigated by the role of lending relationships. Exposed banks to deposits from MMMFs that had an established relationship with their counterparts in the unsecured interbank market exhibited a higher probability to lend funds during the market stress and charged a lower spread compared to spot counterparts. We also observe that reciprocal lending in the unsecured interbank market contributed to alleviate funding costs and increased the access to liquidity during the market stress, in line with the observed role of lending relationships in times of heightened uncertainty in financial markets (Braüning and Fecht, 2017; DiMaggio et al., 2017).

Third, the increase in the supply of central bank liquidity was associated to higher market access and lower unsecured loan prices, suggesting that central bank liquidity effectively contribute to alleviate short-term liquidity tensions during periods of market stress. Moreover, we find that the higher provision of central bank liquidity to MMMFs during the market stress significantly increased the exposed banks' willingness to lend unsecured funds in the interbank market, reduced their spreads on loans and rise their supply of interbank funds. This result provides evidence on the effectiveness of temporarily liquidity facilities by central banks in times of heightened uncertainty in the MMMF sector (Bagattini et al., 2023).

Fourth, we show that changes in the degree of deposits concentration with the MMMF sector influence the transmission of liquidity shocks to the banking sector. We find that the observed effects of the exposition of banks in the deposits market to the MMMF sector on their behavior in the unsecured interbank market are significantly lower when the banks' concentration of deposits is reduced from the top 10 to the top 20 of depositors. This highlights the potential benefits of limitations in the degree of banks' deposits concentration with the MMMF sector to reduce the influence of NBFIs' liquidity shocks on the short-term liquidity of the banking sector. For instance, lowering the weight of deposits from MMMFs in the liquidity ratios for banks, such as net stable funding ratio (NSFR). This can reduce the incentives for banks to attract deposits from these institutions. These regulatory tools have been recently discussed as part of the regulatory framework to mitigate the transmission of risks by NBFIs to the banking sector and financial systems, and especially to tackle the high interdependence among NBFIs and banks (IMF, 2023; Schnabel, 2021; FSB, 2021, 2022).

The remainder of this paper is organized as follows. Section 2 discussed the related literature. Section 3 describes the data and provides the initial evidence on the behavior of MMMFs and the effects of the market stress on the deposits and unsecured interbank markets. Section 4 presents the methodology, and the variables employed in the models' estimation. Section 5 discusses the results. Finally, section 6 concludes.

2 Related Literature

This paper contributes to several strains in the banking literature. First, we find that during the market stress generated by the collapse of a top NBFI, banks with large expositions to deposits of MMMFs contracted their supply of unsecured funding relatively more than non-exposed banks. Moreover, those exposed banks exhibited a lower probability to lend unsecured funds and significantly charged loan spreads to their counterparts in the interbank market. The observed behavior is consistent with liquidity hoarding by precautionary motives associated to the decline in the short-term availability of deposits by MMMFs. This finding is consistent with previous evidence on the effects of the transmission of liquidity shocks on both unsecured and secured interbank markets in the U.S. and Europe (Angelini et al., 2011; Acharya and Merrouche, 2013; Iyer et al., 2014; Gofman, 2017; Craig and Ma, 2022; Bednarek et al., 2023; Bechtel et al., 2023).

Second, the results provide evidence on the interdependences between funds and banks in financial markets. Kacperczyk and Schnabl (2013) document the risk-taking behavior observed by MMMFs during the great financial crisis and their incentives to take on more risk than other financial institutions. Agarwal et al. (2017) find that the uncertainty about equity market explains hedge fund performance both in the cross section and over time. Aramonte et al. (2022) analyze the structural shifts in intermediation and how NBFIs have shaped the demand and supply of liquidity in financial markets. Bagattini et al. (2023) evaluate the liquidity support of parent banks to affiliated MMMFs and the resulting spillovers between these entities. They show that parent banks purchase shares of affiliated funds when the funds experience significant outflows. Afonso et al. (2022) document that the increased use of the Fed's repo facility by MMMFs has declined their deposits in the banking sector affecting short-term interest rates. Müller et al. (2024) find that MMMFs runs in the deposits market affected banks' maturity transformation in the Colombia's corporate credit sector. We extend this literature by showing that high levels of interconnectedness among MMMFs with banks via the deposits channel constitute an amplification channel of financial stress. We show that liquidity shocks faced by MMMFs reallocate deposits in the banking sector affecting banks' funding conditions in the unsecured interbank market.

Third, the results contribute to the recent evidence on behavior of MMMFs and central banks during the Covid-19 liquidity shock. In March 2020, MMMFs experimented the largest outflows of funds since the great financial crisis. This forced central banks to grant liquidity to both NBFIs and MMMFs by large-scale purchases of assets, the extension of liquidity by using alternative collaterals and new facilities (including the use of private debt bills and certificates of deposits) and the modification of the lender of last resort operations, in order to restore liquidity in financial markets and preserve the financial stability (Afonso et al., 2022; Boyarchenko et al., 2022; Breckenfelder and Hoerova, 2023; Falato et al., 2021; Müller et al., 2024). This study shows that the central bank liquidity granted to MMMFs alleviated liquidity tensions in the Colombian unsecured interbank market.

Fourth, we extend the growing evidence on the hedging role of lending relationships in the interbank market during liquidity shocks (Angelini et al., 2011; Acharya and Merrouche, 2013; Afonso et al., 2014; Braüning and Fecht, 2017; DiMaggio et al., 2017). Unlike these studies—that center their analysis on the liquidity shock related to the global financial crisis of 2008 in advanced economies—we examine the effect on the unsecured interbank market associated with the market stress followed by the collapse of one of the most interconnected NBFI in an emerging market economy. We show that lending relationships contribute to increase the supply of unsecured funds by exposed banks during the market stress and to reduce the price of loans. Moreover, we document that reciprocal lending helps banks to smooth better the impact of liquidity shocks on its funding costs. This result can be related to risk-management motivation, as banks tend to combine deposits and commitment lending to provide a liquidity-risk hedge (Kashyap et al., 2002; Gatev et al., 2009).

Lastly, our results highlight some challenges to the regulation of MMMFs and the banking sector. We observe that increased uncertainty on the availability of deposits by MMMFs was associated with a reduction in the supply of unsecured interbank funding and higher liquidity prices. This evidence contributes to understand some of the implications of uninsured depositors of the banking system and the potential effects on the deposits market (Martin et al., 2022; Rajkamal and Puri, 2012; Rajkamal et al., 2019; Jiang et al., 2023). Thus, concentration limits of deposits from uninsured wholesale depositors (as NBFIs or MMMFs) in the banking sector can contribute to reduce the exposition of banks to potential liquidity shocks from these depositors (see, FSB, 2021, 2022).

3 Data

We use three main data sources supplied by the central bank of Colombia and the Financial Superintendence of Colombia (FSC) that allows to trace the impact of liquidity shocks from the MMMFs to the unsecured interbank market. First, we use regulatory data from the FSC at the depositor-bank-deposit level that includes the top 50 depositors of each bank in Colombia. The dataset includes monthly information on the total amount of deposits, type of deposit (i.e., saving and checking (S&C) accounts, and certificate of deposits (CDs)), type of depositor (financial or non-financial institution, public or private entity, firms or individuals) and the bank and depositor identification number. The database includes 13,500 observations at the depositor-bank-deposit level of the top 50 depositors in 27 banks during 2012m6 to 2013m3. The data include the deposits from 1,231 depositors, including 27 commercial banks, 120 NBFIs, 124 mutual funds, from which 17 are MMMF (open-ended), and 978 non-financial firms and households. Total deposits in the banking sector accounts for 79 percent of total deposits in the banking system. During the evaluated period, 95 percent of deposits of

MMMFs were with commercial banks.

Second, we use loan-level data on the universe of unsecured loans among the financial institutions participating in the Colombian interbank market. The sample comprises non-publicly available data on 7,410 daily overnight bilateral unsecured operations among 53 credit institutions during the evaluated period. 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. Thus, we can directly observe the characteristics of the interbank loans (i.e., rates, volumes, maturities, and counterparties) that are registered by the participants and reported daily 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).

Third, to properly gauge the liquidity position of banks over time, we employ daily liquidity reports at the bank level including central bank' repo operations, total deposits, reserve balances, cash holdings, liquid assets, and required reserves. The data include 5,535 bank-level observations during the evaluated period. We match this dataset with bank-specific characteristics of size, risk, capitalization, and liquidity using monthly balance sheet reports from the FSC. The database includes 270 monthly bank level observations. We merged the databases to build an unbalanced daily panel data set composed by 7,410 observations at the borrower-lender-loan level, including bank-level characteristics of 27 banks during 2012m6 to 2013m3.

3.1 The concentration of deposits and the interbank market

We are interested in understanding whether the deposits of MMMFs in the banking sector changed after the collapse of Interbolsa, which can affect the provision of short-term funding in the unsecured interbank market. In Table 1, we present the results of a mean comparison test to check whether the deposits of MMMFs in the banking sector changed after the collapse of Interbolsa. To do this, we define market stress equals 1 to the period between November 2012 and March 2013, while market stress equals 0 corresponds to the period between June and October 2012 (i.e., before the collapse of Interbolsa)[2]. In column 1 we observe that the share of deposit of MMMFs to total deposits from the top 50 depositors before the market stress was on average 10.7 percent, and during the market stress period it declined to 8.4 percent, a reduction of 2.3 percentage points (i.e., 21.5 percent lower). As the main assets of the largest MMMF are certificates of deposits (CDs) issued by banks, we split deposits between the saving and checking accounts (S&C) and CDs. We observe that while deposits in S&C accounts remained relatively stable, deposits in CDs exhibited a significant contraction from 12.3 percent to 9.8 percent, a mean reduction of 20.3 percent during the period. An important increase in the volatility of CDs in the banking sector was also observed, confirming the increasing needs of liquidity by MMMFs (column 2 vs. 4).

[2]Figure 2 shows that the reduction in the volatility of the stock exchange market after March 2023 that coincides with the reduction in the central bank policy rate. As we will observe latter, the uncertainty on the MMMF sector significantly declined by the end of March 2013, when the availability of unsecured liquidity returned to normal levels and the interbank market rate was close to the policy rate.

