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Fragile wholesale deposits, liquidity risk, and banks' maturity transformation*

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— This draft, March 2025 —

Abstract

We investigate the impact of large-scale investment fund redemptions on bank lending. Using detailed data on the link between commercial banks and investment funds in an emerging economy, we document that redemptions lead to a decrease in the demand for certificates of deposit and increasing volatility in this wholesale funding market. We find that banks subject to the fund-induced fragility in their funding markets adjust credit terms: while credit volumes remain stable, terms of credit deteriorate. Affected banks raise interest rates and reduce the maturity of newly issued loans. These findings showcase that wholesale deposit runs affect banks' incentives to engage in maturity transformation.

Keywords: uninsured deposits, wholesale funding, liquidity risk, credit supply, non-bank financial intermediaries

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1 Introduction

In wholesale funding markets for banks, nonbank financial intermediaries (NBFIs) are important lenders and provide liquidity in normal times.[1] In the absence of runs, NBFIs seek to roll over wholesale deposits as these serve as low-risk short-term assets for their liquidity management. Recent episodes of financial distress, however, exposed NBFIs to run-like behaviour of their investors and forced them to liquidate assets, including wholesale deposits.[2] The transmission of liquidity risks from NBFIs to banks in wholesale funding markets is therefore a growing concern for financial stability (FSB, 2023; IMF, 2023). If banks face high liquidity risk, they might cut lending (see Ivashina and Scharfstein (2010) among others) or engage less in maturity transformation (Paligorova and Santos, 2017). Fragile wholesale deposit funding can therefore have negative repercussions for the real economy.

In this paper, we study the transmission of a run-like episode in investment funds to a wholesale funding market for banks and its implications for bank lending. We use granular data linking banks and investment funds through certificates of deposit (CD) which are issued by banks and held by funds. These funds faced sudden redemptions triggered by the Covid-19 shock. First, we isolate the effect of redemptions on CD demand by funds. Then, we estimate the effect of banks' exposure to fund redemptions on credit supply.

While previous work has documented fragilities in wholesale funding markets (Pérignon et al., 2018) or the effect of wholesale funding on bank lending (Cornett et al., 2011), we link both in this article. The granularity of our data allows us to establish a causal link between fund redemptions, the stability of wholesale deposit funding, and loan terms. Thus, we

[1]Money market funds in the US and Europe hold about 70 to 80 percent of their total assets in bank debt instruments and repo financing (Bouveret et al., 2022). In the euro area, NBFIs accounted for 14 percent of bank liabilities in 2023, whereof the largest share consists of unsecured deposits, and held 28 percent of bank debt securities (ECB, 2023).

[2]Recent examples were the "dash for cash" during the outbreak of the Covid-19 crisis in March 2020 (Li et al., 2021; Falato et al., 2021), or the UK gilt market crisis in October 2022 (Pinter, 2023). Less recent examples can be found in the US money market during the European Sovereign Debt Crisis of 2011-14 (Chernenko and Sunderam, 2014; Ivashina et al., 2014) or the Great Financial Crisis of 2008-9 (Schmidt et al., 2016). More examples are listed in Bouveret et al. (2022).

identify the fragility of bank-fund links as a potential source of changes in credit conditions. We show that banks shorten maturities in their loan portfolio after being exposed to liquidity risk from fund redemptions even though the shock was short-lived and counteracted quickly by emergency liquidity from the central bank. Our work thereby contributes novel evidence on the fragility caused by NBFI-bank links in times of high uncertainty.

To study the effect of fragile wholesale deposits on banks' core functions, credit supply and maturity transformation, we look at a period that follows the outbreak of the Covid-19 pandemic in Colombia. First, we describe the occurrence of large redemptions, accounting for 32 percent of assets under management of local investment funds. We then identify the effect of fund redemptions on the demand for CDs, finding that funds exposed to larger redemptions were more likely to liquidate deposits. However, the effect on demand for CDs from funds is short-lived. This is partially explained by timely central bank interventions in the secondary market for CDs. Despite the short-lived effect of fund redemptions, in the medium-term, aggregate bank funding structure shows less reliance on CDs as a source of funding. A closer look at banks' credit registries reveals a nuanced adjustment of credit supply: while credit volumes remain relatively stable, more exposed banks supply loans with shorter maturities and higher interest rates. Thus, the threat of wholesale funding risk changes banks' incentives to engage in maturity transformation.

Our sample links banks and investment funds in Colombia, a mid-sized emerging country. Colombia offers a compelling laboratory to study this question, with its financial markets being globally interconnected and therefore exposed to a risk of sudden redemptions triggered by events that are exogenous from the perspective of local markets (see Williams, 2018). We combine different regulatory fillings collected by the Central Bank of Colombia (Banco de la República, BdR) to construct a panel that allows tracing the impact of fund redemptions on bank funding as well as on credit conditions. We use three main sources of data: weekly information on the balance sheet of all investment funds operating in Colombia;

daily security-by-security data on certificates of deposit issues by Colombian banks and held by funds; and quarterly information on all corporate loans extended by Colombian banks at the level of individual borrowers. The combined information provides a comprehensive picture of bank-fund relationships in the period between 2019q1 and 2021q2.

These rich data sets the stage for our identification strategy, which addresses concerns of omitted variable biases and the endogeneity of fund redemptions. The empirical analysis proceeds in two steps. First, we estimate the effect of fund-specific redemptions (at the weekly level) on the volume of CDs held by a given fund at a bank. While fund redemptions can be caused by local economic conditions, the focus on redemptions triggered by the outbreak of the Covid-19 pandemic reduces concerns of them being a factor of pre-existent fund vulnerabilities. Moreover, we estimate a panel regression saturated with bank-time fixed effects, comparing CDs held by different funds at the same bank while controlling for observed and unobserved bank characteristic that may explain a possible reduction in the supply of CDs. Thus, we can interpret changes in CDs as stemming from funds that liquidate deposits when facing sudden redemptions. We develop an extensive set of robustness tests to confirm the validity of the results.

Second, we estimate the effect of banks' exposure to affected funds on credit supply conditions, including the size, maturity, and interest rate of real-sector loans. We use credit registry data at the bank-firm level to estimate a regression saturated with firm-time fixed effects, following Khwaja and Mian (2008). Thus, we isolate the supply-driven effect of banks' exposure to fund redemptions from other unobserved credit-demand factors that may otherwise bias the estimation. This approach allows tracing the effect of fund redemptions – a proxy for the fragility of wholesale deposits – on the stability of banks' funding and on loan characteristics. Given that fund redemptions represent a materialization of liquidity risk, we conjecture that exposed banks may reduce credit volumes, raise interest rates, and potentially restrict loans' maturity once the fragility of short-term wholesale deposits becomes evident.

We begin by documenting that funds faced sizable redemptions at the outbreak of the Covid-19 pandemic in March 2020, with investors – both domestic and foreign – withdrawing capital mounting to approximately 32 percent of funds' assets. Simultaneously, the register of CDs reveals that the volume of these instruments held by funds in the Colombian banking sector declined by 27 percent. The size of this shock resembles a market freeze (Pérignon et al., 2018) and implies that banks lost access to a significant share of their wholesale funding sources.

Our baseline estimation confirms that fund redemptions were associated with a significant decrease in the demand for CDs, after controlling for supply factors. This effect, however, masks considerable heterogeneity across time and fund characteristics. When evaluating different time-windows after March 2020, we find that the effects arises primarily in the first three months in which most of the fund redemptions concentrate. The effect looses statistical significance when looking at windows of 6 to 12 months. This result highlights that the impact in the CDs market unfolds rapidly, reflecting funds' need to liquidate assets in response to investors' withdrawals.

The heterogeneity of funds' characteristics also plays a role in how redemptions end up translating into a liquidations that affects the stability of bank deposits. We distinguish between open-ended funds (OEF) and closed-ended funds (CEF). Unlike open-ended funds, closed-ended funds do not face the risk of capital flowing out of the fund when investors sell shares, given that shares are not traded directly with the fund. This difference has been linked to a higher vulnerability of OEF to market swings, which offer the possibility for investors to withdraw on demand (see, e.g., Adrian et al., 2018; Jin et al., 2022). Thus, we would expect the relationship between redemptions and CDs to be explained by OEF, particularly from those with a limited volume of cash reserves. In line with this conjecture and using fund-level characteristics, we document that the baseline effect is driven by OEF (which report a stronger effect) and by smaller funds reporting less liquid assets, ex-ante.

Next, we zoom-in into the dynamics in the secondary market to understand the mechanism connecting redemptions with the reduction in the demand for CDs. Using a daily register of CD transactions in the secondary market, we find that affected funds are more likely to sell CDs held in their portfolio, whereas they are also less likely to buy CDs from other counterparties. This reaction confirms that the results are being driven by funds' liquidity needs when sudden large redemptions occur. When liquidating CDs held at banks, affected funds prioritize CDs held at banks that make up a large share of their CDs portfolio but that also represent a small share of that bank's outstanding CDs. Moreover, when a fund is part of the same financial conglomerate of a bank, the liquidation of CDs focuses on those issued by banks that do not belong to the same conglomerate.[3]

We further extend the analysis to account for the effect of outright liquidity interventions by the BdR in the weeks that followed the outbreak of the Covid-19 pandemic. In addition to previous liquidity measures, the BdR announced about two weeks into the crisis to start buying private debt instruments issued by banks with maturities less than three years. We calculate the share of each fund's transactions in the CDs market in which the BdR was the counterparty in a given week to quantify funds' access to central bank liquidity facilities. We find that the pass-through of redemptions to the liquidation of CDs is attenuated in the case of funds able to sell a larger share of their CDs to the central bank in a given week. This finding provides an explanation for the short-lived effects of redemptions on the CDs market.

Motivated by these findings, we analyze how banks' exposure to affected funds lead them to adjust credit conditions to the real economy. We use credit-registry data on all loans issued by banks in Colombia to estimate the effect of a pre-Covid bank-level exposure

[3] This political economy angle – previously discussed in the literature (see, e.g., Golez and Marin (2015), Gil-Bazo et al. (2020) and Bagattini et al. (2023)) – further highlights the different incentives that motivate CD liquidations.

to funds on loan volumes, interest rates, and maturity. To reduce endogeneity concerns, we use an exposure measure based on the pre-Covid volume of outstanding CDs issued by a bank scaled by the bank's liquid assets, mirroring the intuition of Basel III's Liquidity Coverage Ratio. Our supply-driven results show that banks adjust credit terms on impact, with interest rates rising and average loan maturity decreasing for new loans. Banks react to liquidity risk by shrinking the duration of assets, re-balancing their loan portfolio towards shorter maturities. While credit volumes do not react on impact, they affected banks seem to increase loan volumes in the 6 to 12 months following the redemptions. However, this effect is strongly driven by central bank support measures.

We contribute to a strand in the literature that examines the financial-stability implications of non-bank financial intermediaries through the lens of their interaction with the banking sector. Most research documents fragilities and run-like episodes in secured and unsecured wholesale markets caused by NBFIs withdrawing funding (e.g., see Krishnamurthy et al., 2014; Copeland et al., 2014; Li et al. (2021); Pinter (2023); Sarmiento, 2024). Other studies explore whether runs in wholesale funding reflect banks' fundamentals (Chernenko and Sunderam, 2014; Pérignon et al., 2018; Magnani and Wang, 2023). Previous studies on bank-fund connections have highlighted a positive side of some interconnections: funds that are affiliated through institutional or ownership ties to a bank support the bank with liquidity in times of stress (Gil-Bazo et al., 2020) and prop up its share prices (Golez and Marin, 2015). We complement these findings by analysing characteristics of bank-fund links that amplify or mitigate the transmission of liquidity risks from NBFIs to banks in an emerging economy. Moreover, we use the information on fund redemptions to identify an entity-specific effect on demand for bank funding instruments. We further add to this literature by documenting a causal link between fund redemptions and lending conditions in the real sector.