Table 1: DEPOSITS OF MMMFS IN THE BANKING SECTOR DURING MARKET STRESS

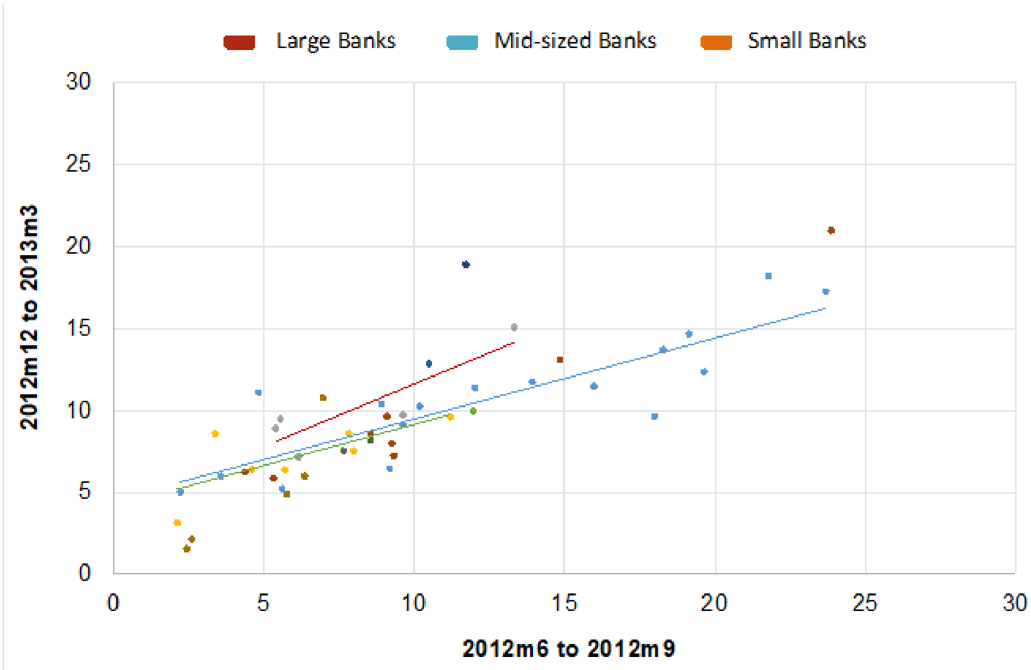
Conditions in the Deposits Market	Market Stress = 0		Market Stress =1			
	Median (1)	Std. Dev. (2)	Median (3)	Std. Dev. (4)	Var.(in %) (5)	Diff (6)=(3)-(1)
Deposits of MMMFs over total deposits (in %)	10.7	13.2	8.4	19.5	-21.5	-2.3**
Deposits of MMMFs in saving & checking accounts over total deposits (in %)	4.2	1.8	3.8	2.5	-9.5	-0.4**
Deposits of MMMFs in CDs over total deposits (in %)	12.3	7.4	9.8	11.6	-20.3	-2.5**
Number of MMMFs with deposits in the banking sector	124	1.4	120	2.3	-3.2	-4
Number of banks with deposits from MMMFs	14	1.2	16	2.5	14.3	2
Deposits of non-financial firms and households over total deposits	65.4	7.3	77.6	12.5	18.7	12.2**
Deposits of top 50 depositors over total deposits in the banking sector	19.4	3.7	21.6	5.3	11.3	2.2**

NOTE: This table presents mean comparison tests using monthly information from the top 50 depositors and balance-sheet data at the bank level. The data correspond to 13,500 depositor-bank-deposit level observations between 27 banks with 1,231 depositors, including 27 banks, 120 NBFIs, 124 funds (from which 21 are MMMF), and 978 non-financial firms and households between June 2012 and March 2013. Total deposits correspond to the total deposits from the top 50 depositors reported monthly by banks to the SFC. Total deposits in the banking sector include the universe of depositors and correspond to the total value reported monthly by banks in their balance-sheet reports to the SFC. Columns (1) and (3) are the median, while columns (2) and (4) the standard deviation during each period. Market Stress =1 corresponds to the deposits observed following the collapse of Interbolsa and covers the period November 2012 to March 2013, while Market Stress =0 covers the deposits observed between June and October 2012 (i.e., five months before the collapse of Interbolsa). Column 5 is the difference between the median values in columns (1) and (3). **p>0.05. Source: Monthly information from the Superintendencia Financiera de Colombia.

The number of MMMFs with deposits in the banking sector remained. It is important to mention that during the period only the 4 mutual funds managed by Interbolsa were liquidated, the remaining 117 mutual funds continued active. Interestingly, the number of banks with deposits from MMMFs increased from 14 to 16, indicating a higher diversification in the holdings of deposits from these institutions. We observe an increase of 18.7 percent in the share of deposits by non-financial firms and households during the market stress period, that can indicate a potential reallocation of deposits within the banking sector, as the share of deposits of the top 50 depositors over total deposits remained relatively stable during both periods. That could suggest that top investors on MMMFs (mainly large non-financial firms) that claimed their investments on these funds kept their liquidity within the banking sector in regular deposits (i.e., as cash holdings). However, these figures also indicate that banks with MMMFs as depositors exhibited an important increase in the volatility of deposits with potential implications on short-term lending.

Figure 1 depicts the share of deposits from MMMFs over total liabilities at the bank level distinguishing by the size of the bank. We compute the median share during the period November 2012 to March 2013 (after the collapse of Interbolsa) and during the period June to October 2012 (before the collapse of Interbolsa). We observe the important heterogeneity in the exposition of banks to deposits from MMMFs, ranging from 3 percent to 23 percent of their liabilities.

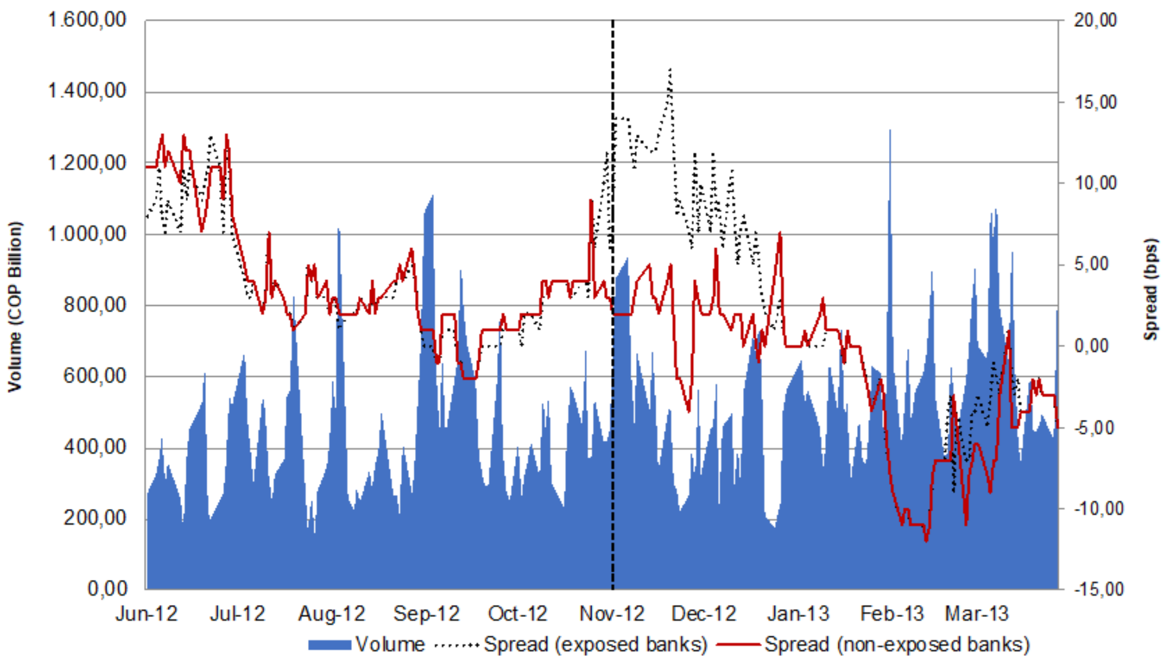
Figure 1: Concentration of deposits from MMMFs in the banking sector



Notes: This figure presents the share of deposits from MMMFs over total liabilities at the bank level (median of total deposits during each period). Vertical axis is for the period November 2012 to March 2013 (after the collapse of Interbolsa). Horizontal axis is for the period June to October 2012 (before the collapse of Interbolsa). Red dots (line) are for large banks, blue dots (line) are for mid-sized banks, and orange dots (line) denote for small banks. Monthly data from Superintendencia Financiera de Colombia.

In Figure 2, we observe that during the market stress period, the unsecured interbank market exhibited higher rates and greater volatility in the availability of funds. The interbank market rate tends to be close to the central bank rate due to it is the target rate for the monetary policy implementation. Large or persistent deviations of the interbank rate from the policy rate constitute a signal of liquidity imbalances (excess or deficit of liquidity) among participants of the interbank market. We show the spread to the central bank policy rate for those unsecured interbank loans that involved an exposed bank as lender (exposed bank) and for those loans without exposed banks as lenders (non-exposed banks). Exposed banks are banks that have at least one MMMF in the top 10 depositors three months before the collapse of Interbolsa (i.e., July 31, 2012).

Figure 2: The unsecured interbank market during the market stress



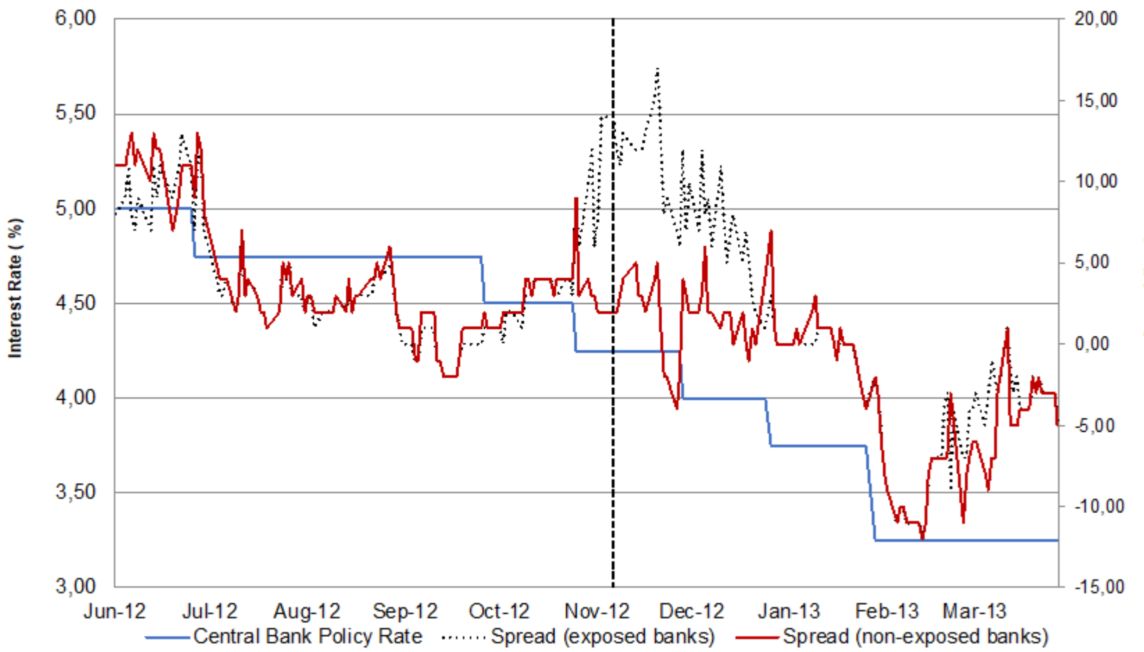
Note: This figure depicts the total volume negotiated in the overnight unsecured interbank market in COP Billion (left axis) along with the spread to the central bank policy rate for interbank unsecured loans that involved an exposed bank as lender (exposed bank) and for those interbank unsecured loans without exposed banks as lenders (non-exposed banks). Exposed banks are banks that have at least one MMMF in the top 10 depositors three months before the collapse of Interbolsa (i.e., July 31, 2012). We use the volume weighted-average interbank loan rate to compute both spreads. The vertical line corresponds to the announcement date of the collapse of Interbolsa to the market (November 2, 2012). The sample period is from June 2012 to March 2013. Source: Daily information from the Superintendencia Financiera de Colombia and Banco de la República Colombia.

We use the volume weighted-average interbank loan rate to compute both measures. The dotted line corresponds to the announcement date of the collapse of Interbolsa to the market (November 2, 2012). We observe that few days before the collapse of Interbolsa, banks with high deposits from MMMFs charged higher spreads on their interbank loans, reaching a spread of 13.5 basis points (bps) over the central bank policy rate by the day of the announcement, while the spread charged by non-exposed banks was around 3 bps. During the following weeks, the gap between the spread of exposed banks vs. non-exposed banks significantly increased, while the total amount of funds exhibited large fluctuations. The observed gap continued until January 2013 when both types of spreads converged to lower levels, signaling higher liquidity. However, the amount of unsecured funds remained relatively low until mid-February (around COP 400 billion) per day, which then increased to roughly 650 COP billion by end of March [3]

Figure 3 presents the evolution of the central bank policy rate along with the spreads of unsecured interbank loans of exposed banks and non-exposed banks. We observe that the unsecured interbank market exhibited a liquidity contraction between June and July 2012, which was associated with monetary policy announcements on the potential end of the monetary tightening period (Banco de la República, 2012b). We observe that during that episode, the difference between the spreads of exposed and non-exposed banks was significantly lower (around 3.2 bps) and short-lived (3.7 weeks), compared to the one observed around the collapse of Interbolsa (11 bps and 7.4 weeks). These figures suggest that the exposure of banks to deposits of MMMFs exacerbated the spread differentials on unsecured funds among banks during the market stress, indicating a potential transmission of the deposit channel to the unsecured interbank market.

[3]This can be the results of the effective intervention by the central bank. Moreover, the U.S. tapering observed in March 2013 was another liquidity shock for some banks that affected the availability of liquidity in the interbank market (see, Sarmiento, 2022).

Figure 3: The unsecured interbank market during the market stress



Note: This figure depicts the evolution of the central bank policy rate (in percentage points) (left axis) along with the difference between the volume-weighted average interbank loan rate and the policy rate (spread) charged by both exposed and non-exposed banks. Exposed banks are lenders of unsecured funds that have at least one MMMF in the top 10 depositors three months before the collapse of Interbolsa. Non-exposed banks are those lenders that do not have deposits from MMMFs in the top 10 three months before the collapse of Interbolsa (July 31, 2012). The vertical line corresponds to the announcement date of the collapse of Interbolsa to the market (November 2, 2012). The sample period is from June 2012 to March 2013. Source: Daily information from the Superintendencia Financiera de Colombia and Banco de la República Colombia.

In Table 2, we present the results of a mean comparison test that allows to compare interbank market conditions during the market stress period (2012m11-2013m3) and the previous period (2012m6-2012m10). We observe the mean loan volume was -7.4 percent lower during the market stress compared to the mean volume registered the period before. Although the unsecured interbank market rate remained (on average) below the central bank rate during the market stress period, we observe significantly higher loan spreads and greater volatility of interest rates compared to the previous period. The standard deviation of loan spreads increased from 3.74 to 6.70. During the market stress period there was a rise in the number of borrowing banks and a decline in the number of lending banks. We compute the amount lent and the price charged by banks that have MMMF in the top 10 depositors (i.e., exposed banks) before and during the market stress period. This allows to check whether those exposed banks exhibited a different behavior in the unsecured interbank market. We observe that exposed banks charged on average a spread on 7.23 bps during the market stress, while during the previous period the mean spread was 3.79 (i.e., an overprice of 3.44 bps). The mean loan amount lent by exposed banks exhibited a significant decline of 16.1 percent, from 17,436 million COP to 14,621 less.

These figures suggest that during the market stress period initiated with the collapse of Interbolsa, banks with high concentration of MMMFs deposits hoarded liquidity and charged higher prices on unsecured loans. In addition, the wider dispersion across individual interest rates during the market stress period may reflect concerns over counterparty risk across banks, which can be related to uncertainty over the availability of short-term liquidity, forcing exposed banks to hoard liquidity for precautionary reasons.

Table 2: The unsecured interbank market during market stress

Conditions of the unsecured interbank market	**Market Stress =0**	**Market Stress =1**		
	Mean	**Mean**	**Var. %**	**Difference**
Number of loans	42.32	35.63	-15.8	-6,69**
Total volume of loans	680,375	625,721	-8.0	-54,654**
Average amount of loans	12,573	11,638	-7.4	-935**
Average interbank market rate (%)	4.76	3.64	-23.5	-1,12**
Average policy rate (%)	4.71	3.67	-22.1	-1.04**
Spread to CB rate	4.07	5.16	26.8	1,09**
Std Dev. of spreads of loans	3.74	6.70	79.1	2,96**
Number of lending banks	23.19	20.27	-12.16	-2,92**
Number of borrowing banks	19.72	21.46	8.8	1,74**
Average spread of loans (exposed banks)	3.79	7.23	90.8	3,44**
Average amount of loans (exposed banks)	17,436	14,621	-16.1	-2,815**

Note: This table presents mean comparison tests for daily variables of the unsecured interbank market using 7,410 interbank loans during the period 2012:06 to 2013:03. Market Stress =1 corresponds to the unsecured interbank loans observed following the collapse of Interbolsa and cover the period November 2012 and March 2013, while Market Stress =0 covers the unsecured interbank loans observed between June and October 2012 (i.e., five months before the collapse of Interbolsa observed on November 2, 2012). Amount in COP million. Spread is the difference between the volume-weighted unsecured interbank loan rate to the central bank policy rate (in basis points). Exposed banks are banks that have at least one MMMF in the top 10 depositors three months before the collapse of Interbolsa. We use the volume weighted-average interbank loan rate to compute spreads to the policy rate. ** p>0.05. Source: Daily information from the Superintendencia Financiera de Colombia and Banco de la República Colombia.

3.2 Empirical Strategy

We are interested in understanding how the market stress period affected the availability and pricing of unsecured funding for the banking sector. Figure 2 shows that during the market stress, banks with ex-ante exposure of MMMFs deposits significantly increased the spread charged on unsecured loans in the interbank market. As observed in Table 1, a plausible explanation for this behavior is that those banks exhibited a decline in deposits from MMMFs during the market stress period. To formally test this prediction, we evaluate the behavior of banks in the unsecured interbank market before and during the market stress and distinguish between exposed and non-exposed banks in the deposits market.

Our empirical strategy combines the approach in Braüning and Fecht (2017) to study the unsecured interbank market with the estimation process in Jiménez et al. (2012, 2014) to evaluate the transmission of shocks in credit markets. Under this setting, we need to account for the fact that the loan amount and the interest rate of an unsecured interbank loan are only observed when the loan is granted (i.e., we need to control for the possibility of a sample selection on unobservable conditions). To account for the potential selection bias, we employ a panel data version of a Heckman-type selection model (Heckman, 1974). 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 (Heckman, 1979; Wooldridge, 1995). The model combines a selection mechanism for participating in the interbank market with a regression model.

The selection equation is as follows:

$$Z^*_{lbt} = \gamma' W_{lbt} + \mu_{lbt} \tag{1}$$

The regression model is:

$$p_{lbt} = \beta' X_{lbt} + \epsilon_{lbt} \tag{2}$$

In 1, Z^*_{lbt} is not observed; the variable is observed as:

$$\begin{aligned} Z_{lbt} =& 1 \quad \text{if} \quad Z^*_{lbt} > 0 \quad \text{with} \quad Prob(Z_{lbt} = 1) = \theta(\gamma' W_{lbt}) \\ Z_{lbt} =& 0 \quad \text{o.w with} \quad Prob(Z_{lbt} = 0) = 1 - \theta(\gamma' W_{lbt}) \end{aligned} \tag{3}$$

In the regression model (2), the latent variable p_{lbt} (i.e., the price of the loan or the loan amount) is observed only if $Z_{lbt} = 1$, which in our case, indicates that the bank l granted a loan to borrower bank b in the interbank market at time t, and X_{lbt} is a vector of variables (i.e. bank-specific characteristics and market conditions) that determines p_{lbt}. The bank's decision to lend funds is modeled by the selection equation (1), under the mechanism denoted in (3), where W_{lbt} is a set of variables assumed to determine whether Z_{lbt} is observed, and θ is the standardized normal cumulative distribution function. Therefore, in the selected sample, we have the following:

$$\mathbb{E}[p_{lbt}|Z_{lbt}] = \beta' X_{lbt} + \rho\sigma_\epsilon \lambda(\gamma' W_{lbt}) \tag{4}$$

In (4), λ is the inverse Mills ratio. In addition, $(\mu_{lbt}, \epsilon_{lbt})$ are assumed to be bivariate normal, with $\mu_{lbt} \sim \mathbb{N}(0, 1)$; $\epsilon_{lbt} \sim N(0, \sigma_\epsilon)$ and $corr(\mu_{lbt}, \epsilon_{lbt}) = \rho$. Thus, if ρ is different from 0, then standard ordinary least squares (OLS) models applied to (2) will yield biased results. To overcome this problem, we follow the approach in Jiménez et al. (2012, 2014) by using a type-2 Tobit sample selection model, which is a two-step panel data version of a Heckman-type selection model that provides consistent parameter estimates of the second-stage parameters (Heckman, 1974;Greene et al., 2002). In the first stage, the unknown coefficients of the selection equation are consistently estimated. In the second stage, these estimates are used to estimate the equation of interest by a weighted least squares regression. Under this approach, the fixed effects from the main equation are eliminated by taking differences on the observed selected variables, while the first stage estimates are used to construct the weights whose magnitudes depend on the size of the sample selection bias (see Appendix A.2 for details).