The focus on loan-level effects connects our work with an extensive literature analyzing the impact of financial shocks to the real economy in different settings (e.g., see Ivashina and

Scharfstein, 2010; Cornett et al., 2011; Kapan and Minoiu, 2014; Ippolito et al., 2016). To the best of our knowledge, this literature has not looked at funds' redemptions as a source of changes in loan terms through their impact on bank funding. Closer to our findings is a subset of this literature that has empirically assessed the impact of wholesale funding shocks on bank credit. Ivashina et al. (2014) and Correa et al. (2021) study how global banks' exposure to wholesale dollar funding affects credit supply in times of financial distress. Aldasoro et al. (2022) explores how a regulation-driven squeeze in U.S. Money Market Funds triggered a spillover that reduced liquidity in other wholesale funding markets, negatively affecting credit. Differences in the empirical setting aside, our approach complements these findings in two ways. First, we shift the focus to the implications for retail loan terms, illustrating a link between loans' maturity and price and the liquidity risk faced by investment funds. Second, we show that the transmission of liquidity risks from NBFI investors to wholesale funding markets can cause such a reaction in bank loan portfolios.

Our findings link individual wholesale investor decisions to wholesale funding risk, allowing us to trace the causal connection between the CDs' funding shock and loan terms through shifts in investor-level market dynamics. Therefore, our results are useful to inform policy debates about vulnerabilities in the banking sector stemming from NBFIs.[4] While NBFIs can boost financial system efficiency, shifts in investor sentiment leading to fund redemptions can indirectly threaten the stability of bank funding. Therefore, strengthening policies that address the ripple effects of investor-level dynamics on bank funding risks could improve the resilience of financial markets and allow countries grasping the benefits of NBFIs while mitigating their downside risks.

[4] Our findings on the role of central bank outright liquidity provision in stabilizing the Colombian wholesale deposit market further relate our work to studies on the effectiveness of central bank interventions (see, e.g, Garcia-de Andoain et al., 2016; Falato et al., 2021; Breckenfelder and Hoerova, 2023).

2 Institutional Background

2.1 Regulatory setting of investment funds in Colombia

In Colombia, mutual investment funds – the funds we analyze – are financial savings and investment vehicles managed by non-bank financial intermediaries (NBFIs) in which resources from several investors (individuals and firms) are invested in a portfolio. The value of funds' assets increased by 118.4% between 2016 and 2022, reaching COP 147.6 billion (approx. USD 42.2 billion) as of December 2022. The NBFIs authorized to manage the funds are broker companies, trust companies, and investment management companies (IMC). The portfolio constituted corresponds to an autonomous patrimony of the IMC.[5]

Funds are classified into three categories: i) open-ended funds, with or without a notice period after which the investor can make withdrawals on demand; ii) closed-ended funds, where the IMC establishes deadlines for redemptions; and iii) stock market, in which case the redemption policy will depend on what is stipulated in the funds' regulations. In particular, open-ended funds have a maximum period of three business days to liquidate assets or five business days when international assets are involved, counted from the moment the investor requests a redemption. Open-ended funds with a redemption notice period determine in their regulations the existence of minimum terms. From the expiration of this period, the number of business days is stipulated within which investors can request the total or partial withdrawal of their shares without incurring a penalty. Once this term has expired, the notice period begins again. In the case of closed-ended funds, the redemption is carried out at the end of the duration of the fund or within the deadlines established by the fund in its regulations to carry out these operations, with a minimum interval of thirty days. Although the redemption policy is the most prominent characteristic in distinguishing open-ended from closed-ended funds in practice, there are also differences in terms of contributions, shares,

[5]The administration of funds by these financial companies is subject to Chapter 3 (Fondos de Inversion Colectiva) of Decree 2555 of 2010.

and the limit on the concentration of shares per investor.

Open-ended funds are subdivided into three categories: a) money market funds, which seek the stability and preservation of capital and liquidity; b) variable income funds, which must hold at least 70% of their portfolio in variable income assets; and c) balanced, mixed, or fixed income funds, which do not have significant exposures in the other two categories and are characterized by investing in fixed income instruments. Between the three categories, there is a distinction in terms of redemptions: variable-income and mixed funds have three to five business days to carry them out, while money market funds only have one business day.

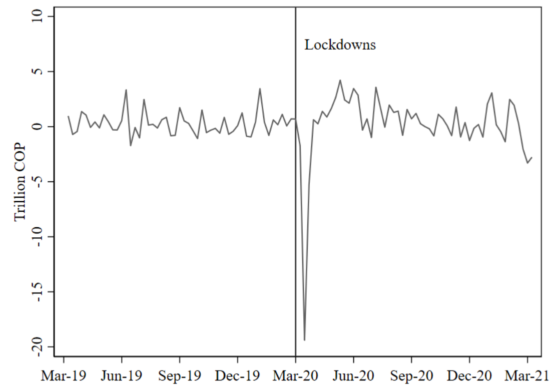
Colombian regulation stipulates that all funds must maintain a Liquidity Coverage Ratio (LCR) greater than 100%. The indicator is defined as: HQLA/ max(0.1*FVN;PNW), where the high-quality liquid assets (HQLA) are required to be greater than the maximum between 10% of the net value of the fund (FVN) and the maximum probable net withdrawal (PNW). In addition to this, money market funds have the following liquidity limits: At least 5% of the fund's net value in cash (cash over the net value); at least 10% of the fund's net value in liquid resources (cash plus one day contractual flow/ net value); and at least 25% of the fund's net value in 30-day liquidity (HQLA plus 30-day contractual flow/net value).[6]

2.2 Sudden redemptions in March 2020

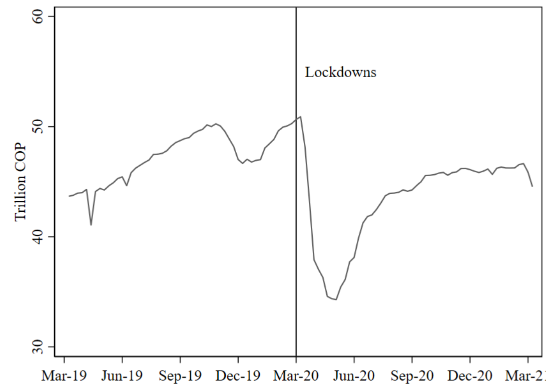
In March 2020, open-ended funds in Colombia faced massive withdrawals by their investors admidst a general decline in stock markets and public debt market devaluations. Total assets of open-ended funds fell by 31.3% between March 6 and March 31, 2020 due to redemptions. In the same time, investors withdrew COP 24.6 trillion (approx. USD 7.1 billion). Meanwhile,

[6] In the case of open-ended funds, when there is no minimum notice period, a single investor cannot directly or indirectly have a participation greater than 10% of the value of the fund's assets.

Figure 1: Redemptions and outstanding certificates of deposit.



(a) Funds' net contributions.



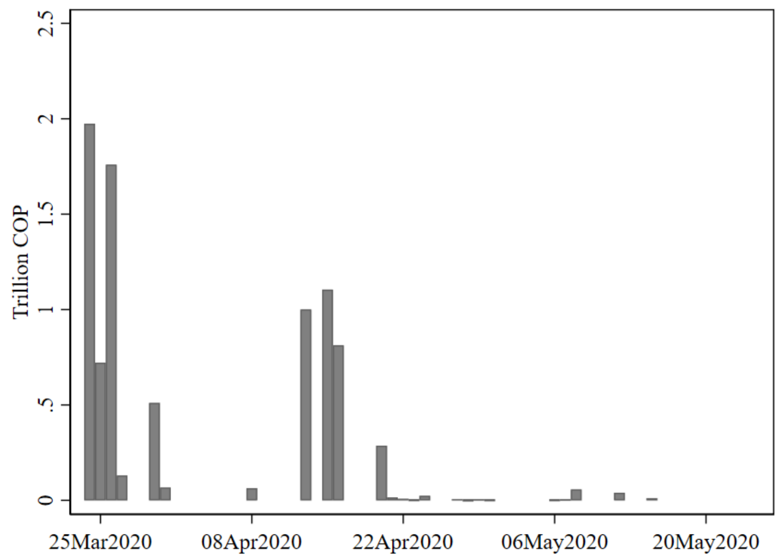
(b) Banks' outstanding CDs held by funds.

Notes: Panel (a) shows the time series of the funds' net contributions (contributions minus redemptions). The graph plots weekly data between March 2019 and March 2021. Panel (b) displays the weekly time series of the banks' outstanding CDs held by funds for the same period. Panel (c) exhibits the daily total CDs purchased by the Central Bank. Values in the figures are expressed in trillion COP.

the volume of outstanding certificates of deposit (CDs) held by open-ended funds declined by 27%, corresponding to a COP 13.8 trillion drop (USD 3.9 billion) (see figure 1). These numbers reflect that around 58% of assets held by open-ended funds are invested in CDs issued by domestic banks. Therefore, as redemptions from investors in those funds rose, funds were forced to sell or liquidate CDs to cope with investors' claims.

Consequently, the funds' liquidity was reduced, and some funds even breached regulatory limits. In response to the Covid-19 shock, the BdR adopted several measures that gave funds access to central bank liquidity: i) on March 12, 2020, it authorized repo operations with private debt securities and access to temporary expansion auctions with these titles for the managed funds through the management companies (i.e., NBFIs); ii) on March 18, 2020, the central bank authorized access to temporary expansion auctions with public debt securities for the funds through the management companies; and iii) on March 23, 2020, the central bank authorized the definitive expansion operations carried out in the secondary market with private debt securities for credit institutions and the funds' management companies on their own behalf and on behalf of third parties. Only CDs or bonds of highly rated banks and with

Figure 2: Central bank CD purchases.



Notes: The figure shows the daily total CDs purchased by the central bank. Values in the figures are expressed in trillion COP.

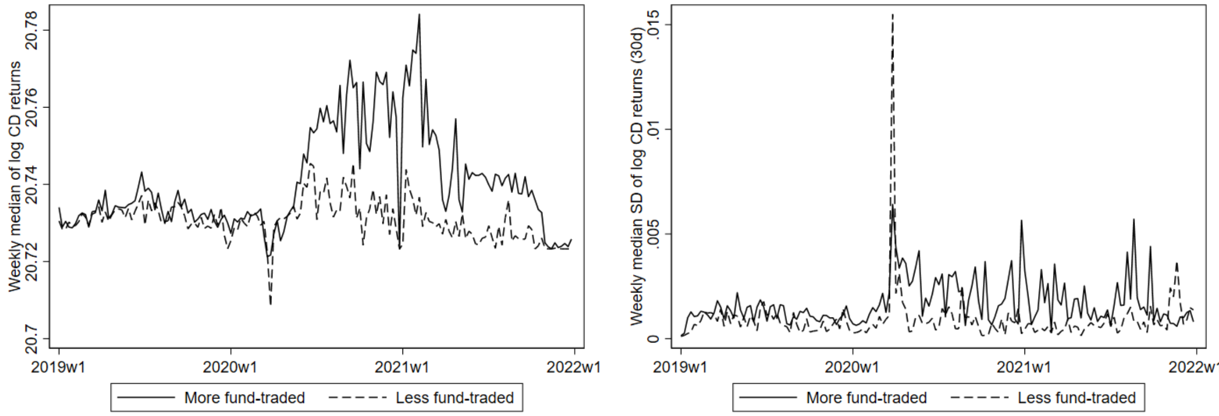
remaining maturities of three years or less and issued at least 30 days before were accepted (see Vargas et al. (2022)). Figure 2 shows the amounts of CDs purchased by the central bank between March and May. These measures resemble similar policy reactions by the U.S. Federal Reserve or the European Central Bank, for instance, through the Secondary Market Corporate Credit Facility (SMCCF) and the Pandemic Emergency Purchase Programme (PEPP) facilities, respectively.[7] The measures implemented by the BdR, which extended funds' access to central bank auctions with public and private debt securities being used as collateral, contributed to increasing funds' available liquidity, attenuating investors' incentives to redeem their shares.[8] In line with this narrative, the volume of redemptions ceased to increase in May 2020, reaching average pre-Covid monthly flows in August of that year.