The empirical specification is presented in equation (5):

$$
\begin{aligned}
I(\text{Interbank loan is granted}_{lbt}) = & \alpha_t + \alpha_l + \alpha_b + \alpha_{lb} + \alpha_{bt} + \beta_1 \text{Exposed\_Bank}_l + \\
& \beta_2 \text{Market\_Stress} \times \text{Exposed\_Bank}_l + \\
& \beta_3 \text{Market\_Stress} \times \text{Lend\_Rel}_{lbt-1} \times \text{Exposed\_Bank}_l + \\
& \text{Controls}_{lbt-1} + \epsilon_{lbt}, \\
LN(\text{Credit Amount}_{lbt}) = & \alpha_t + \alpha_l + \alpha_b + \alpha_{lb} + \alpha_{bt} + \\
& \gamma_1 \text{Exposed\_Bank}_l + \beta_2 \text{Market\_Stress} \times \text{Exposed\_Bank}_l + \\
& \beta_3 \text{Market\_Stress} \times \text{Lend\_Rel}_{lbt-1} \times \text{Exposed\_Bank}_l + \\
& \text{Controls}_{lbt-1} + \epsilon_{lbt}
\end{aligned} \tag{5}
$$

The first part of equation (5) states the selection model where the dependent variable is an indicator of whether the interbank loan is granted by the lender bank l to the borrower bank b at time t (i.e., $Z_{lbt} = 1$) and 0 otherwise. The second part in (5) corresponds to the regression equation using as dependent variable either the observed loan amount or the price of the loan. In the case of the credit amount, we use the Log of the credit amount (in COP million) of all the overnight unsecured loans granted by bank l to bank b in the day (t). The mean loan amount during the period is 11,823 COP million and the standard deviation is

5,034 million COP (about 4,3 USD million and 1,4 USD million, respectively) (See Table A.1) for variables definition and summary statistics). We also use the price of the loan (p_{lbt}) defined as the spread in bps between the volume-weighted average interest rate charged by bank l to bank b over all its overnight unsecured loans during the day t and the central bank rate in t. We use the spread to the central bank rate because all interbank market participants have access to the liquidity of the central bank [4]. Thus, p_{lbt} gauges how costly the liquidity is compared to the central bank liquidity. The mean spread is 4,62 bps with standard deviation of 21,80 bps.

We employ a large set of fixed effects that allow to control for unobserved heterogeneity and to disentangle supply from demand effects. Eq. (5) includes time fixed effects (α_t) for the days of the banks' fulfillment of the reserve requirement (i.e., every 2 weeks by groups of banks that correspond to 54 days spanned during the full period) to isolate aggregate changes in liquidity. Borrower and lender fixed effects (α_b and α_l) are included to control for unobservable bank characteristics. Borrower*lender fixed effects (α_{bl}) are used to account for borrower-lender variation in credit that may affect lenders' participation and loan pricing in the interbank market. The sample includes 74 different borrower-lender pairs trading liquidity in the unsecured interbank market. Importantly, the model includes borrower*time fixed effects (α_{bt}) to control for variation in demand by borrowers in the day t, such as the variation in supply of liquidity of lender bank l to this borrower b in that day t will reflect supply factors (as the common demand effect is controlled for) (Jiménez et al., 2014).

The variable Exposed_Bank$_l$ is an indicator equals 1 for banks that have at least one MMMF (open-ended) in the top 10 depositors three months before the collapse of Interbolsa, and 0 for banks without deposits from MMMFs in the top 10 depositors and that participate in the unsecured interbank market. The estimated coefficient of Exposed_Bank$_l$ gauges how the intensity of the deposits channel influences the supply (and price) of liquidity in the

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

unsecured interbank market. In the sample, about 38 percent of the banks (i.e., 27 banks) have deposits of MMMFs during the evaluated period, and around 11 of these banks had MMMFs in the top 10 depositors. To check the robustness of our baseline results and the effects of changes in deposits concentration on the behavior of exposed banks in the interbank market, in alternative specifications we define exposed banks as those lenders with deposits of MMMFs in the top 20 of depositors (Exposed_Bank_l(top 20)).

We use the market stress associated to the collapse of a top NBFIs (i.e., Interbolsa) as an exogenous liquidity shock that led to redemptions from investors in MMMFs affecting their deposits in the banking sector (i.e., the main assets and cash holdings of MMMFs, Figure 2). Therefore, in the specification we include the variable Market_Stress as a dummy variable equals 1 from November 2, 2012 (the announcement date of the liquidation of Interbolsa) to March 31, 2013, and 0 five months before the collapse of Interbolsa (i.e., between June 1st and November 1st , 2012). The estimated coefficient of the interaction between Market_Stress $\times$ Exposed_Bank_l gauges how the intensity of the deposits channel affected the supply (and price) of liquidity in the unsecured interbank market during the market stress compared to the previous period. In the selection equation, a negative sign will indicate that during the market stress period exposed banks had a lower probability to lend in the unsecured interbank market compared to a non-exposed bank, while in the regression model (second part in Eq (5)) the size of the estimated coefficient indicates how much liquidity granted the exposed banks compared to non-exposed banks during the market stress period.

We are interested in understanding the role of lending relationships in mitigating this liquidity shock, as banks with stable lending relationships benefit from greater access to the interbank market (Cocco et al., 2009; Braüning and Fecht, 2017). Thus, we include the variable Lend_Rel_{lbt-1} as a measure of the frequency and intensity of the borrower-lender relationship. We employ two alternative measures. First, we use the frequency of interactions between two banks in the interbank market computed by the logarithm of one plus the number of days a lender l has granted a loan to a borrower b during the last 30 days preceding day t (i.e., $\text{Lend\_Rel}_{lbt-1} = log(1 + \sum_{t \in T} I(y_{lbt-1} > 0))$. A positive coefficient in this variable indicates that lenders with stable lending relationships are more willing to grant interbank funds to their established counterparts compared to spot borrowers (DiMaggio et al., 2017). Second, we use a measure of lending reciprocity that accounts for possible mutual insurance against liquidity shocks. The measure is computed as $\text{Lend\_Rec}_{blt-1} = log(1 + \sum_{t \in T} I(y_{blt-1} > 0))$, which gauges the number of loans granted from borrower b to lender l during the last 30 days preceding day t. Note that the direction of the loan now is from the borrower b to the lender l (i.e., reciprocal)[5]. We expect a mitigating effect of reciprocal lending on lenders affected by the market stress, as banks tend to combine deposits and commitment lending to provide a liquidity-risk hedge (Kashyap et al., 2002; Gatev et al., 2009).

We include several controls at the lender bank level ($\text{Lender Controlsl}_{lt-1}$) to account for bank heterogeneity. Using monthly balance sheet data at the bank-level, we compute the log of the value of the bank's assets (size_{lt-1}), the ratio of non-performing loans over total loans (npl_{lt-1}), and the capital ratio ($\text{capital ratiol}_{lt-1}$), defined as capital equity (Tier I and Tier II) over risk-weighted assets [6]. We also employ alternative measures of liquidity to control for the impact of liquidity imbalances on the availability and price of interbank funds, given that, when banks are exposed to relatively large liquidity shocks, they might need to trade funds at unfavorable prices (Cocco et al., 2009; Afonso et al., 2014). We account for this effect by including a measure of the liquidity risk of a lender bank l at time t ($\text{Liquidity risk}_{lt-1}$), 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 (Braüning and Fecht, 2017).

[5]The correlation between the variables of lending relationships and lending reciprocity is 0.18, meaning that not necessarily a borrower b that obtained a loan in the unsecured interbank loan during the last 30 days also granted a loan in this market to that particular lender l in the same period.

[6]Colombian financial 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.

To control for the banks' structural liquidity, we also employ the ratio of liquid assets to total assets (Liquidity ratio_{lt-1}).

Market conditions can affect the access of banks to the unsecured interbank market (Fecht et al., 2011). We include two variables to account for the effects of market conditions on the availability of liquidity in the unsecured interbank market. First, we use Market Liquidity risk_{t-1} that corresponds to the standard deviation of the normalized excess reserves among banks at time $t-1$. 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 the participants of the unsecured interbank market have access to the central bank liquidity. Thus, we expect that increases in the liquidity supply by the central bank might increase the activity of the interbank market and exert downward pressure on interbank prices (Freixas et al., 2011). We account for this effect by including the log of the total liquidity supply of the central bank at time t (CB Liquidity Supply_{t-1}) [7]. We include the double and triple interactions of the market stress variable with both measures of market conditions and bank exposure to check for the influence of market conditions during this period and to observe how they affected the supply of credit of exposed banks. In alternative specifications we include the amount of central bank liquidity granted to MMMFs (CB Liq_MMMF_t) to check whether the access to central banks liquidity reduced the transmission of the deposits channel to the unsecured market. Summary statistics and definitions of the set of variables employed in the model are presented in Table A.1 in the appendix.

[7] 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.

4 Results

4.1 The access and price of unsecured interbank funds during market stress

In this section, we present results on the impact of the market stress period in accessing and pricing unsecured interbank funds. In Table 3 (panel A), columns (1) to (6), we present the results of the selection models, where the dependent variable is the probability of a lender bank l to grant a loan to a borrower bank b in the interbank market ($Z_{lbt} = 1$). Panel B, columns (1) to (6) correspond to the second stage estimates of the interest rate models in which the spread to the central bank policy rate (in bps) is employed as dependent variable (i.e., the price of liquidity (p_{lbt})).