In reaction to the shock, the secondary CD market experienced unusual fluctuations.

[7]These liquidity facilities have been positively evaluated in recent literature. See, for example, Falato et al. (2021) for the U.S. Fed and Breckenfelder and Hoerova (2023) for the ECB programs, respectively.

[8]Following BdR interventions, investors had arguably smaller incentives to redeem anticipating a fire-sales scenario, in which a fund may be forced to liquidate assets inducing negative price spirals and further market externalities (see Goldstein et al., 2017).

Figure 3: Return and volatility in the secondary CD market.



(a) Log returns. (b) Standard deviation of log returns.

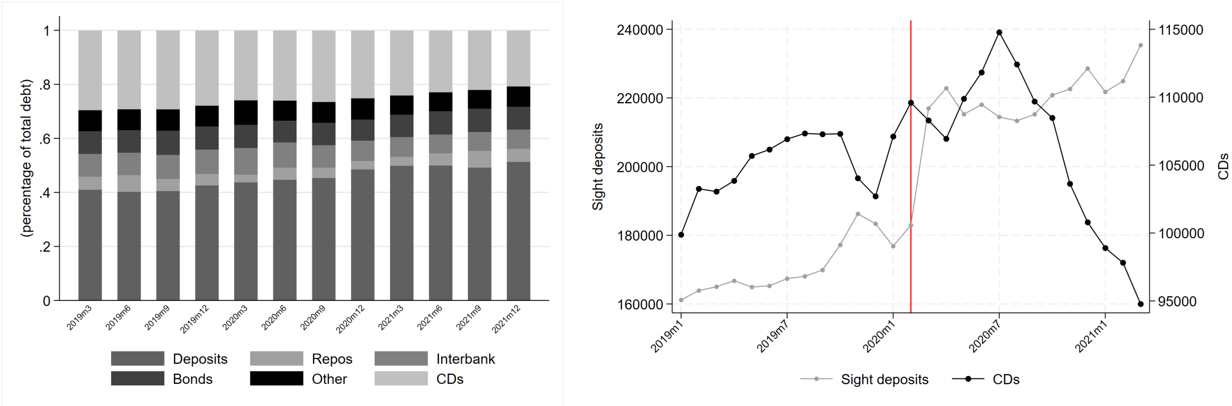
Notes: The figure shows in panel (a) the median of logarithmized CD returns and in panel (b) the median of a 30-day moving average standard deviation of logarithmized CD returns. To calculate returns and standard deviation of returns, CDs were divided into those more or less traded by OEFs. The split was made at the median share of fund-trades over all CDs.

Due to the increasing selling pressure from funds, CD prices fell, returns on CDs rose, and volatility increased. As we show in figure 3, returns and volatility rose after March 2020 especially for CDs which are traded on average more by funds (solid lines) although they perform similarly to less fund-traded CDs (dashed lines) in normal times. We define CDs as "more fund-traded" or "less fund-traded" based on the median number of transactions in the secondary market where funds acted either as buyers or sellers in 2019. In comparison, returns and standard deviation of CDs less traded by funds returned quickly to pre-shock levels while yields and volatility of more fund-traded CDs stayed elevated for more than a year after the shock.

CDs are an important funding instrument for Colombian commercial banks. At the time of the shock, CDs made up about 28 percent of total liabilities of the aggregate banking sector, while retail deposits accounted for about 43 percent.[9] Colombian investment funds

[9]The aggregate is more representative for the large banks. Larger banks depend less on CDs and more on retail deposits than small banks. For the largest 10 banks with asset volumes above COP 20 billion, CDs made up about 26 percent of their total debt and retail deposits 44 percent of total debt. For the remaining smaller banks, CDs account for 42 percent and retail deposits 34 percent of total debt. For small banks, CDs

Figure 4: Aggregate CDs and deposit volumes.



(a) Funding sources. (b) Funding structure of banks.

Notes: The figure shows in panel (a) the share of different funding sources to total liabilities of the aggregate banking sector. Panel (b) shows the monthly aggregate volume in COP billion of sight deposits (left axis) and CDs (right axis).

are crucial investors in the CD market. They held on average around 23 percent of banks' outstanding CDs in the year before the shock. The share fell to about 16 percent after March 2020 and only recovered to pre-shock levels in the largest banks. As we show in figure 4, the funding structure of banks changed after the shock. The share of CDs fell to around 24 percent in the period after the shock (left panel). At the same time, the deposit share increased, especially for large banks. The shift in funding structure resulted mostly from an inflow of sight deposits during the crisis (right panel, left axis) that was large enough in aggregate to more than compensate for the CD outflow (right panel, right axis).

These shifts can be seen in the light of two phenomena often observed during crisis: a flight to safety of investors and a too-big-to-fail premium for the largest banks. In a crisis, investors reallocate toward safe assets, including insured deposits. During the Covid crisis, banks in the US experienced large deposit inflows (Levine et al., 2021; Castro et al., 2022). Indeed, also in Colombia the deposit insurance fund noted a substantial increase in insurable deposits (over COP 50 trillion) as well as insured deposits (COP 11 trillion)

are more important than retail deposits. In part, these are specialized banks with small systemic importance.

between January and April, 2020 (Fogafín, 2021).[10]. Simultaneously, policy interventions, in particular emergency liquidity provision by the central bank, were key to keep banks afloat. In addition to the aforementioned intervention in the CD market, the central bank enacted several liquidity measures directed at banks. During March 2020, they offered COP 23.5 trillion in repurchase agreement (repo) auctions, almost triple to what is offered in normal times. They also extended the collateral framework for these auctions and offered longer maturities than usual. In addition, the central bank started buying Colombian treasuries from banks and reduced reserve requirements. Overall, the central bank replaced market funding by the provision of ample emergency liquidity. Therefore, although experiencing serious stress in one crucial wholesale funding market, in aggregate banks did not experience a liquidity shortage partly due to the large public safety net in place for the banking sector.

As a result of this change in funding structure, banks relied more on liabilities with short maturities. First, banks experienced a substantial inflow of sight deposits without any minimum holding periods.[11] And second, CDs issued after the shock had on average shorter maturities than before.[12] In the next sections, we empirically assess the effect of fund-specific redemptions on fund CD holdings and whether this shock led to subsequent changes in banks' loan terms.

[10]The deposit insurance fund in Colombia covers up to COP 50 million per account and depositor. Fogafín (2021) remarks that the percentage increase in insured deposits was higher than the increase in insurable deposits, implying that depositors distributed funds across multiple accounts in order to achieve higher insurance coverage.((Fogafín, 2021)). The amount covered by deposit insurance was changed in 2017 from COP 20 million to COP 50 million (before the Covid-19 shock). In that year, the change in deposit insurance led to bunching around the new threshold, with heterogeneous effects on the growth of individual deposits. ((de Roux and Limodio, 2023))

[11]Since these deposit inflows were a clear reaction to a crisis surrounded by high uncertainty, it is reasonable to question whether these should be considered *stable* funding.

[12]Duration of banks' CD holdings fell from about 0.65 to 0.55 on average. The duration of issued bonds also fell. The duration of interbank loans was close to zero and did not change significantly. Only the duration of repos increased, presumably do to central bank repo transactions at longer maturities.

3 Data and sample

3.1 Data

We combine four data sources provided by the Central Bank of Colombia (Banco de la República, BdR) and the Colombian Financial Supervisory Authority (Superintendencia Financiera de Colombia).

First, we employ detailed information on funds registered in Colombia. As explained in section 2.1, funds have to fulfil regulatory liquidity requirements that imply reporting their holdings of liquid assets. The report includes the amount, type of rate (fixed or variable) and counterparty of financial instruments held by funds considered to be HQLAs, including certificates of deposit (CDs), government bonds, and other liquid bonds. The data are available at daily frequency, but we aggregate the net weekly holdings of these assets. In that case, if a fund buys and sells certain CDs within one week, we consider this fund to have zero exposure. From another report, we get daily information on in- and outflows of funds, based on which we calculate whether funds experience net outflows, i.e., redemptions, during a week. The report further contains information on funds' total assets, liabilities, cash holdings, and equity, which we use to construct several ratios to describe fund characteristics.

Second, we use daily frequency data of transactions in the secondary market of CDs. In these, we observe the buyer and seller, as well as the nominal and transaction value of the traded CD. The CDs are reported with an instrument identifier that allows us to identify the issuing bank. From these data, we focus on transactions where the funds are either buyers or sellers and construct weekly net sales or purchases aggregated at the fund-bank level. These data also allow us to observe the implementation of central bank policies as captured by transactions in which funds sell CDs to the central bank starting at the date of the intervention.

Third, we match funds' holdings of CDs with the balance sheet information of the banks issuing the CDs. These data are reported on a monthly frequency to the supervisory authority. We construct several control variables described below from this data source to use them in the analysis of loan terms recorded in the credit registry.

Last, we employ quarterly information on loans extended by Colombian commercial banks to local firms (i.e., credit registry data). The data comprises the volume, interest rate, and maturity of the extended loans. We focus on new loans at the time of issuance. We study the period from 2019q1 to 2021q2. We conduct most of our analysis using weekly frequency, but we switch to quarterly frequency when using the credit registry data.

3.2 Sample

Based on the data described above, we work with a sample of 14 open-ended funds and 141 closed funds that are invested in 52 Colombian commercial banks by holding CDs issued by them. During the sample period, neither the banks nor the funds experienced bankruptcy or acquisition. The sample is balanced, though not all funds hold CDs of all banks at all times.

Funds manage, on average, an asset volume of about COP 830 billion (bn) (USD 214 million (mn)), while the median fund manages only around COP 207 bn (USD 53 mn). We report the summary statistics in table 1. Banks hold an average of COP 15 bn (USD 3.8 mn) in assets. The banking market in Colombia is fairly concentrated among five banks that jointly account for about two-thirds of total assets.

The banks in the sample are commercial banks with traditional business models focusing on loans and deposits. The average deposit-to-asset ratio is 61 percent, and the average loan-to-asset ratio is 65 percent. In addition to retail deposits, banks extensively use CDs as an additional wholesale funding source. CDs account for, on average, 34 percent of total assets at book value.

The funds in our sample usually own CDs from an average of 8 banks. However, their

Table 1: Summary Statistics

Variables	(1) Mean	(2) Std. Dev.	(3) P25	(4) P50	(5) P75	(6) Min	(7) Max	(8) Obs
Funds								
Assets*	829.8	1,646.1	30.0	207.0	920.0	0.6	12,300	12,307
Liabilities*	3.0	10.6	0.1	0.4	1.6	0	89.4	12,307
Equity*	824.3	1,637.2	29.6	206.0	915.7	0.2	12,300	12,307
Redemptions*	31.4	74.6	0.0	1.2	19.3	0	408	12,130
Contributions*	33.1	80.3	0.0	1.2	18.8	0	442.5	12,130
Net Contributions*	1.3	26.5	-0.6	0.0	1.1	-113.3	130	12,130
Equity-to-assets	0.99	0.03	0.995	0.998	0.9996	0.8	1	12,298
Cash-to-assets	23.84	13.76	10.21	26.02	34.19	0	59.8	12,413
Total CDs*	245.0	511.3	0	15.4	223.7	0	2,653.7	24,180
Bonds*	26.9	72.3	0	0	11.5	0	448.1	24,180
Government Treasuries*	31.5	77.4	0	1.2	24.3	0	517.3	24,180
CDs held at different banks	7.6	6.8	0	8	13	0	22	24,180
Portfolioshare	0.1	0.1	0	0.1	0.1	0	0.4	185,114
Banks								
Assets*	15,621.1	33,260.7	795.2	1,994.7	15,015.7	48.1	185,454	1,732
Liabilities*	13,451.1	28,647.6	615.0	1,627.1	11,540.3	1.1	158,867.9	1,732
Equity*	2,165.3	4,920.8	121.5	387.7	1,816.3	25.6	26,285.3	1,732
CDs*	3,472.9	6,756.2	231	660	2,918.3	0	35,172.7	1,732
Bonds*	1,132.7	2,931.6	0.0	0.0	512.0	0	15,178.4	1,732
Equity-to-assets	0.22	0.22	0.11	0.14	0.20	0.06	0.1	1,732
Liabilities-to-assets	0.78	0.22	0.80	0.86	0.89	0.01	0.94	1,732
Deposits-to-assets	0.61	0.25	0.53	0.70	0.78	0	0.87	1,732
Loans-to-assets	0.65	0.30	0.60	0.76	0.83	0	0.98	1,732
CDs issued-to-assets	0.34	0.23	0.18	0.32	0.51	0	0.8	1,732
Bonds-to-assets	0.06	0.12	0.00	0.00	0.08	0	0.8	1,732
Liquid assets-to-total assets	0.18	0.21	0.08	0.11	0.18	0.02	0.96	1,732
Non-performance loans	0.05	0.03	0.04	0.05	0.07	0	0.15	1,506
CDs sold to different funds	22.8	28.9	0	9.0	40	0	91	8,112
Marketshare CDs	0.03	0.05	0.00	0.01	0.03	0	0.3	185,114
Credit Register								
Loan volume**	286.26	1,024.60	4	20	118.3	0.0002	8,002.59	629,044
Loan rate	13.83	8.99	7.73	10.7	23	0.05	29.03	623,968
Maturity	33.36	31.24	10	31	49	0.00	180	629,044

Notes: This table reports the summary statistics for the working samples. Cols. 1 to 5 report the mean, the standard deviation (Std. Dev), and the percentiles 25, 50, and 75 of the respective distributions. The final columns report variables' minimum and maximum and the number of observations. * Expressed in billion COP. ** Expressed in million COP.

portfolios can be concentrated on specific banks, especially when the fund is affiliated with the bank.