We proceed gradually with the inclusion of the fixed effects to arrive to our benchmark model in column (5). Model (1) introduces the measure of Exposed_Bank_l in levels, and models (2) and (3) include its interaction with the market stress period, without borrower fixed effects [8]. The results indicate that exposed banks are more likely to lend unsecured interbank fund (on about 12 percent) compared to non-exposed banks, and that those exposed banks tend to charge lower prices on unsecured interbank funds (i.e. a discount of around 6 bps). However, during the market stress exposed banks are associated with a lower probability to lend funds and a significant increase in the price of unsecured interbank funds. The estimated coefficient of the interaction of $\text{Exposed\_Bank}_l \times \text{Market\_Stress}$ indicates that during the market stress period those banks that (ex-ante) have MMMFs in the top 10 depositors exhibited a lower probability to lend unsecured funds of about 7.5 percent compared to the previous period. This implies that the overall probability to lend unsecured funds by exposed banks declined from 11.8 percent to 4.3 percent (i.e., a contraction of 63

[8] In models (1) to (3) we estimate Eq. (5) without the triple interactions and with a large set of borrower controls to account for demand effects and bank behavior including capital ratio, nonperforming loans ratio, size, liquidity ratio and liquidity risk.

percent compared to the period before the collapse of Interbolsa). The price of interbank funds charged by exposed banks increased from a discount of 6.5 bps to a spread of 14 bps (i..e, an increase of 20.5 bps, almost one standard deviation). The estimated effects remain relatively similar when we control for unobserved heterogeneity at the lender and borrower-lender levels using lender fixed effects and borrower-lender fixed effects, respectively (model 3).

As explained in section 3, the identification of the supply of credit requires having borrower-time fixed effects in the probability models: the double interaction of exposed bank and the market stress can capture changes in the composition of interbank funding but not in the composition of the supply of credit. Therefore, in models (4) to (5) we include the triple interaction of exposed bank, market stress and lending relationships to identify how lending relationships between exposed banks and borrowers affected the supply of unsecured funds during the market stress. In model (5) we replace borrower fixed effects with borrower*time fixed effects to identify credit supply.

The estimated coefficient of lending relationships in model (4) indicates that banks that lent funds to established counterparts during the last 30 days are associated to a 21 percent higher probability to grant unsecured funds in the interbank market, compared to banks that trade liquidity with spot borrowers. The effect is computed as: $[0.141 \times (\log 31 - \log 1)] = 0.2102$. Interestingly, we observe that during the market stress, lending relationships marginally increase the probability of granting interbank funds by exposed banks, suggesting that the lack of access to unsecured funding during the market stress was partially absorbed by the role of lending relationships. The estimated coefficient of the triple interaction indicates that during the market stress, borrowers with established lending relationships with exposed banks had a 2.5 percent higher probability to get unsecured funds from those banks compared to spot lenders.

In the price models (second stage), the estimated coefficient of lending relationships indicates that lenders with established counterparts grant funds (on average) at 10 bps under the central bank policy rate. The estimated coefficient of the triple interaction indicates that, during the market stress, exposed banks charged a discount of 4 bps (i.e.,$-2.821 \times (\log 31 - \log 1) = 4.207$) to their known lenders, suggesting a reduction of around 23 percent compared to the estimated spread charged to all counterparts (i.e., 14 bps). Model (5) shows that the estimated spread charged by exposed banks remains relatively similar and statistically significant when borrower-time fixed effects are included. Note that models (4) to (5) also include the double and triple interaction with lender controls and market conditions, which are unreported in the table. These results suggest that consistent with previous evidence, during aggregate liquidity shocks, lending relationships contribute to increase the access of banks to interbank funds (Braüning and Fecht, 2017; DiMaggio et al., 2017)[9].

As we are interested in understanding the role of central bank liquidity in mitigating liquidity constraints in the unsecured interbank market, we report the estimated coefficients of the double and triple interaction between the market stress, central bank liquidity supply and exposed banks. We find that during the market stress the higher central bank liquidity was associated to increased access to the unsecured interbank market, and to lower unsecured loan prices. The estimated coefficient in model (2) indicates that an increase of 10% in the supply of liquidity by the central bank was associated to a discount of 3.5 bps in unsecured funds, suggesting that central bank liquidity can exert downward pressure on market interest rates during liquidity shocks. The triple interaction in model (5) shows that the central bank liquidity does not has a statistically significant effect on the probability to grant unsecured funds by exposed banks. However, in Panel B, we find that the higher supply of liquidity by the central bank was associated to lower prices. On average, during the market stress, an increase of 10% in the supply of central bank liquidity was associated to a decline in the

[9] Braüning and Fecht (2017) find that during the global financial crisis of 2008 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. DiMaggio et al. (2017) show that dealers charge lower spreads to dealers with whom they have the strongest ties and more so during periods of market turmoil.

price of unsecured funds by exposed banks of 7 bps (model (5)).

Table 3: The access and price of unsecured interbank funds during market stress

Variables	(1)	(2)	(3)	(4)	(5)
Panel A. First stage: Prob. to lend unsecured funds ($Z_{lbt} = 1$)					
Exposed_Bank$_l$	0,012***	0,118***	0,113***	0,119***	
	(3,24)	(3,13)	(2,99)	(3,03)	
Lend_Rel$_{lbt-1}$		0,139***	0,144***	0,141***	
		(7,12)	(7,08)	(7,03)	
Market_Stress × Exposed_Bank$_l$		-0,075***	-0,075***	-0,079***	
		(3,70)	(3,61)	(3,28)	
Market_Stress × Exposed_Bank$_l$ × Lend_Rel$_{lbt-1}$				0,017**	0,019**
				(2,85)	(2,92)
Market_Stress × CB Liquidity supply$_t$		0,011**	0,013**	0,012**	
		(2,62)	(2,55)	(2,70)	
Market_Stress × CB Liquidity supply$_t$ × Exposed_Bank$_l$				0,019	0,013
				(1,18)	(1,24)
Panel B. Second stage: Pricing Models (P_{lbt}) (spread to the central bank policy rate (bps))					
Exposed_Bank$_l$	-6,103***	-6,501***	-6,523**	-6,829***	
	(3,27)	(3,83)	(3,14)	(4,32)	
Lend_Rel$_{lbt-1}$		-6,427***	-7,075***	-6,826***	
		(4,31)	(5,13)	(4,85)	
Market_Stress × Exposed_Bank$_l$		14,021**	14,452**	14,126	
		(2,39)	(2,71)	(2,7)	
Market_Stress × Exposed_Bank$_l$ × Lend_Rel$_{lbt-1}$				-2,821***	-2,593***
				(3,92)	(3,84)
Market_Stress × CB Liquidity supply$_t$		-0,351***	-0,374***	-0,326***	
		(4,01)	(3,68)	(3,61)	
Market_Stress × CB Liquidity supply$_t$ × Exposed_Bank$_l$				-0,713***	-0,744***
				(3,23)	(3,62)
Time FE	Yes	Yes	Yes	Yes	—
Borrower FE	No	No	No	Yes	—
Lender FE	No	No	Yes	Yes	Yes
Borrower-Lender FE	No	No	Yes	Yes	No
Borrower-Time FE	No	No	No	No	Yes
Lender Controls$_{lt-1}$	Yes	Yes	Yes	Yes	Yes
Market_Stress × Exposed_Bank$_l$ × Lender Controls$_{lt-1}$	No	No	No	Yes	Yes
Market_Stress$_t$ × Exposed_Bank$_t$ × Market$_t$	No	No	No	Yes	Yes

Note: This table presents estimates from Heckman type-2 Tobit sample selection models. Panel A reports the results of the selection models, where the dependent variable is the probability of a lender l to grant a loan to a borrower b in the unsecured interbank market in day t ($Z_{lbt} = 1$). Panel B corresponds to the second stage estimates of the interest rate models in which the spread of the interbank interest rate to the central bank policy rate (in bps) is employed as a dependent variable (i.e., the price of liquidity (p_{lbt})). The estimates of the first step in this table come from linear probability models using OLS and 15,615 observations from the 2012:06–2013:03 period. The estimates of the second step come from the second stage of a two-step estimation procedure for panel data sample selection models outlined by Kyriazidou (1997) using kernel least squares. It uses 7,410 observations. Where possible, a constant is included but its coefficient is left unreported. The definition of the independent variables can be found in the Appendix (Table A.1). Where possible, all market conditions, lender, and borrower variables in triple interactions are included in levels and in double interactions but their coefficients are left unreported. Time fixed effects correspond to the reserve requirement period. Fixed effects are either included ("Yes"), not included ("No"), or spanned by another set of effects ("—"). For each variable the first row lists the coefficient, the second row lists t-statistics in parentheses using robust standard error corrected for multiclustering at the time and borrower level. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

4.2 The supply of unsecured interbank funds during market stress

In Table 4 we present the results of the second stage models using the Log of the interbank credit amount (in million COP) as dependent variable instead of the price of the interbank loans. This allows to identify the effects of the market stress on the supply of unsecured funds and more specifically on the supply of funds by banks with dependency of deposits from MMMFs. The specification follows the same approach than one in Eq (5), and the same variables included in the baseline specification reported in Table 3.

In model (1) we find that exposed banks in the deposits market to MMMFs are associated to higher loan amount in the unsecured interbank market (around 11 percent more) compared to non-exposed banks. Model (2) shows that those exposed banks that trade unsecured funds with established counterparts grant 14 pp more liquidity compared to lenders that trade unsecured funds with spot borrowers. We also find that during the market stress, exposed banks to deposits from MMMFs exhibited a lower supply of credit of around 17 pp. The estimated effects remain very similar to the inclusion of borrower fixed effects (model (3)). In model (4), the estimated coefficient of the triple interaction of interest further indicates that lending relationships contributed to increase the supply of unsecured funds by exposed banks during the market stress on 9.11 pp (i.e., $6.113 \times (\log 31 - \log 1) = 9.116$). The estimated effects are quantitatively similar in model (5) when borrower-time fixed effects are included, suggesting that we are observing the compositional changes on the supply of interbank funds associated to the market stress. The results also reflect that the credit rationing observed by exposed lenders during the market stress remained after controlling for other potential idiosyncratic liquidity shocks during the evaluated period.

Table 4: The supply of unsecured interbank funds during market stress

Variables	(1)	(2)	(3)	(4)	(5)
Panel A. Second stage: Loan amount (Log of loan amount, COP million)					
Exposed_Bank$_l$	0,112***	0,114**	0,112**	0,118**	
	(3,18)	(3,05)	(3,14)	(2,98)	
Lend_Rel$_{lbt-1}$		0,087***	0,071***	0,094***	
		(4,23)	(4,04)	(4,01)	
Market_Stress × Exposed_Bank$_l$		-0,172**	-0,178**	-0,171**	
		(2,27)	(2,36)	(2,43)	
Market_Stress × Exposed_Bank$_l$ × Lend_Rel$_{lbt-1}$				6,113***	6,119**
				(2,97)	(2,88)
Market_Stress × CB Liquidity supply$_t$		0,021**	0,017**	0,018**	
		(3,13)	(3,35)	(3,17)	
Market_Stress × CB Liquidity supply$_t$ × Exposed_Bank$_l$				0,044***	0,046***
				(3,52)	(3,23)
Time FE	Yes	Yes	Yes	Yes	—
Borrower FE	No	No	No	Yes	—
Lender FE	No	No	Yes	Yes	Yes
Borrower-Lender FE	No	No	Yes	Yes	No
Borrower-Time FE	No	No	No	No	Yes
Lender Controls$_{lt-1}$	Yes	Yes	Yes	Yes	Yes
Market_Stress ×Exposed_Bank$_l$ × Lender Controls$_{lt-1}$	No	No	No	Yes	Yes
Market_Stress$_t$ × Exposed_Bank$_t$ × Market$_t$	No	No	No	Yes	Yes

Note: This table presents estimates from the second stage of Heckman type-2 Tobit sample selection models. The dependent variable is the Log of credit amount granted by lender l to borrower b in the unsecured interbank market in day t. The estimates of the first step come from linear probability models using OLS and 15,615 observations from the 2012:06– 2013:03 period. The estimates of the second step come from the second stage of a two-step estimation procedure for panel data sample selection models outlined by Kyriazidou (1997) using kernel least squares. It uses 7,410 observations. Where possible, a constant is included but its coefficient is left unreported. The definition of the independent variables can be found in the Appendix (Table A.1). Where possible, all market conditions, lender, and borrower variables in triple interactions are included in levels and in double interactions but their coefficients are left unreported. Time fixed effects correspond to the reserve requirement period. Fixed effects are either included ("Yes"), not included ("No"), or spanned by another set of effects ("—"). For each variable the first row lists the coefficient, the second row lists t-statistics in parentheses using robust standard error corrected for multiclustering at the time and borrower level. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

The results confirm that the liquidity shock was partially alleviated by the central bank liquidity supply. The estimated coefficient in model (5) suggests that an increase of 10 percent in the central bank liquidity supply was associated with an increase of 4.4 pp in the amount of interbank funds granted to exposed lenders. As we mentioned in section 2, during the market stress MMMFs were able to get liquidity from the central bank by using a broader range of collaterals (including CDs), which seems to effectively reduce the liquidity tensions in the unsecured interbank market as exposed banks were able to lend more. The potential mechanism is that as MMMFs were able to use their CDs, they do not need to reduce their deposits in the banking sector thereby affecting less the availability of unsecured interbank liquidity by banks with strong dependency of MMMF deposits.

Overall, these results can indicate that during the market stress associated to the collapse of a top NBFI, banks depending on deposits from MMMFs significantly reduced their participation in the unsecured interbank market, charged higher prices and contracted their supply of unsecured funds to a greater extend compared to banks that have less dependency of deposits from MMMFs. This behavior can be associated to liquidity hoarding by exposed banks in the interbank market due to the decline of deposits from MMMFs. Importantly, lending relationships and central bank liquidity contributed to effectively alleviate the liquidity shock transmitted by exposed banks to the unsecured interbank market by increasing market access and the supply of funds. Moreover, we identify an important reduction on loan prices when the central bank liquidity is included as market condition, meaning that central bank liquidity help to smooth liquidity shocks in short-term financial markets.

4.3 Deposits concentration, lending reciprocity and central bank liquidity to MMMFs

In this section, we present the results of the estimation of equation (5) using alternative measures of exposed banks, lending relationships, and central bank liquidity. First, we reduce the measure of deposits concentration in MMMFs from the top 10 to the top 20 depositors. This increases our set of exposed banks from 11 to 17 (on average) and allows to check our baseline results using a less restrictive measure of banks' deposits concentration with the MMMF sector. Specifically, we define $\text{Exposed\_Bank (top\_20)}_l$ equals 1 for banks with at least one MMMF in the top 20 of their depositors three months before the collapse of Interbolsa, and 0 for those banks with MMMFs below top 20 depositors during the same period.

Second, we test if the effects of lending relationships hold when there is lending reciprocity, a measure that accounts for the possible mutual insurance against liquidity shocks (Braüning and Fecht, 2017). The use of $\text{lending\_reciprocity}_{blt-1}$ allows to check if borrowers b that received unsecured interbank funding by exposed lenders l were more likely to grant funds to those lenders during the market stress, based on the hypothesis that banks tend to combine deposits and commitment lending to provide a liquidity-risk hedge (see, Kashyap et al., 2002; Gatev et al., 2009). Third, we include the amount of central bank liquidity granted to MMMFs in day $t-1$(t-1) instead of the total amount of central bank liquidity, to check whether the access to central bank liquidity by these funds effectively reduced the transmission of the deposits channel to the unsecured interbank market. As explained in Section 2, during the market stress the central bank increased the range of eligible collaterals for the open market operations by including private debt (i.e., CDs issued by banks that are the main assets of the top MMMFs). The proposed exercise aims at testing whether this change in the access of central bank liquidity by MMMFs influences the liquidity in the unsecured interbank market by lowering the intensity of the deposits channel.

4.3.1 The price of liquidity during market stress and the role of deposits concentration

The results on the probability to lend and the price of unsecured funds are presented in Table 5. We observe that banks with deposits of MMMFs in the top 20 of depositors exhibited lower probability lo lend unsecured funds and increased the price of funds relatively more than non-exposed banks during the market stress associated to the collapse of Interbolsa, confirming our baseline results in Table 3. Interestingly, the magnitude of the observed effects is significantly lower in terms of the probability to lend and the price of funds, which can indicate that changes in the degree of deposits concentration of MMMFs in the banking sector reduce the transmission of liquidity shocks across sectors.

In model (1), we find that exposed banks exhibit a probability to lend unsecured funds of 13.3 percent, which is slightly higher than the one we observe for exposed banks with MMMFs in the top 10 of depositors (i.e., 11.2 percent). These banks also exhibit a lower price in almost 5.8 bps, a level relatively similar than in the baseline model (6.1 bps). Model (2) shows that during the market stress the probability to grant funds by exposed banks significantly decline to 5.1 percent, while the price of funds increased by 9.3 bps. Both effects hold when we control for borrower and lender fixed effects (model (3)). The effects are slightly lower compared to those observed for banks with higher deposits concentration with the MMMFs (7.5 percent and 14 bps) (i.e., 2.4 pp lower and 4.7 bps less spread, respectively).

Table 5: THE PRICE OF LIQUIDITY DURING MARKET STRESS AND THE ROLE OF DEPOSITS CONCENTRATION

Variables	(1)	(2)	(3)	(4)	(5)
Panel A. First stage: Prob. to lend unsecured funds ($Z_{lbt} = 1$)					
Exposed_Bank(top_20)$_l$	0,132***	0,138***	0,134***	0,139***	
	(3,73)	(3,72)	(3,66)	(3,71)	
Lending_Rec$_{blt-1}$		0,149***	0,157***	0,159***	
		(5,11)	(5,22)	(4,73)	
Market_Stress × Exposed_Bank(top_20)$_l$		-0,051**	-0,053**	-0,05**	
		(2,28)	(2,42)	(2,35)	
Market_Stress × Exposed_Bank(top_20)$_l$ × Lending_Rec$_{blt-1}$				0,021**	0,018**
				(2,90)	(3,24)
Market_Stress × CB_Liq_MMMF$_t$		0,012**	0,013**	0,008**	
		(2,72)	(2,59)	(2,38)	
Market_Stress × CB_Liq_MMMF$_t$ × Exposed_Bank(top_20)$_l$				0,019	0,013
				(1,18)	(1,24)
Panel B. Second stage: Pricing Models (P_{jit},) (spread to the central bank policy rate (bps))					
Exposed_Bank(top_20)$_l$	-5,815***	-5,712***	-5,751**	-5,333**	
	(3,71)	(3,92)	(3,75)	(4,21)	
Lending_Rec$_{blt-1}$		-6,164***	-6,023***	-5,247***	
		(4,18)	(4,91)	(4,36)	
Market_Stress × Exposed_Bank(top_20)$_l$		9,346***	9,461***	9,035***	
		(4,02)	(3,94)	(4,19)	
Market_Stress × Exposed_Bank(top_20)$_l$ × Lending_Rec$_{blt-1}$				-3,513**	-3,728**
				(2,92)	(3,12)
Market_Stress × CB_Liq_MMMF$_t$		-0,412***	-0,405***	-0,417***	
		(4,23)	(3,91)	(3,59)	
Market_Stress × CB_Liq_MMMF$_t$ × Exposed_Bank(top_20)$_l$				-0,911**	-0,912**
				(3,15)	(3,28)
Time FE	Yes	Yes	Yes	Yes	—
Borrower FE	No	No	No	Yes	—
Lender FE	No	No	Yes	Yes	Yes
Borrower-Lender FE	No	No	Yes	Yes	No
Borrower-Time FE	No	No	No	No	Yes
Lender Controls$_{lt-1}$	Yes	Yes	Yes	Yes	Yes
Market_Stress×Exposed_Bank(top_20)$_l$×Lender Controls$_{lt-1}$	No	No	No	Yes	Yes
Market_Stress × Exposed_Bank(top_20)$_l$ × Market$_t$	No	No	No	Yes	Yes

NOTE: This table presents estimates from Heckman type-2 Tobit sample selection models. Panel A reports the results of the selection models, where the dependent variable is the probability of a lender l to grant a loan to a borrower b in the unsecured interbank market in day t ($Z_{lbt} = 1$). Panel B corresponds to the second stage estimates of the interest rate models in which the spread of the interbank interest rate to the central bank policy rate (in bps) is employed as a dependent variable (i.e., the price of liquidity (p_{lbt})). The estimates of the first step in this table come from linear probability models using OLS and 15,615 observations from the 2012:06–2013:03 period. The estimates of the second step come from the second stage of a two-step estimation procedure for panel data sample selection models outlined by Kyriazidou (1997) using kernel least squares. It uses 7,410 observations. Where possible, a constant is included but its coefficient is left unreported. The definition of the independent variables can be found in the Appendix (Table A.1). Where possible, all market conditions, lender, and borrower variables in triple interactions are included in levels and in double interactions but their coefficients are left unreported. Time fixed effects correspond to the reserve requirement period. Fixed effects are either included ("Yes"), not included ("No"), or spanned by another set of effects ("—"). For each variable the first row lists the coefficient, the second row lists t-statistics in parentheses using robust standard error corrected for multiclustering at the time and borrower level. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

Model (4) confirms the hedging role of lending relationships as banks involved in lending reciprocity benefited from a higher access to unsecured funding in about 24 percent compared to banks that trade with sport counterparts (i.e.,$0.159 \times (\log 31 - \log 1) = 0.237$, and from a lower price in around 9 bps (Panel B). The estimated coefficient of the triple interaction indicates that if an exposed bank granted an unsecured interbank loan in the past 30 days it had 3.1 percent higher probability to get funding from that counterpart during market stress, and that the price was lower in about 5.2 bps. These effects are relatively higher than the ones observed in the baseline (compare 2.1 percent and 4 bps), indicating potential higher benefits from reciprocal lending. The effects remain statistically significant when we include borrower*time fixed effects (model (5)).