Overall, we observe 2,008 fund-bank CD contractual relationships during the sample period, 272 of which involve open-ended funds (OEFs), and 1,736 involve non-OEFs. We refer to one contractual relationship as a fund holding one or more CD instruments from the same bank.

In the credit registry, we observe a total of 384,279 loans during the sample period to different firms operating in all sectors across the country. The average loan amount is COP 286 mn (USD 73 thousand), and the median loan amount is less than a tenth of the mean (COP 20 mn, corresponding to about USD 5,000). Interest rates are quite high and range between 7.73 (25th percentile) and 23 percent (75th percentile). Common maturities are 3, 6, 12, 24, 36, or 48 months. When reducing the sample to firms that borrow from more than one bank at the same time, we observe 8,865 different firms. This is only a fraction of the total universe of Colombian firms. Usually, these firms are larger than those operating with only one bank relationship.

4 Empirical strategy

4.1 Isolating effects on CD demand

We first propose an identification strategy seeking to assess whether fund redemptions affect bank funding instruments. In the first stage, we therefore study the effect of redemptions on CD demand during the liquidity shock faced after March 2020. We look at CD demand from two angles: CD holding volumes as well as CD holding volatility. Therefore, we study different outcome variables to proxy for CD demand. In particular, we use logarithmized CD holding volumes ($LogCD$), CD holding log growth rates ($\Delta logCD$), growth in CD sales ($\Delta CDSales$) and CD purchases ($\Delta CDPurchases$) in the secondary market as well as the standard deviation of CD growth ($SD(\Delta logCD)$). These measures are defined based on CDs held by fund i at bank b in period t. We estimate

$$CD\text{-}Outcome_{i,b,t} = \beta RED_{i,t} + \omega X_{i,t-1} + \gamma_{b,t} + \delta_i + \epsilon_{i,b,t} \tag{1}$$

where *CD-Outcome* is one of the outcomes described above and $RED_{i,t}$ is the logarithm of redemptions faced by fund i in period t. Therefore, we are interested in β, which measures the effect of redemptions on CD demand. We estimate the relationship separately for "normal" times, i.e., from 2019q1 to 2020q1, and "stressed" times, i.e., from 2020q2 to 2021q1, where we study different time windows of 3, 6, and 12 months after the initial Covid-19 shock.

To make sure the effect is driven by redemptions and not by news about banks nor by banks' CD issuance behavior, we include bank-time fixed effects $\gamma_{b,t}$. The identification then relies on comparing how different funds change CD demand for the same bank. Thereby, we can abstract from any interpretation of the effect explained by the CD issuing side (i.e., banks' supply of CDs). We further include fund fixed effects δ_i to absorb any time-invariant differences between funds that could account for different investment strategies as well as time-varying control variables at the fund-level $\omega X_{i,t-1}$, which we lag by one period to mitigate endogeneity. Here we control for general differences between funds including the size of the fund (*Log total assets* and *Log number of investors*), the availability of cash to satisfy redemptions (cash-to-assets ratio), and the investment strategy (*Share of fixed rate investments*). Further, we control for the importance of CDs for the fund. For the latter, we use the share of CDs to total assets (*CDs-to-assets ratio*), as well as the share of CDs from a bank held by a fund relative to the total CDs issued by that bank (*market share*) and relative to the total of CDs held by that fund (*portfolio share*). We further control for the alternative liquid assets that the fund could potentially liquidate to satisfy redemptions by including the past standard deviation in treasury and bold holdings. Last, we control for regulatory measures. These include the liquidity ratio applicable to funds (*LCR 30-day*) and the aforementioned central bank interventions in the CD market (*Share of CD trades with CB*). For this control variable, we count the number of transactions in the secondary market in which a fund sold CDs to the central bank relative to the total number of trades the fund exercised in a given week. We cluster standard errors at the fund-bank level.

4.2 Isolating effects on credit supply

In a second stage, we evaluate whether the stress in banks' funding markets has an effect on loan terms. To estimate this, we regress

$$Y_{b,f,t} = \beta(Exposure_b \times Post_t) + \omega X_{b,t} + \gamma_{f,t} + \delta_b + \epsilon_{b,f,t} \tag{2}$$

where Y is a loan term (the logarithm of the loan volume, the loan rate, or the maturity) given by bank b to firm f at time t. *Post* is a dummy variable that is defined with 3, 6, or 12 month symmetric window around March 2020. We saturate the model with firm-time fixed effects, thus excluding credit demand-driven explanations for our results. We further control for bank fixed effects and time-varying bank variables, which are lagged by one period. These are bank size (logarithm of total assets), as well as CAMEL variables: a tier-1 equity ratio to control for capital levels, a non-performing loan ratio to control for the quality of the loan portfolio, a cost-income-ratio to control for management quality, return-on-equity to assess bank profitability, and a liquid-asset ratio to account for the liquidity buffer of a bank. We also control for the other characteristics of the loan given that banks usually determine loan terms simultaneously. Therefore, we include logarithmized loan volume, loan rate, or loan maturity – whenever they are not the outcome of the regression - as well as controls to capture the riskiness of a loan. These are a dummy for A-rated firms and a dummy for the loan being covered by guarantee.

We employ different measures to proxy for banks' exposure to the stress. First, we measure banks' pre-Covid exposure to a potential shock as logarithm of the volume of CDs held by OEF funds in the week before the stress starts (*CDs outstanding (2020w9)*).[13] By using pre-shock exposures instead of realized post-shock exposures, we mitigate endogeneity issues arising from common factors that determine Covid-induced fund redemptions and

[13] Alternatively, we can use the average CD volume held by funds during the year 2019. Results are robust.

adjustments in credit markets simultaneously, such as the rising uncertainty about future economic developments in Colombia.

The second exposure measure which ex ante determines ex post stress is the ratio of trades in the secondary market with funds involved (*Fund-traded ratio*). As shown in figure 3, returns and volatility of CDs traded on average more by funds increased substantially more after the shock than those of CDs less traded by funds. Yet, before the shock return and volatility behave similar for both groups. The fund-traded ratio is defined as the share of trades executed by funds relative to the total number of trades executed in a CD instrument of a bank. Then, we aggregate the share at the bank-level by taking the average fund-traded share across all CDs issued by a bank. We take this from 2019 and extrapolate the 2019 average over the entire sample period to get a time-invariant ex ante exposure measure.

While these two measures have the advantage of avoiding endogeneity concerns, they have the disadvantage of overestimating potential effects. Since exposures might not realize, especially with central bank support kicking in, real effects might be better represented with measures focused on realized exposures. Therefore, we aggregate two of the outcome variables from the first stage regression and use them as exposures.[14] First, we take the bank-level average of Δ *Log CD* during the first three months after the shock. Second, we calculate the bank-level average of *SD(Δ Log CD)*. These exposures should reflect the fall in CD demand and increasing uncertainty of CD demand due to the redemptions.

[14] Alternatively, we can also use beta estimates from the first stage as exposure measures. These might be prone to measurement bias. However, results are robust to this variation.

5 Results

5.1 The transmission of redemptions to bank funding markets

In this section, we discuss whether the extraordinary stress that Colombian funds faced during the outbreak of Covid-19 in March 2020 affected commercial bank funding markets. To this end, we report the results from estimating equation 1 in table 2. We focus on the reaction of open-ended funds (OEFs) in the first months after the first news of withdrawals. For each outcome, we compare the effect of redemptions in normal and stressed times. To test the effect in normal times, we restrict the sample to the pre-Covid period, i.e., the year 2019. The stressed period is defined as the first three months after the Covid outbreak, covering March 2020 to May 2020.

The results in columns 1 and 2 illustrate that redemptions in normal times do not have a significant effect on CD holdings, while the large redemptions as seen in March significantly reduce CD holdings within the first three months. On average, funds that experience one percent higher redemptions reduced their CD holdings by 0.16 percent. The redemptions that we observe in the first two weeks of March are on average about COP 245 billion which is above the 75th percentile of the distribution of redemptions before the event or about the size of two standard deviations (COP 123 bil.) of usual redemptions. An increase in redemptions of two standard deviations would then expectedly lead to a reduction in CD holdings of about 1.5 percent which represents 19 percent of the standard deviation in CD holdings. As the results in columns 3 and 4 illustrate, redemptions usually also not affect funds' CD holdings growth rate. However, during the stress between March and May 2020, funds more exposed to redemptions significantly reduce CD growth by almost 0.2 percentage points. This change represents about 10 percent of the standard deviation of log growth rates in CD holdings in normal times. Given our specification with bank×time fixed effects, these results demonstrate a sizeable reduction in CD demand by investment funds in reaction to the large redemptions they faced after the Covid-19 shock.