As in the baseline models in Table 3, we also report the estimated coefficients of the double and triple interaction between the market stress, central bank liquidity supply and exposed bank to understanding the role of the central bank liquidity during the market stress. In model (2), we find that the higher central bank liquidity granted to MMMFs was associated to higher access and lower prices in the unsecured interbank market. Models (4) to (5) show that the mitigating effect of the central bank liquidity granted to MMMFs is observed for banks with deposits of MMMFs in the top 20 of depositors, but only in terms of pricing. Using the point estimates in model (5) we can argue that, on average, during the market stress, an increase of 10% in the liquidity granted by the central bank to MMMFs was associated to a decline in the price of unsecured funds to exposed banks by around 9 bps.

4.3.2 The supply of liquidity during market stress and the role of deposits concentration

In Table 6 we present the results of the second stage models using the Log of the interbank credit amount (in million COP) as dependent variable and alternative measures of exposed banks, lending reciprocity, and central bank liquidity. We find similar results than those in Table 4. In model (2) we confirm that banks that have MMMFs in the top 20 of their depositors reduced by around 12 percent more the supply of funds compared with non-exposed banks. The reduction in credit is relatively lower than the one we observed in the baseline model (17 pp), suggesting that lower concentration of deposits with the MMMF sector can reduce the strength of the deposits channel on the supply of unsecured funds.

Table 6: THE SUPPLY OF LIQUIDITY DURING MARKET STRESS AND THE ROLE OF DEPOSITS CONCENTRATION

Variables	(1)	(2)	(3)	(4)	(5)
Panel A. Second stage: Loan amount (Log of loan amount, COP million)					
Exposed_Bank(top_20)$_l$	0,112**	0,104**	0,134**	0,116**	
	(3,01)	(3,04)	(2,94)	(2,82)	
Lending_Rec$_{blt-1}$		0,061***	0,063***	0,058***	
		(3,73)	(3,56)	(3,35)	
Market_Stress × Exposed_Bank(top_20)$_l$		-0,122**	-0,123**	-0,118**	
		(2,45)	(2,58)	(2,97)	
Market_Stress × Exposed_Bank(top_20)$_l$ × Lending_Rec$_{blt-1}$				0,041**	0,045**
				(3,17)	(3,18)
Market_Stress × CB_Liq_MMMF$_t$		0,023***	0,026**	0,022**	
		(3,63)	(3,25)	(3,21)	
Market_Stress × CB_Liq_MMMF$_t$ × Exposed_Bank(top_20)$_l$				0,067**	0,065**
				(2,89)	(3,32)
Time FE	Yes	Yes	Yes	Yes	—
Borrower FE	No	No	No	Yes	—
Lender FE	No	No	Yes	Yes	Yes
Borrower-Lender FE	No	No	Yes	Yes	No
Borrower-Time FE	No	No	No	No	Yes
Lender Controls$_{lt-1}$	Yes	Yes	Yes	Yes	Yes
Market_Stress × Exposed_Bank(top_20)$_l$ × Lender Controls$_{lt-1}$	No	No	No	Yes	Yes
Market_Stress × Exposed_Bank(top_20)$_l$ × Market$_t$	No	No	No	Yes	Yes

NOTE: This table presents estimates from the second stage of Heckman type-2 Tobit sample selection models. The dependent variable is the Log of credit amount granted by lender j to borrower i in the unsecured interbank market in day t. The estimates of the first step come from linear probability models using OLS and 15,615 observations from the 2013:03– 2013:12 period. The estimates of the second step come from the second stage of a two-step estimation procedure for panel data sample selection models outlined by Kyriazidou (1997) using kernel least squares. It uses 7,410 observations. Where possible, a constant is included but its coefficient is left unreported. The definition of the independent variables can be found in the Appendix (Table A.1). Where possible, all market conditions, lender, and borrower variables in triple interactions are included in levels and in double interactions but their coefficients are left unreported. Time fixed effects correspond to the reserve requirement period. Fixed effects are either included ("Yes"), not included ("No"), or spanned by another set of effects ("—"). For each variable the first row lists the coefficient, the second row lists t-statistics in parentheses using robust standard error corrected for multiclustering at the time and borrower level. *, **, and *** denote significance level at 1%, 5% and 10%, respectively.

Banks that trade liquidity with known counterparts also benefit from higher supply of credit (i.e., 6 pp more credit in model (2)). The estimated coefficient of the triple interaction in model (4) indicates that if an exposed bank in the deposits market with MMMFs granted an unsecured interbank loan in the past 30 days it obtained 6 pp higher unsecured funding from that counterpart during the market stress. The estimated effects are similar when we include borrower*time fixed effects (model (5)), confirming that we are observing compositional changes in the supply of credit in the unsecured interbank market during the market stress. The estimated effects of the liquidity granted by the central bank to MMMFs remain similar to the ones observed in Table 4, but with a slightly higher level. This result, in conjunction with the ones observed on the probability of access to interbank market, can indicate that the higher liquidity granted by the central bank to the MMMF sector during the market stress contributed to enhance the access to interbank liquidity.

5 Conclusions

This paper provides evidence on a novel deposits channel that links liquidity shocks from the MMMF sector to the banking sector. Using granular data at the bank-depositor-deposits level matched with lender-borrower-unsecured interbank loan level data and bank-specific characteristics, we show how the market stress associated to the failure of a top NBFIs is transmitted by MMMFs to the banking sector via the deposits channel. We first document that banks with high concentration of deposits from MMMFs are active lenders of unsecured funds in the interbank market and charge relatively lower prices on unsecured loans, compared with banks with less concentration of deposits from the MMMF sector. Then, we identify that during the market stress, those lenders banks with an ex-ante high concentration of MMMF deposits exhibited a lower probability to lend funds, charged significantly higher prices and reduced to a greater extend their supply of unsecured funds compared to non-exposed lenders banks.

We further show that lending relationships and the central bank liquidity partially smoothed the liquidity shock on the unsecured interbank market. The smoothing effect of the central bank liquidity on the unsecured interbank market is intensified when the liquidity granted to the MMMF sector is included. Moreover, the intensity of the deposits channel changes with the degree of concentration of banks' deposits with the MMMF sector. This highlights the potential benefits of limiting the concentration of bank deposits with the

MMMF sector to reduce the transmission of non-banking liquidity shocks to the banking sector.

6 Bibliography

Acharya, V., Gromb, D., Yorulmazer, T., 2012. Imperfect competition in the interbank market for liquidity as a rationale for central banking. American Economic Journal: Macroeconomics 2, 184–217.

Acharya, V., Merrouche, O., 2013. Precautionary hoarding of liquidity and interbank markets: Evidence from the sub-prime crisis. Review of Finance 17, 107–160.

Afonso, G., Cipriani, M., La Spada, G., 2022. Banks' balance-sheet costs, monetary policy, and the on rrp. Federal Reserve Bank of New York Staff Reports, no. 1041 December 2022 .

Afonso, G., Kovner, A., Schoar, A., 2014. Trading partners in the interbank lending market. Staff Reports 620, Federal Reserve Bank of New York .

Agarwal, V., Arisoy, E., Naik, N., 2017. Volatility of aggregate volatility and hedge fund returns. Journal of Financial Economics 125, 491–510.

Angelini, P., Nobili, A., Picillo, M., 2011. The interbank market after august 2007: what has changed and why? Journal of Money, Credit and Banking 43, 923–958.

Aramonte, S., Schrimpf, A., Shin, H., 2022. Non-bank financial intermediaries and financial stability. BIS Working Papers No 972, Bank for International Settlements .

Bagattini, G., Fecht, F., Maddaloni, A., 2023. Liquidity support and distress resilience in bank-affiliated mutual funds. Journal of Money, Credit, and Banking ECB Working Paper No. 2799.

Banco de la República, 2012a. Resolución Externa No. 11 de 2012. "Por la cual se expiden normas sobre operaciones para regular la liquidez de la economía". Banco de la República, Noviembre. https://www.banrep.gov.co/sites/default/files/reglamentacion/archivos/bjd_41_2012_res_11.pdf.

Banco de la República, 2012b. Financial Markets Report. Banco de la República, May.

Bechtel, A., Ranaldo, A., Wrampelmeyer, J., 2023. Liquidity risk and funding cost. Review of Finance 27, 399–422.

Bednarek, P., Dinger, V., Schultz, A., von Westernhagen, N., 2023. Banks of a feather: The informational advantage of being alike. Deutsche Bundesbank Discussion Paper No 09/2023 .

Boyarchenko, N., Kovner, A., Sharchar, O., 2022. It's what you say and what you buy: A holistic evaluation of the corporate credit facilities. Journal of Financial Economics 144, 695–731.

Braüning, F., Fecht, F., 2017. Relationship lending in the interbank market and the price of liquidity. Review of Finance 21, 33–75.

Breckenfelder, J., Hoerova, M., 2023. Do non-banks need access to the lender of last resort? evidence from fund runs. Working Paper Series 2805, European Central Bank .

Brunnermeier, M.K., Pedersen, L., 2009. Market liquidity and funding liquidity. Review of Financial Studies 22, 2201–2238.

Cocco, J., Gomes, F., Martins, N., 2009. Lending relationships in the interbank market. Journal of Financial Intermediation 18, 24–48.

Craig, B., Ma, Y., 2022. Intermediation in the interbank lending market. Journal of Financial Economics 145, 179–207.

DiMaggio, M., Kermani, A., Song, Z., 2017. The value of trading relationships in turbulent times. Journal of Financial Economics 124, 266–284.

Falato, A., Goldstein, I., Hortaçsu, A., 2021. Financial fragility in the covid-19 crisis. Journal of Monetary Economics 123, 35–52.

Fecht, F., Nyborg, K.G., Rocholl, J., 2011. The price of liquidity: The effects of market conditions and bank characteristics. Journal of Financial Economics 102, 344 – 362.

Freixas, X., Martin, A., Skeie, D., 2011. Bank liquidity, interbank markets, and monetary policy. The Review of Financial Studies 24, 2656–2692.