Table 2: The Effect of Redemptions on Funds' CD Demand

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log CD Holdings		Δ Log CD		SD(Δ Log CD)		Δ CD Sales		Δ CD Purchases	
	normal	stress	normal	stress	normal	stress	normal	stress	normal	stress
Log redemptions	-0.002	-0.156*	-0.001	-0.196***	0.004	0.175**	0.049*	1.487***	0.006	-1.022**
	(0.007)	(0.093)	(0.002)	(0.072)	(0.002)	(0.068)	(0.027)	(0.403)	(0.026)	(0.424)
Log total assets (t-1)	1.193	1.553	0.707***	0.929*	0.212	-1.135*	4.461***	0.867	-2.196	-1.974
	(1.191)	(1.216)	(0.229)	(0.507)	(0.343)	(0.576)	(1.510)	(2.043)	(1.740)	(1.925)
Cash-to-assets ratio (t-1)	-0.043	-0.021	0.029***	-0.021	-0.028**	-0.006	-0.107**	-0.130***	-0.028	-0.119***
	(0.040)	(0.022)	(0.009)	(0.013)	(0.013)	(0.009)	(0.053)	(0.049)	(0.055)	(0.042)
CDs-to-assets ratio (t-1)	0.053*	-0.031	0.019***	-0.041**	-0.011	-0.006	0.106***	-0.074	0.013	-0.090**
	(0.032)	(0.019)	(0.006)	(0.018)	(0.009)	(0.007)	(0.036)	(0.050)	(0.034)	(0.041)
Portfolioshare (t-1)	-0.021	0.120	0.000	0.009	-0.024**	0.007	0.046***	-0.022	-0.054***	-0.016
	(0.093)	(0.166)	(0.005)	(0.008)	(0.011)	(0.015)	(0.017)	(0.021)	(0.020)	(0.030)
Marketshare (t-1)	0.483***	0.574***	-0.006	-0.017*	-0.007	-0.058***	-0.013	0.015	0.017*	-0.025
	(0.096)	(0.093)	(0.005)	(0.010)	(0.008)	(0.016)	(0.011)	(0.017)	(0.010)	(0.017)
SD of log growth in treasuries (t-1)	0.070*	-0.044	0.004	-0.109*	-0.010	0.026	-0.010	0.396**	-0.006	-0.373**
	(0.039)	(0.113)	(0.005)	(0.063)	(0.011)	(0.027)	(0.023)	(0.161)	(0.024)	(0.155)
SD of log growth in bonds (t-1)	-0.013	6.112	0.040***	2.839*	0.799***	2.844	-0.027	-2.985	-0.079	-4.395
	(0.042)	(4.790)	(0.010)	(1.449)	(0.015)	(2.676)	(0.042)	(4.618)	(0.052)	(4.863)
Log(number of investors) (t-1)	1.412	8.513	0.766	-5.786*	0.172	-1.497	-6.170***	38.369**	-1.621	-31.868**
	(4.249)	(6.613)	(0.498)	(3.468)	(0.690)	(2.875)	(2.085)	(15.832)	(2.167)	(15.234)
LCR 30-day (t-1)	0.039	-0.003	-0.019**	0.002	0.021**	0.005	0.058	-0.059***	0.071	0.028
	(0.035)	(0.008)	(0.008)	(0.005)	(0.010)	(0.004)	(0.046)	(0.021)	(0.052)	(0.018)
Share of fixed rate investments (t-1)	-0.066	0.024	-0.035	-0.318*	0.101	0.024	0.172	0.726*	-0.215	-0.015
	(0.245)	(0.279)	(0.085)	(0.179)	(0.091)	(0.158)	(0.324)	(0.371)	(0.359)	(0.234)
Share of CD trades with CB (t-1)		-0.009		0.018		0.019**		-0.055		0.012
		(0.012)		(0.017)		(0.009)		(0.056)		(0.044)
Bank x Week, Fund Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,314	2,990	10,314	2,990	10,314	2,990	7,279	2,358	7,279	2,358
R2-within	0.180	0.269	0.004	0.021	0.469	0.038	0.002	0.016	0.001	0.008

Notes: The table shows the effects of weekly redemptions on weeky log CD holdings in columns 1 and 2, the week-on-week change in funds' CDs held at banks in columns 3 to 4, on the standard deviation of weekly log CD growth in columns 5 and 6, on weekly changes in CD sale transaction volumes in columns 7 and 8, and on weekly changes in purchase transaction volumes in columns 9 and 10. The sample includes only OEFs. The pre-Covid period is defined as all weeks in 2019 and the post-Covid period is defined as all weeks in March to May 2020. All specifications include bank-week and fund fixed effects. Standard errors clustered at the fund-bank level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Besides, reduced CD demand, funds with large redemptions also exhibit more uncertain demand as we show in columns 5 and 6 of table 2. During the stress episode, volatility in CD demand of funds with large redemptions is significantly higher than demand from funds facing small redemptions. An increase in redemptions by two standard deviations - taken from the distribution in non-stressed times - increases the standard deviation of CD growth by 1.7 which represents almost 75 percent of the standard deviation of this variable.

Funds can reduce their CD holdings by buying less and selling off CDs in the secondary market or by buying less of newly issued CDs. However, as a last resort, funds can also liquidate CDs before they mature at an additional cost. In columns 7 to 10, we test these channels. The results show that funds that face higher redemptions sell significantly more CDs in the secondary market. As can be expected, this is also a mechanism to satisfy redemption demands in normal times. However, the coefficient in stressed times 30 times larger than in normal times. In addition, funds also buy significantly fewer CDs during the stress period.

When studying longer periods after the shock, we see that the pass-through of redemptions to CD holdings is no longer significant. Table 3 replicates the results from table 2 studying the first six months after March 2020 in the upper panel and the year after in the lower panel. In most cases, we cannot find any significant results. Only the volatility in CD holdings seems to normalize again during the six months following March 2020. These findings indicate that the pass-through was rather short-lived, in line with the short period of unusually high redemptions.

5.2 The transmission of funding market stress to maturity transformation

Based on the analysis above, we test whether the stress in bank funding markets caused by redemptions affected firms' lending conditions. For this purpose, we estimate eq. 2 based on

Table 3: The Medium-term Effect of Redemptions on CD demand

	(1) Log CD	(2) Δ Log CD	(3) SD(Δ)	(4) ΔSales	(5) ΔPurchases
6-months after March 2020					
Log redemptions	-0.003	-0.003	-0.014**	0.078	-0.055
	(0.016)	(0.006)	(0.007)	(0.075)	(0.065)
Fund x Week, Fund x Bank x Week Controls	Yes	Yes	Yes	Yes	Yes
Bank x Week, Fund Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	5932	5932	5932	4691	4691
R2-within	0.297	0.012	0.031	0.005	0.001
12-months after March 2020					
Log redemptions	-0.001	-0.001	0.004	0.033	0.047
	(0.010)	(0.002)	(0.003)	(0.044)	(0.050)
Fund x Week, Fund x Bank x Week Controls	Yes	Yes	Yes	Yes	Yes
Bank x Week, Fund Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	12182	12182	12182	9576	9576
R2-within	0.320	0.005	0.026	0.001	0.001

Notes: The table shows the effects of weekly redemptions on the week-on-week change in funds' CDs held at banks, CD sales, and CD purchases in the secondary market. The sample includes only OEFs. The pre-Covid period is defined as all weeks in 2019, and the post-Covid period is defined as all weeks from March to August 2020 in columns 1 to 3 and all weeks from March 2020 to March 2021 in columns 4 to 6. The Post dummy is zero in the pre-Covid period and equals one in the post-Covid period. High Redemptions is a dummy equal to one for fund weeks with redemptions above the pre-Covid median of redemptions. All specifications include bank-week and fund fixed effects. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

a matched firm-bank dataset. The results are reported in tables 5 to 7.

First, we focus on the effect of stress in funding markets on loan maturities. The results in table 5 and 6 show that banks that were more exposed to the short-lived stress episode significantly reduced the maturity of their loans in response. This finding is robust to using different exposure measures. In table 5 we use exposure measures that focus on the decrease in demand for banks' CDs by funds driven by the redemption shock. In columns 1 to 3, banks' exposure is calculated as the logarithm of total CD volume outstanding held by funds in week 9 of 2020, right before the shock. A higher ratio implies that a bank is more exposed to potential withdrawals during distress times. In columns 4 to 6, banks' exposure is calculated as the average of the log-growth rate in CDs within the first three months after the shock. This measure represents an aggregation of the dependent variable estimated in equation 1 at the bank-level over the post-period. As the summary statistics of this variable in table 4

Table 4: Summary statistics of exposure measures to the redemption shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exposure measure	N	Mean	SD	Min	p5	p25	p50	p75	p95	Max
CDs outstanding (2020w9)	20	26.730	2.074	23.608	23.954	25.087	26.446	28.620	29.712	29.748
Δ log CD	22	-0.123	0.156	-0.574	-0.451	-0.176	-0.081	-0.011	0.026	0.050
SD(Δlog CD)	22	0.516	0.264	0.000	0.336	0.452	0.491	0.523	0.615	1.575
Fund-traded ratio	20	0.857	0.442	0.000	0.013	0.602	0.975	1.179	1.469	1.487

Notes: The table shows the number of distinct observations (col 1), the mean (col 2), the standard deviation (col 3), the minimum (col 4), the maximum (col 10) as well as the 5th, 25th, 50th, 75th and 95th percentile (columns 5, 6, 7, 8, and 9, respectively) of the different exposure measures. *CDs outstanding* is measured in logarithms of total COP volume of CDs outstanding and held by funds in week 9 of 20202. Δ *log CD* is measured as the bank-level average of changes in logarithms of CDs outstanding and held by funds over the first 3 months after the shock. *SD(Δ log CD)* is the bank-level standard deviation of the before mentioned changes. *Fund-traded ratio* is the bank-level average number of trades in the secondary market in which funds were one or both of the counterparties relative to the total number of trades. When both buyer and seller were funds, the trade is counted double.

show, for most banks the change was negative after the shock.

To make the coefficients comparable across the exposure measures, we calculate the effect of a change in exposure corresponding to an interquartile range of the measure ($IQR_{Exposure}$). The effect of IQR is shown in italics below the coefficient and its standard error. According to the ex ante exposure measure in columns 1 to 3, banks in the upper quartile of exposure extend loans with maturities that are on average 9.2 to 13.3 months shorter than banks in the lower quartile. The effect is strongest when we explore loans issued within a 6-months window after the shock and ebbs off when we extend the estimation period to 12 months. Since we measure exposure before the shock occurs, this measure does not pick up endogenous effects, such as funds withdrawing from CDs of banks with shorter maturities. However, this measure might overestimate the effect when potential withdrawals are not realized or counteracted by central bank measures. Accordingly, we find a positive significant effect of the share of CD trades with the central bank during the first 3 months which is large enough to compensate for the negative impact of exposure.

In comparison, the estimated effect is smaller when using the ex-post exposure measure in columns 4 to 6 where central bank interventions are intertwined with the exposure measure.

We cannot find a significant effect on maturities in the 3-months window after the shock. However, within a 6-months window after the shock, banks in the upper quartile of exposure extend loans with maturities that are on average 6.9 months shorter than banks in the lower quartile; within a 12-months window the difference increases to 10.7 months. Given an average maturity of around 19 months in the sample, banks' reaction is sizeable and represents a third (6-months window) or 45 percent (12-months window) of the standard deviation of maturity. These results indicate that banks that experienced severe stress in their short-term wholesale funding market adapt their liquidity risk management and reduce the maturity mismatch between their asset and liability side for an extended period after the shock. Interestingly, we find these effects, although the shock was relatively short-lived and counteracted by ample liquidity support from the central bank.

The impact of other control variables is mostly as expected. Larger banks extend longer maturities, while riskier banks (higher NPL ratios, higher CIR, higher ROE) extend shorter maturities. Also banks with more liquid assets, hold shorter maturities in the loan portfolio. The effect of higher regulatory equity ratios is mixed. The estimated relationships between loan terms show the expected signs. Larger loans have on average longer maturities. Shorter maturity loans have higher interest rates. If a loan is guaranteed and hence less risky, the maturity is on average longer while A-rated firms receive shorter maturities given the control for guarantees. The coefficients on the controls are similar in the following tables and therefore only shown in the appendix.