Freixas, X., Parigi, B., Rochet, J., 2000. Systemic risk, interbank relations and liquidity provision by the central bank. Journal of Money, Credit, Banking 32, 611–638.

FSB, 2021. Policy proposals to enhance money market fund resilience: final report. Financial Stability Board, October .

FSB, 2022. Global monitoring report on nonbank financial intermediation. Financial Stability Board, Basel, Switzerland .

Furfine, C., 2001. Banks monitoring banks: Evidence from the overnight federal funds market. Journal of Business 74, 33–58.

Gatev, E., Schuermann, T., Strahan, P.E., 2009. Managing bank liquidity risk: How deposit-loan synergies vary with market conditions. Review of Financial Studies 22, 995– 1020.

Gofman, M., 2017. Efficiency and stability of a financial architecture with too-interconnected-to-fail institutions. Journal of Financial Economics 124, 113–146.

Greene, W., Han, C., Schmidt, P., 2002. The bias of the fixed effects estimator in nonlinear models. NYU Working Paper, Department of Economics, Stern School of Business, New York University .

Heckman, J., 1974. Effects of child-care programs on women's work effort. Journal of Political Economy 82, 136–163.

Heckman, J., 1979. Sample selection bias as a specification error. Econometrica 47, 153–161.

Heijmans, R., Heuver, R., Walraven, D., 2010. Monitoring the unsecured interbank money market using target2 data. DNB Working Paper, No. 276, De Nederlandsche Bank .

IMF, 2023. Global financial stability report. International Monetary Fund, Washington D.C .

Iyer, R., Peydró, J., da Rocha-Lopes, S., Schoar, A., 2014. Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007-2009 crisis. The Review of Financial Studies 27, 347 – 372.

Jiang, E.X., Matvos, G., Piskorski, T., Amit, S., 2023. Monetary tightening and u.s. bank fragility in 2023: Mark-to-market losses and uninsured depositor runs? NBER Working Paper No. 31048 .

Jiménez, G., Ongena, S., Peydró, J., Saurina, J., 2012. Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications. American Economic Review 102, 2301–26.

Jiménez, G., Ongena, S., Peydró, J., Saurina, J., 2014. Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking? Econometrica 82, 463–505.

Kacperczyk, M., Schnabl, P., 2013. How safe are money market funds? Quarterly Journal of Economics 128, 1073–1122.

Kashyap, A., Rajan, R., Stein, J., 2002. Banks as liquidity providers: An explanation for the co-existence of lending and deposit-taking. Journal of Finance 57, 33–74.

Kyriazidou, E., 1997. Estimation of a panel data sample selection model. Econometrica 65, 1335– 1364.

León, C., Machado, C., Cepeda, F., Sarmiento, M., 2011. Too-connected-to-fail institutions and payment system's stability: assessing challenges for financial authorities. Paper prepared for the 2nd BIS CCA Conference on "Monetary policy, financial stability and the business

cycle" Ottawa, 12–13 May 2011. https://www.bis.org/events/ccaconf2011/leon.pdf
.

León, C., Machado, C., Sarmiento, M., 2018. Identifying central bank liquidity super-spreaders in interbank funds networks. Journal of Financial Stability 35, 75–92.

Martin, C., Puri, M., Ufier, A., 2022. Deposit inflows and outflows in failing banks: The role of deposit insurance. FDIC CFR WP 2018-02, Federal Deposit Insurance Corporation, Center for Financial Research .

Müller, C., Ossandon-Busch, M., Pinzón, F., S.M., 2024. Fragile wholesale deposits, liquidity risk and banks' maturity transformation. mimeo, Banco de la República .

Rajkamal, I., Jensen, T., Johannesen, N., Sheridan, A., 2019. The distortive effects of too big to fail: Evidence from the danish market for retail deposits. Review of Financial Studies 32, 4653–4695.

Rajkamal, I., Puri, M., 2012. Understanding bank runs: The importance of depositor-bank relationships and networks. American Economic Review 102, 1414–1445.

Rochet, J., Tirole, J., 1996. Interbank lending and systemic risk. Journal of Money, Credit and Banking 28, 733–762.

Sarmiento, M., 2022. Sudden yield reversals and financial intermediation in emerging markets. Journal of Financial Stability , 101050.

Schnabel, I., 2021. The rise of non-bank finance and its implications for monetary policy transmission. Speech at the Annual Congress of the European Economic Association (EEA), Frankfurt am Main, August .

Wooldridge, J.M., 1995. Selection corrections for panel data models under conditional mean independence assumptions. Journal of Econometrics 68, 115–132.

A Appendix

A.1 The unsecured 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 [10]. 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 2012m6 to 2013m3, approximately 84 percent 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 credit 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). Importantly, NBFIs (including MMMFs) do not participate in the unsecured interbank market. These intermediaries exchange short-term liquidity in other money markets, mainly in the secured repo market. This is crucial for our identification strategy as we can observe how the liquidity shock from MMMFs is transmitted to the unsecured interbank market via the deposits channel. Moreover, as shown in Table 1, deposits of MMMFs are concentrated in 27 commercial banks, while the unsecured interbank market includes 53 credit institutions. This allows to observe participants in the unsecured market that do not have direct affectation from the decline in deposits by MMMFs along

[10] 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.

with those banks that exhibited a reduction their deposits from these institutions.

A.2 Estimation and Sample

In the estimation we employ Heckman type-2 Tobit sample selection models. In the selection model the dependent variable is the probability of a lender l to grant a loan to a borrower b in the unsecured interbank market in day t ($Z_{lbt} = 1$). In the second stage the dependent variable is the spread of the interbank interest rate to the central bank policy rate (in bps) (i.e., the price of liquidity (p_{lbt})). In the first we employ linear probability models using OLS and 15,615 observations from the 2012:06–2013:03 period. The estimates of the second step are from the second stage of a two-step estimation procedure for panel data sample selection models outlined by Kyriazidou (1997) using kernel least squares. It uses 7,410 observations. The definition of the independent variables can be found in the Appendix (Table A.1).

To achieve identification under the proposed model, we match the bank-specific-characteristics of all the banks operating at time t with the interbank loan data to have borrowing and non-borrowing banks in t. Thus, in our matched data, we have banks that are active in the financial system but are not borrowing or lending funds from the interbank market ($Z_{lbt} = 0$), compared to banks that are both active and lend in the interbank market ($Z_{lbt} = 1$). This allows to assume that, conditional on the large set of fixed effects we include, the errors are identically distributed for the granting decisions made by the banks (albeit the errors can have correlations that are different from zero). Therefore, as in Jiménez et al. (2014) we can assume that the aforementioned errors have the same distribution as the conditional exchangeability assumption proposed by Kyriazidou (1997) to differentiate out the fixed effects and the sample selection bias. This is possible given the large data set we have. Moreover, it is less stringent than the parametrization of the unobserved heterogeneity and errors using alternative methods (see, Wooldridge, 1995; Acharya et al., 2012; Greene et al., 2002).

We also limit the interest rates to values between -100 bps and 100 bps to the central bank rate to control for the effect of outliers in the estimation. The pricing measure is given by the spread in bps between the volume-weighted average interest rate charged by lender bank l to borrower bank b over all its overnight unsecured loans during the day (t) and the central bank rate in t. This helps to mitigate the impact of outliers (i.e., small loans with a relatively high (or low) interest rate) in the estimation.

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

Variable	Definition	Mean	Std. Dev.	Min	Max	Obs.
Dependent variables						
p_{lbt} (spread to the central bank policy rate)	The difference in basis points (bps) between the volume-weighted average interest rate charged by lender l of all its overnight unsecured loans granted to borrower b during the day t and the central bank rate in t.	4.62	21.80	(35.18)	123.45	7,41
Loan amount (unsecured interbank market)$_{lbt}$	Total credit amount (in million COP) granted by lender l to borrower b in the unsecured interbank market at time t.	11,823	5,034	1,322	15,271	7,41
Variables of interest						
Market_Stress	Dummy variable equals 1 from November 2, 2012 (the announcement date of the liquidation of Interbolsa) to March 31, 2013, and 0 five months before the collapse of Interbolsa (i.e., between June 1st and November 1st , 2012)	0.18	0.11	0	1	15,615
Exposed_Banks$_l$	Dummy variable equal to 1 for lender banks that have at least one MMMF in the top 10 depositors three months before the collapse of Interbolsa, and 0 for those lender banks with deposits from MMMFs below the top 10 depositors and that participate in the unsecured interbank market.	0.23	0.16	0	1	15,615
Exposed_Banks(top20)$_l$	Dummy variable equal to 1 for lender banks that have at least one MMMF in the top 20 depositors three months before the collapse of Interbolsa, and 0 for those banks with deposits from MMMFs below the top 20 depositors and that participate in the unsecured interbank market .	0.35	0.38	0	1	15,615
Lending relationships$_{lbt-1}$	Frequency of interaction between two banks in the interbank market. Computed as the logarithm of one plus the number of days a lender l has granted loans to borrower b over the period T: $RL_{lbt} = \log(1 + \sum_{t \in T} I(y_{jit} > 0)$, with T = 30 days.	0.27	0.56	0	1.42	15,615
Lending reciprocity$_{blt-1}$	Defined as the Logarithm of (1 + the number of loans granted from borrower b to lender l during the last 30 days preceding day t). Note that the direction of the loan now is from the borrower b to the lender l (i.e., reciprocal).	0.09	0.17	0	1.38	15,615
Market conditions						
CB Liquidity Supply$_t$	Log of the total liquidity supply of the central bank at time t (in million COP)	30.61	0.62	30.73	40.18	15,615
CB Liq_MMMF$_t$	Log of the total liquidity supply of the central bank granted to MMMFs at time t (in million COP)	19.25	0.82	25.10	33.36	15,615
Market_liquidity_risk$_t$	Standard deviation of the normalized excess reserves among all banks during the period t.	0.15	3.18	(19.24)	35.16	15,615
Lender controls$_{lt-1}$						
Capital ratio$_{lt-1}$	Capital equity (Tier I and Tier II) over risk-weighted assets (in %)	12.14	4.93	11.95	16.17	15,615
Size$_{lt-1}$	Log of total assets (million COP, end of month)	13.83	1.94	9.32	18.90	15,615
Liquidity_risk$_{lt-1}$	Liquidity risk is measured as the standard deviation of daily change in reserve holdings during the last 30 days divided by reserve requirements	0.25	9.19	(92.63)	165.23	15,615
Liquidity_ratio$_{lt-1}$	Liquidity position computed as liquid assets over total assets (end of month) (%)	0.36	0.08	0.25	0.77	15,615