As evidenced in section 5.1, the redemptions not only decreased funds' demand for CDs but also increased volatility in the CD market. To investigate how the increased uncertainty might impact loan terms, we employ two additional exposure measures in table 6. In columns 1 to 3, exposure is calculated as the average of a four-week rolling window standard deviation of the log-change in CDs up to 12 months after the shock. This measures represents an aggregation of the dependent variable estimated in equation 1 at the bank-level over the

Table 5: Impact of exposure to redemptions on loan maturity

Y= Log(Maturity in months)	(1)	(2)	(3)	(4)	(5)	(6)
	CDs outstanding (2020w9)			Δ log CD		
	3m	6m	12m	3m	6m	12m
Post × Exposure	-0.144**	-0.274***	-0.209***	-1.337	-2.082*	-3.111***
	(0.0661)	(0.0447)	(0.0270)	(1.102)	(1.135)	(0.729)
[Effect of $\Delta IQR_{Exposure}$, in months]	*-9.2*	*-17.5*	*-13.3*	*-4.0*	*-6.9*	*-10.7*
Share of CD trades with CB	0.855***	-0.0529	-0.869***	0.818	-0.0917	-0.923
	(0.198)	(0.164)	(0.146)	(1.282)	(0.831)	(0.595)
Log(loan volume)	0.242***	0.236***	0.243***	0.242***	0.236***	0.243***
	(0.0161)	(0.0112)	(0.00785)	(0.0438)	(0.0489)	(0.0683)
Log(loan rate)	-0.402***	-0.292***	-0.233***	-0.401**	-0.293*	-0.232
	(0.0177)	(0.0143)	(0.0108)	(0.148)	(0.147)	(0.160)
A-rated =1	-0.860***	-0.377***	-0.211***	-0.862***	-0.383***	-0.209
	(0.0763)	(0.0531)	(0.0324)	(0.286)	(0.121)	(0.176)
Guaranteed = 1	1.322***	1.227***	1.218***	1.322***	1.228***	1.216***
	(0.0468)	(0.0361)	(0.0276)	(0.360)	(0.210)	(0.142)
Log(assets) [t-1]	0.232	3.910***	4.282***	0.0843	3.880	4.590***
	(0.786)	(0.437)	(0.280)	(2.743)	(2.546)	(1.012)
Tier1 ratio [t-1]	-26.02***	-2.958*	6.337***	-24.98	-1.849	7.180
	(4.917)	(1.656)	(0.850)	(47.76)	(11.87)	(4.342)
NPL ratio [t-1]	-37.06***	-36.00***	-2.697**	-36.86	-35.92	-2.543
	(6.480)	(4.013)	(1.143)	(57.97)	(30.06)	(9.186)
CIR [t-1]	0.00592	-0.00152	-0.0173***	0.0107	0.00120	-0.0140
	(0.0119)	(0.00269)	(0.00137)	(0.0681)	(0.00831)	(0.00947)
ROE [t-1]	-76.72***	-47.29***	-21.20***	-75.45**	-44.70***	-18.90*
	(4.010)	(2.160)	(1.059)	(35.88)	(11.41)	(9.125)
Liquid assets ratio [t-1]	-31.91***	-25.59***	-14.12***	-31.77	-25.40***	-14.77**
	(2.548)	(1.072)	(0.686)	(19.02)	(8.365)	(5.594)
Firm x qtr , firm x bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12379	29189	70751	12396	29246	70951
R2-within	0.474	0.391	0.322	0.474	0.390	0.322

Notes: The table shows the effects of the banks' exposure to funds redemptions on loan maturity measured as the logarithm of maturity in months. The post-period is defined in a symmetric time window on a weekly basis around March 15 (2020w10). In columns 1 and 4, *Post* is zero 12 weeks ahead of and equals one 12 weeks after week 10 of 2020. In columns 2 and 5, the time window includes 6 months, in columns 3 and 6 12 months. In columns 1 to 3, the *Exposure* of the bank b is calculated as the logarithm of total CD volume outstanding held by funds in week 9 of 2020, right before the shock. Note this is a continuous time-invariant pre-shock measure at the bank level. A higher ratio implies a bank is more exposed to potential withdraws during distress times. In columns 4 to 6, the *Exposure* of the bank b is calculated as the average of the log-growth in CD holdings within the first three months after the shock. Note this is a continuous time-invariant post-shock measure at the bank level. All specifications include firm-quarter and bank-firm fixed effects. Standard errors clustered at the bank level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Impact of exposure to volatility in the CD market on loan maturity

Y= Log(Maturity in months)	(1)	(2)	(3)	(4)	(5)	(6)
	SD(Δ log CD)			Fund-traded ratio		
	3m	6m	12m	3m	6m	12m
Post × Exposure	-6.715***	-2.977***	-0.873	-0.949**	-1.186***	-1.033***
	(1.617)	(1.108)	(0.636)	(0.386)	(0.297)	(0.167)
[Effect of $\Delta IQR_{Exposure}$, in months]	*-8.6*	*-3.8*	*-1.1*	*-9.9*	*-12.4*	*-10.8*
Share of CD trades with CB	0.905***	0.0180	-0.787***	0.838***	-0.0273	-0.778***
	(0.198)	(0.164)	(0.146)	(0.199)	(0.164)	(0.145)
Firm x qtr , firm x bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank , loan controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,396	29,246	70,951	12,380	29,218	70,832
R2-within	0.475	0.390	0.321	0.475	0.391	0.322

Notes: The table shows the effects of the banks' exposure to volatility in the CD secondary market after funds redemptions on loan maturity measured as the logarithm of maturity in months. The post-period is defined in a symmetric time window on a weekly basis around March 15 (2020w10). In columns 1 and 4, *Post* is zero 12 weeks ahead of and equals one 12 weeks after week 10 of 2020. In columns 2 and 5, the time window includes 6 months, in columns 3 and 6 12 months. In columns 1 to 3, the *Exposure* of the bank b is calculated as the average of a four-week rolling window standard deviation of the log-growth in CD holdings up to 12 months after the shock. In columns 4 to 6, the *Exposure* of the bank b is calculated as the average share of trades in the secondary market of bank b's CDs where funds were a counterpart relative to the total number of trades in the pre-period. Note these are both continuous time-invariant measure at the bank level. All specifications include firm-quarter and bank-firm fixed effects. Standard errors clustered at the bank level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

post-period. In columns 4 to 6, exposure is calculated as the average of the number of trades in the secondary market of a bank's CDs where funds were a counterpart relative to the total number of trades. This measure is based on the pre-period.

Interestingly, the effect of exposure to uncertainty shows a different dynamic than the exposure to decreasing CD demand. The strongest effect is estimated for the short 3-months window and fades off for longer periods after the shock. In the short run, banks in the upper quartile of exposure to volatility reduce maturities on average by 8.6 months more than banks in the lower quartile. Taking into account the positive significant impact of central bank interventions, the difference is still 7.4 months. The difference reduces to 3.8 months over a 6-months window and is insignificant over a 12-months estimation period. In contrast, the effect of exposure to fund-trading in the secondary market shows a similar dynamic to the effect of exposure to decreasing CD demand. The strongest effect is measured over a 6-months horizon: banks in the upper quartile of exposure reduce maturities by over a year compared to those in the lower quartile. These results highlight that banks adapt their maturity transformation not only to the availability of short-term wholesale funding but also its volatility.

5.3 The transmission of funding market stress to terms of credit

While the impact of fragile wholesale deposit funding on loan maturities is pronounced and economically large, the effect on loan volumes is modest. The results are shown in the upper panel of table 7. Surprisingly, although we would have expected a negative impact of a funding shock on lending, the estimates on the post-exposure interaction are either positive and significant or insignificant. The significant effects are estimated only in the mid-run, i.e., over a 6-months or 12-months period. It would imply that banks more exposed to the fund redemption shock extend more credit than banks less exposed. To make results comparable across different exposure measures and easier to interpret, we show the difference in credit volumes in COP bn between the 25th and 75th percentile of exposure in italics below the coefficients and their standard errors. The significant difference in lending between banks in the lower and upper quartile of exposure to the decrease in CD demand (columns 1 to 6) ranges between around COP 343 and 668 bn which is only 2.3 to 4.5 percent of a standard deviation in loan volumes. The effect is stronger when estimating the effect of banks' exposure to volatility in CD markets (columns 7 to 12) reaching 18 percent (column 12) and 109 percent (column 9) of the standard deviation of loan volumes.

These findings can be rationalized when taking into account central bank measures aimed at stabilizing credit in response to the shock. In line with this interpretation, we find a positive and significant effect of the share of central bank trades whenever the interaction term is insignificant (except for results in column 4). As pointed out previously, being exposed to the shock might be synonymous to being prone to accept central bank assistance. Therefore, the exposure measures based on ex-post shock impact can pick up effects of central bank assistance. In addition to the liquidity provision in the CD market, for which we control, the central bank implemented loan guarantee schemes and debt moratoria. Our data does not allow us to control for these measures which might be an explanation for the results. Under these limitations, our results indicate that the stress in bank funding markets did not lead to a longer-term credit crunch, possibly due to the timely central bank intervention.

Finally, we study whether the shock also affected lending rates. The results are shown in the lower panel of table 7. In line with expectations, exposure to stress in wholesale funding markets increases interest rates on loans. However, the results are not uniform across different exposure measures. Using the ex-ante exposure to fund redemptions (columns 1 to 3), we find a significant difference of around 1 percentage point in interest rates on new loans of banks in the upper quartile compared to rates of banks in the lower quartile of the exposure measure. The effect appears slightly smaller with of about 72 basis points when we use the exposure to CD outflows in the first 3 months after the shock instead (columns 4 to 6). The effect is economically significant as well and represents about 95 percent (CDs outstanding) and 75 percent ($\Delta logCD$) of a standard deviation in loan rates, respectively. However, exposure measures focused on the volatility in the CD market do not give consistent significant results. The coefficient on central bank support is insignificant as well in most cases. Only within a longer window of 12 months around the shock, are we able to estimate a negative significant effect of central bank liquidity support on interest rates. Overall, our analysis points out that while banks kept on providing credit, the terms of credit have deteriorated for borrowers in response to the stress in banks' funding markets.

6 Concluding remarks

Recent episodes of financial turmoil, including prominently the 2023 U.S. regional banking crises, have highlighted the financial-stability implications of wholesale funding markets.

Table 7: IMPACT OF REDEMPTIONS ON CREDIT VOLUMES AND RATES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	CDs outstanding (2020w9)			Δ Log CD			SD(Δ Log CD)			Fund-traded ratio		
	3m	6m	12m	3m	6m	12m	3m	6m	12m	3m	6m	12m
Log(Volume)												
Post × Exposure	0.117	0.141***	0.110***	0.563	1.544***	1.671***	-2.355	1.634	2.578***	0.614	0.408	0.432**
	(0.0734)	(0.0493)	(0.0292)	(0.815)	(0.328)	(0.361)	(1.911)	(1.284)	(0.728)	(0.465)	(0.347)	(0.190)
[Effect of $\Delta IQR_{Exposure}$, in mil COP]	*497.8*	*667.9*	*548.2*	*112.3*	*342.9*	*390.5*	*-10018.9*	*7739.8*	*12848.4*	*2612.1*	*1932.6*	*2153.0*
Share of CD trades with CB	1.169***	0.672***	0.297	1.133	0.714	0.333	1.137***	0.637***	0.247	1.129***	0.661***	0.256
	(0.244)	(0.220)	(0.185)	(0.789)	(0.605)	(0.670)	(0.244)	(0.220)	(0.186)	(0.244)	(0.220)	(0.186)
Loan, Bank x Qtr Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Qtr , Firm x Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,379	29,189	70,751	12,396	29,246	70,951	12,396	29,246	70,951	12,380	29,218	70,832
R2-within	0.376	0.389	0.381	0.375	0.388	0.380	0.375	0.388	0.380	0.375	0.388	0.380
Log(Rate)												
Post × Exposure	0.129*	0.121**	0.124***	1.796**	1.969**	1.943**	-2.182	1.373	2.994*	1.321**	0.318	-0.239
	(0.0740)	(0.0500)	(0.0300)	(0.648)	(0.885)	(0.802)	(4.395)	(1.403)	(1.514)	(0.618)	(0.300)	(0.379)
[Effect of $\Delta IQR_{Exposure}$, in pp]	*1.106*	*0.981*	*0.962*	*0.724*	*0.745*	*0.704*	*-0.377*	*0.223*	*0.465*	*1.858*	*0.419*	*-0.302*
Share of CD trades with CB	0.915	-0.0134	-0.542*	0.929	0.0379	-0.503*	0.901	-0.0575	-0.605**	0.897	-0.0363	-0.587*
	(1.130)	(0.367)	(0.279)	(1.133)	(0.412)	(0.286)	(1.139)	(0.370)	(0.291)	(1.123)	(0.373)	(0.296)
Loan. Bank x Qtr Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm x Qtr , Firm x Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,463	29,378	71,253	12,480	29,435	71,466	12,480	29,435	71,466	12,464	29,407	71,347
R2-within	0.316	0.211	0.184	0.315	0.212	0.185	0.314	0.209	0.184	0.319	0.210	0.182

NOTES: The table shows the effects of the banks' exposure to CD outflows and volatility in the CD secondary market after funds redemptions on loan volumes measured as the logarithm of issued loan volume in bil COP in the upper panel and on loan rates measured as the logarithm of the interest rate in percentage points in the lower panel. The post-period is defined in a symmetric time window on a weekly basis around March 15 (2020w10). In columns 1, 4, 7, and 10 *Post* is zero 12 weeks ahead of and equals one 12 weeks after week 10 of 2020. In columns 2, 5, 8, and 11, the time window includes 6 months, in columns 3, 6, 9, and 12 it is 12 months. In columns 1 to 3, the *Exposure* of the bank b is calculated as the logarithm of total CD volume outstanding held by funds in week 9 of 2020, right before the shock. In columns 4 to 6, the *Exposure* of the bank b is calculated as the average of the log-change in CD hodlings within the first three months after the shock. In columns 7 to 9, the *Exposure* of the bank b is calculated as the average of a four-week rolling window standard deviation of the log-change in CDs up to 12 months after the shock. In columns 10 to 12, the *Exposure* of the bank b is calculated as the average share of trades in the secondary market of bank b's CDs where funds were a counterpart relative to the total number of trades. Note these are continuous time-invariant measures at the bank level. All specifications include firm-quarter and bank-firm fixed effects. Standard errors clustered at the bank level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

While the fragility of wholesale deposits has been a matter of ample discussion in policy and academic circles, any policy guidance to address related systemic vulnerabilities requires understanding the mechanisms linking wholesale depositors' fragility and banks' liquidity risk.

In this paper, we advance this understanding by examining the consequences of disruptions in wholesale deposit markets originated in episodes of large-scale redemptions from investment funds in Colombia. We use novel data linking banks and investment funds connected through the market for certificates of deposit issued by banks and held by funds. The empirical analysis isolates the effect of funds' redemptions on banks' funding and quantifies the effect of banks' exposure to wholesale deposits on credit conditions. Our main conclusion is that even though the pass-through of stress from investment funds to bank funding markets was short-lived, banks adapted their liquidity risk management by rising interest rates and reducing the duration of credit. Thus, the threat of liquidity risk stemming from wholesale depositors leads banks to adjust core business functions, including an attenuation of their maturity transformation.

From a policy perspective, the results suggest that improving financial monitoring in the non-bank financial sector can strengthen supervisors' capacity to anticipate sources of banks' liquidity risk, which may impair credit market functioning in times of distress. Moreover, the documented effectiveness of central bank liquidity facilities in reducing funding market stress lends support to the idea that a timely intervention of central banks can mitigate the spread of liquidity risk. Finally, the fact that banks react to surges in liquidity risk by reducing loans' duration means that borrowers requiring long-term funding – including large investment projects – can be particularly affected when wholesale deposit markets become disrupted, which could be considered in the design of public support measures and credit guarantees in times of crisis.

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A Appendix

A Additional tables

Table A1: Credit Register Summary Statistics in the Pre-period

Variables	(1) Std. Dev.	(2) Mean	(3) Median
Loan volume	1,214.28	344.25	31.72
Loan rate	0.10	0.16	0.13
Maturity	31.66	31.20	24
Exposure	0.41	0.57	0.63

NOTES: This table reports summary statistics for the pre-period sample (March 2019-February 2020) for the credit register outcomes. Cols. 1 to 3 report the standard deviation (Std. Dev), mean, and median of the respective distributions. The loan volume is expressed in million COP, and the maturity is in months. The exposure of the bank i is calculated as the average share of deposits held by funds over the bank's liquid assets in 2019.

Table A2: The Effect of Redemptions at Non-OEFs on CDs Held at Banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	3 months		6 months		12 months	
Log redemptions	-0.0019***		-0.0003		-0.0003**	
	(0.0004)		(0.0002)		(0.0001)	
High redemptions x Post		-0.0028		-0.0006		-0.0007
		(0.0034)		(0.0021)		(0.0017)
Log total assets (t-1)	0.0254**	0.0357***	0.0177***	0.0019	0.0075	0.0002
	(0.0105)	(0.0055)	(0.0060)	(0.0047)	(0.0049)	(0.0030)
Cash-to-assets ratio (t-1)	-0.0004	0.0001	0.0003	0.0006***	0.0004***	0.0005***
	(0.0005)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Share of CDs per bank (t-1)	-0.1585***	-0.1484***	-0.1333***	-0.1248***	-0.1048***	-0.1125***
	(0.0355)	(0.0240)	(0.0248)	(0.0204)	(0.0135)	(0.0138)
CDs held at different banks (t-1)	-0.0143***	-0.0069***	-0.0077***	-0.0038***	-0.0042***	-0.0029***
	(0.0027)	(0.0012)	(0.0014)	(0.0007)	(0.0007)	(0.0004)
Log change Government Treasuries (t-1)	0.0014**	0.0004	0.0009**	0.0005***	0.0009***	0.0005***
	(0.0006)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0001)
Log change Bonds (t-1)	-0.1119***	-0.0671***	-0.0538***	-0.0307**	-0.0253***	-0.0075
	(0.0288)	(0.0184)	(0.0151)	(0.0134)	(0.0090)	(0.0065)
Fund FEs, Bank-Week FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,118	19,554	20,063	36,396	36,591	68,250
R-squared	0.1223	0.1091	0.1116	0.0959	0.0956	0.0848
R-squared within	0.012	0.009	0.008	0.007	0.006	0.007

NOTES: The table shows the effects of weekly redemptions on the week-on-week change in funds' CDs held at banks. The sample includes only non-OEFs. The pre-Covid period is defined as all weeks in 2019 and the post-Covid period is defined as all weeks in the first 3 months after the shock in columns 1 and 2, the first six months in columns 3 and 4, and the first 12 months in columns 5 and 6. The Post dummy is zero in the pre-Covid period and equals one in the post-Covid period. High Redemptions is a dummy equal to one for fund weeks with redemptions above the pre-Covid median of redemptions. All specifications include bank-week and fund fixed effects. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Robustness to the Specification of Fixed Effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS				DiD			
Log redemptions	-0.0036*	-0.0031	-0.0042**	-0.0051*				
	(0.0020)	(0.0033)	(0.0019)	(0.0026)				
High Redemptions					0.0203***		0.0094**	
					(0.0041)		(0.0042)	
High Redemptions × Post					-0.0174***	-0.0248***	-0.0094*	-0.0155***
					(0.0041)	(0.0044)	(0.0048)	(0.0047)
Log total assets (t-1)	0.0164***	0.1311***	0.0110***	0.1082***	0.0082***	0.0902***	0.0029	0.0932***
	(0.0039)	(0.0187)	(0.0038)	(0.0328)	(0.0025)	(0.0125)	(0.0027)	(0.0178)
Cash-to-assets ratio (t-1)	0.0029***	0.0032***	0.0010***	0.0015***	0.0024***	0.0027***	0.0010***	0.0012***
	(0.0004)	(0.0006)	(0.0003)	(0.0005)	(0.0003)	(0.0005)	(0.0002)	(0.0004)
Share of CDs per bank (t-1)	-0.0924**	-0.0807**	-0.2450***	-0.2347***	-0.0611**	-0.0541**	-0.1383***	-0.1311***
	(0.0436)	(0.0345)	(0.0698)	(0.0590)	(0.0253)	(0.0220)	(0.0492)	(0.0450)
CDs held at different banks (t-1)	0.0018***	-0.0330***	0.0011***	-0.0222***	0.0007**	-0.0178***	0.0005*	-0.0128***
	(0.0004)	(0.0053)	(0.0004)	(0.0050)	(0.0002)	(0.0024)	(0.0003)	(0.0023)
Log change Government Treasuries (t-1)	-0.0018	-0.0033	-0.0036	-0.0036	-0.0009	-0.0008	-0.0012**	-0.0010*
	(0.0023)	(0.0023)	(0.0024)	(0.0024)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Log change Bonds (t-1)	0.2090***	0.1478***	0.1391**	0.1165*	0.1064***	0.0854***	0.0725**	0.0557*
	(0.0521)	(0.0539)	(0.0607)	(0.0651)	(0.0250)	(0.0241)	(0.0295)	(0.0301)
Fund FE	No	Yes	No	Yes	No	Yes	No	Yes
Bank-time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	4,284	4,284	4,097	4,097	7,560	7,560	7,230	7,230
R-squared	0.0422	0.0892	0.2242	0.2395	0.0364	0.0649	0.2186	0.2293
R-squared within	.042	.085	.013	.028	.036	.062	.009	.019

NOTES: The table shows the effects of weekly redemptions on the week-on-week change in funds' CDs held at banks. The sample includes only OEFs. The pre-Covid period is defined as all weeks in 2019, and the post-Covid period is defined as all weeks in the first 3 months after the shock. The Post dummy is zero in the pre-Covid period and equals one in the post-Covid period. High Redemptions is a dummy equal to one for fund weeks with redemptions above the pre-Covid median of redemptions. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Impact of exposure to volatility in the CD market on loan maturity (all estimators).

Y= Log(Maturity in months)	(1)	(2)	(3)	(4)	(5)	(6)
		SD(Δ log CD)			Fund-traded ratio	
	3m	6m	12m	3m	6m	12m
Post × Exposure	-6.715***	-2.977***	-0.873	-0.949**	-1.186***	-1.033***
	(1.617)	(1.108)	(0.636)	(0.386)	(0.297)	(0.167)
[Effect of $\Delta IQR_{Exposure}$, in months]	*-8.6*	*-3.8*	*-1.1*	*-9.9*	*-12.4*	*-10.8*
Log(loan volume)	0.241***	0.236***	0.242***	0.242***	0.235***	0.243***
	(0.0160)	(0.0112)	(0.00783)	(0.0160)	(0.0112)	(0.00782)
Log(loan rate)	-0.404***	-0.295***	-0.235***	-0.400***	-0.294***	-0.236***
	(0.0176)	(0.0143)	(0.0108)	(0.0177)	(0.0143)	(0.0108)
A-rated =1	-0.847***	-0.390***	-0.226***	-0.866***	-0.397***	-0.229***
	(0.0763)	(0.0530)	(0.0322)	(0.0765)	(0.0530)	(0.0322)
Guaranteed = 1	1.319***	1.228***	1.220***	1.324***	1.232***	1.222***
	(0.0467)	(0.0361)	(0.0275)	(0.0468)	(0.0361)	(0.0276)
Share of CD trades with CB	0.905***	0.0180	-0.787***	0.838***	-0.0273	-0.778***
	(0.198)	(0.164)	(0.146)	(0.199)	(0.164)	(0.145)
Log(assets) [t-1]	-0.208	3.465***	3.713***	-0.112	3.649***	4.002***
	(0.764)	(0.428)	(0.268)	(0.774)	(0.430)	(0.269)
Tier1 ratio [t-1]	-23.60***	-2.562	5.919***	-28.81***	-4.023**	5.633***
	(4.883)	(1.649)	(0.835)	(4.857)	(1.666)	(0.836)
NPL ratio [t-1]	-36.72***	-35.96***	-2.807**	-40.81***	-37.97***	-2.882**
	(6.470)	(4.027)	(1.148)	(6.197)	(4.056)	(1.149)
CIR [t-1]	0.0172	0.00122	-0.0155***	0.0108	0.00135	-0.0155***
	(0.0113)	(0.00272)	(0.00134)	(0.0115)	(0.00270)	(0.00134)
ROE [t-1]	-76.75***	-45.50***	-18.71***	-74.98***	-44.37***	-18.37***
	(3.991)	(2.121)	(1.018)	(3.979)	(2.123)	(1.020)
Liquid assets ratio [t-1]	-31.53***	-24.59***	-13.04***	-30.70***	-24.92***	-13.66***
	(2.538)	(1.062)	(0.678)	(2.451)	(1.065)	(0.677)
Firm x qtr , firm x bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12396	29246	70951	12380	29218	70832
R2-within	0.475	0.390	0.321	0.475	0.391	0.322

NOTES: The table shows the effects of the banks' exposure to volatility in the CD secondary market after funds redemptions on loan maturity measured as the logarithm of maturity in months. The post-period is defined in a symmetric time window on a weekly basis around March 15 (2020w10). In columns 1 and 4, *Post* is zero 12 weeks ahead of and equals one 12 weeks after week 10 of 2020. In columns 2 and 5, the time window includes 6 months, in columns 3 and 6 12 months. In columns 1 to 3, the *Exposure* of the bank b is calculated as the average of a four-week rolling window standard deviation of the log-change in CDs up to 12 months after the shock. In columns 4 to 6, the *Exposure* of the bank b is calculated as the average share of trades in the secondary market of bank b's CDs where funds were a counterpart relative to the total number of trades. Note these are both continuous time-invariant post-shock measure at the bank level. All specifications include firm-quarter and bank-firm fixed effects. Standard errors clustered at the bank level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

B Strength and fragility in the bank-fund relationship

Besides the interventions of the BdR, other factors might also mitigate or facilitate the transmission of redemptions to bank funding markets. In the following, we exploit the heterogeneity in funds and banks to study which characteristics are associated with weaker bank-fund links and which contributed to a steadier relationship despite the sudden redemptions. For this purpose, we re-estimate the baseline expressed in eq. 1 on subsamples which we split according to the bank and fund characteristics. We calculate the median of the distribution of average pre-Covid characteristics and then split the sample into above-median and below-median banks or funds.

Table B1: Amplifying Fund Characteristics

	(1) Fund size		(2) CD Ratio		(3) Cash Ratio		(4) Distance to RLI limit	
	$x < p50$	$x \geq 50$	$x < p50$	$x \geq 50$	$x < p50$	$x \geq 50$	$x < p50$	$x \geq 50$
Log redemptions	-0.0026***	0.0021	-0.0023***	0.0026*	-0.0025**	-0.0009	-0.0024**	-0.0012*
	(0.0003)	(0.0025)	(0.0003)	(0.0015)	(0.0010)	(0.0007)	(0.0009)	(0.0006)
Observations	6,341	8,976	6,783	8,517	7,599	7,633	7,922	7,344
R-squared	0.1418	0.1783	0.1577	0.1616	0.1577	0.1688	0.1530	0.1586
	(5) Open-Ended Funds		(6) Conglomerate		(7) Portfolio share		(8) Market share	
	$x = 1$	$x = 0$	$x = 1$	$x = 0$	$x < p50$	$x \geq 50$	$x < p50$	$x \geq 50$
Log redemptions	-0.0051*	-0.0019***	-0.0093	-0.0017***	-0.0042	-0.0008**	-0.0014***	-0.0013
	(0.0026)	(0.0004)	(0.0134)	(0.0004)	(0.0028)	(0.0003)	(0.0004)	(0.0014)
Observations	4,097	11,118	15,232	119	10,081	5,151	1,275	13,974
R-squared	0.2395	0.1223	0.1233	0.8603	0.1433	0.1352	0.2436	0.1336

Notes: The table shows the effects of weekly funds' redemptions on the week-on-week change in funds' CDs held at banks. Each column runs the regression, breaking the sample according to different characteristics. For instance, column 1 divides the sample based on the fund size and shows the results for two subsamples; the first subsample comprises funds below the median of the funds' size distribution, whereas the second subsample includes funds equal to or above the median. Also, note there are some columns that split the sample based on a dichotomic condition. For example, column 5 displays the results for two subsamples: Open-Ended funds and Non-Open-Ended funds. All specifications include the set of controls as in the baseline specification and bank-week and fund fixed effects. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

First, we focus on fund characteristics. The results are illustrated in table B1, where we report the estimated coefficients on redemptions. All regressions include covariates as well as bank-time fixed effects and fund-fixed effects. In each column, we report first the estimation based on funds with the characteristic named in the column header below the median, then the estimation based on funds with above-median characteristics. The results in the upper panel of the table show that especially smaller funds (column 1) that hold a lower share of their assets in CDs (column 2) withdrew their CD holdings in response to redemptions. As we would expect that funds first use cash to redeem customers, we find that especially funds with low cash holdings start to liquidate CD contracts, as shown in column 3. Also, these funds tend to be relatively closer to the regulatory liquidity risk limit (column 4). While we also find a significant decrease in CD holdings of funds with a relatively high distance to the regulatory minimum ratio, the pass-through is only half as strong as the pass-through of funds closer to the regulatory ratio.

The results in the lower panel of table B1 show that funds that hold a relatively smaller market share of the CDs of a certain bank (column 8) are those that withdraw their investments. The estimations in column 7 further demonstrate that funds tend to liquidate CDs, of which they hold a relatively high share in their CD portfolio. In line with the findings in Golez and Marin (2015); Gil-Bazo et al. (2020); Bagattini et al. (2023) that argue that banks and funds in the same financial conglomerate support each other in stressed times, our results in column 6 confirm that funds are more likely to sell off CDs of banks to whom they are not affiliated. Finally, we distinguish between open-end funds (OEF) and closed-end funds (CEF) in column 5. Unlike OEF, CEF does not face the risk of capital flowing out of the fund when investors sell shares, given that shares are not traded directly with the fund. Therefore, we expect our results to be driven in the first months after the shock by OEFs. Indeed, the results confirm that both types of funds significantly reduce their CD holdings, but the effect is almost three times larger for open-end funds. We show in table A2 in the appendix that we cannot find a statistically significant DID effect when comparing CD holdings of CEFs before and after the sudden redemption shock.

Overall, these results point out that the fragilities in bank funding relationships are focused mainly on peripheral funds, which are smaller, have weaker liquidity risk management, and are also less relevant for the CD market. Meanwhile, funds that provide important parts

Table B2: Amplifying Bank Characteristics

	(1) Bank size		(2) CD market size		(3) NPL Ratio		(4) Tier 1 Ratio	
	x < p50	x ≥ 50	x < p50	x ≥ 50	x < p50	x ≥ 50	x < p50	x ≥ 50
Log redemptions	-0.0044	-0.0018***	0.0055	-0.0011***	-0.0009	-0.0012**	-0.0012***	0.0004
	(0.0051)	(0.0004)	(0.0052)	(0.0003)	(0.0006)	(0.0004)	(0.0003)	(0.0014)
Observations	833	12,733	1,139	10,336	5,270	7,735	9,435	2,108
R-squared	0.1885	0.1229	0.2104	0.1076	0.0992	0.1267	0.0974	0.1374

Notes: The table shows the effects of weekly funds' redemptions on the week-on-week change in funds' CDs held at banks. Each column runs the regression breaking the sample according to different characteristics. For instance, column 1 divides the sample based on the bank size and shows the results for two subsamples; the first subsample comprises banks below the median of the banks' size distribution, whereas the second subsample includes banks equal to or above the median. All specifications include the set of controls as in the baseline specification and bank-week and fund fixed effects. Robust standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

of bank funding proved more resilient to sudden outflows.

Furthermore, we also investigate which type of banks were more affected by the redemptions. The results are shown in table B2. On the one hand, the findings in columns 1 and 2 highlight that especially banks with more liquid CD markets are affected by the redemptions. We find a negative significant effect of redemptions on CD holdings of large banks and those with a high market share relative to total CDs issued by banks. We expect funds to liquidate these CDs as the likelihood of finding buyers at less constrained prices is higher in larger markets. On the other hand, we find evidence for a selection of selling CDs of riskier banks. As the estimates in columns 3 and 4 show, funds are more likely to reduce their exposures to banks with relatively high non-performing loan ratios (NPL) and lower Tier 1 equity ratios. These results confirm the idea that funds as wholesale investors monitor the riskiness of banks when investing in them.

C Central bank measures to stabilize bank funding markets

As mentioned in section 2, the BdR enacted several emergency measures as early as in the second week of March to support banks and non-bank financial intermediaries with liquidity. Among these, starting on March 23, the central bank started to buy CDs from market participants, including funds, in the secondary market. In the following, we analyse if and how these transactions helped funds to satisfy the redemptions they faced and how it affects the transmission of the shock faced by funds to bank funding markets.

First, we construct a measure of central bank support at the fund level. For each fund, we relate the number of transactions in which the fund could sell a CD to the central bank to the total number of sales the fund did during a given week, i.e.,

$$\text{CB purchases}_{i,t} = \frac{\#\text{ sales from fund } i \text{ to the CB in week } t}{\#\text{ sales from fund } i \text{ in week } t} \tag{A.1}$$

We further weight this measure by the importance the potential support from the central bank might have for a fund by multiplying it with the logarithmized redemptions.

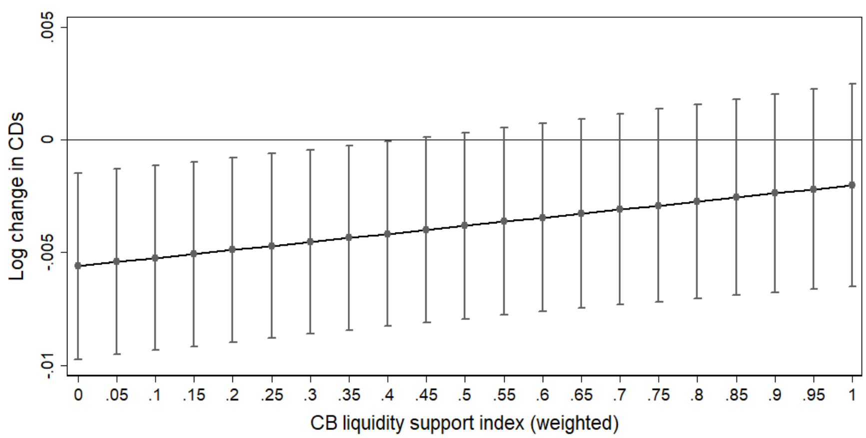
To analyze whether the central bank support had a mitigating effect on the transmission of redemptions, we interact the afore-described measures with the redemption volume. The results are reported in table C1 and show that the coefficient of the interaction is positive and significant, independent of which specification of central bank support we use. Importantly, the results highlight that, on average, the central bank support outweighs the negative pass-through of redemptions on CD holdings. This is illustrated in figure C1, which shows the marginal effect of redemptions on CD holdings depending on the level of liquidity support by the central bank. As can be seen, the transmission quickly becomes insignificant as funds make more use of central bank liquidity.

Table C1: Central Bank Liquidity Support After the Liquidity Shock

	(1)	(2)	(3)	(4)
		Log change in CDs		
Log redemptions	-0.006**	-0.006**	-0.006**	-0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
Log redemptions × CB purchases	0.018**			
	(0.008)			
Log redemptions × Weighted CB purchases		0.449**		
		(0.186)		
Log redemptions × CB liquidity support index			0.004**	
			(0.002)	
Log redemptions × Weighted CB liquidity support index				0.004**
				(0.001)
Log total assets (t-1)	0.116***	0.115***	0.116***	0.115***
	(0.031)	(0.031)	(0.031)	(0.031)
Cash-to-assets ratio (t-1)	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Share of CDs per bank (t-1)	-0.258***	-0.258***	-0.258***	-0.258***
	(0.063)	(0.063)	(0.063)	(0.063)
CDs held at different banks (t-1)	-0.020***	-0.020***	-0.020***	-0.020***
	(0.005)	(0.005)	(0.005)	(0.005)
Log change Government Treasuries (t-1)	-0.003	-0.003	-0.003	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Log change Bonds (t-1)	0.130**	0.130**	0.130**	0.130**
	(0.061)	(0.061)	(0.061)	(0.061)
Observations	4,097	4,097	4,097	4,097
R-squared	0.244	0.244	0.244	0.244
R-squared within	.032	.032	.032	.032

NOTES: The table shows the effects of weekly funds' redemptions on the week-on-week change in funds' CDs held at banks. Each column includes an interaction of the funds' redemptions and central bank liquidity support measures specified in subsection 2. All specifications include bank-week and fund fixed effects. Standard errors clustered at the bank level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure C1: Marginal Effects of Funds' Redemptions on the Percentage Change in CDs.



Notes: The Figures show the marginal effects of funds' redemptions on the log change in funds' CDs held at banks conditional on the central bank liquidity support weighted index surrounded by 95% confidence intervals.

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