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# A Tale of Demand and Supply for Central Bank Reserves\*

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## Abstract

In an ample-reserves framework, administered rates anchor money markets but suppress information from unsecured interbank trading. We recover that information by isolating the small interbank segment of the federal funds market. Using high-frequency bank-level data, we employ deposit shocks as an instrument for bank borrowing demand. Our analysis reveals that non-bank lenders, such as Federal Home Loan Banks, supply funds elastically, whereas bank lenders exhibit price inelasticity, which intensifies as their reserve balances decline, particularly for *bankers' banks*. This interbank segment highlights distributional frictions in the federal funds market that emerge well before aggregate reserves become scarce and provides new evidence on monetary policy transmission in an ample-reserves regime.

*Keywords:* monetary policy implementation, balance sheet policy, central bank reserves, fed funds market

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# 1 Introduction

The Federal Reserve’s (Fed) monetary policy implementation framework underwent a significant shift following the policy response to the Global Financial Crisis (GFC) and the official adoption of an ample-reserves regime in 2019. In this framework, the Fed steers money market rates into the target range by setting administered rates on its liabilities, primarily the interest on reserve balances (IORB) and the overnight reverse repo facility (ON RRP).<sup>1</sup> IORB is the main policy tool for rate control and conceptually operates by determining banks’ opportunity cost to lend to the broader financial system and the economy as a whole. This framework departs from the pre-GFC approach. Rather than managing reserve quantities on a day-to-day basis through open market operations, the Fed now relies on administered rates, along with banks’ liquidity management and arbitrage behavior, to keep its policy rate—the effective federal funds rate (EFFR)—within the target range.

A consequence of the ample-reserves framework is the atrophy of interbank markets. By greatly increasing the amount of reserves in the system, banks have not had to rely on unsecured interbank borrowing and lending in the federal funds market (fed funds) to manage their liquidity. In this environment, the lion share of trading reflects arbitrage opportunities between participants that do and do not receive IORB. Therefore, short-term money market rates often trade well below IORB, suggesting that it is a poor measure of banks’ true opportunity cost of lending to one another. Most trading in the federal funds market thus appears largely disconnected from broader bank liquidity conditions and from the price of the marginal interbank dollar. Moreover, the framework also mutes a classic real-time barometer of bank health: the price and quantity of interbank credit. With few unsecured trades, movements in the interbank rate become harder to observe precisely when they are most useful—during episodes when the cross-sectional distribution of liquidity tightens. Our paper converts this challenge into an identification strategy: we exploit the remaining sliver of unsecured interbank activity in the federal funds market to measure demand and supply conditions and diagnose reserve-related fragilities among banks.

Our contribution is twofold. First, we show that intermediaries who lend in fed funds market shape what the data say about reserve conditions. When trades are dominated by nonbank lenders—most notably FHLBs that price elastically to capture the spread between IORB and fed funds trading—standard regressions of rates on aggregate reserves mainly identify nonbank arbitrage activity, not banks’ aggregate demand for reserves to manage

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<sup>1</sup>IORB is the rate the Fed pays banks on their reserve deposits held at the Fed. The ON RRP offering rate is the rate the Fed offers to non-bank financial institutions for overnight cash investments in reverse repurchase agreements; it is set below the IORB rate to establish a floor under short-term money market rates.

their liquidity. By contrast, bank lenders’ volume-weighted rates co-move with aggregate reserves and with the lenders’ own reserve positions. These facts underscore the importance of accounting for lender heterogeneity for inferring bank liquidity conditions. Second, we show that the thin interbank segment still carries rich information about the cross-sectional distribution of reserves well before important information on distributional frictions becomes apparent in aggregate reserve conditions.

Much of the literature devoted to understanding at what point reserves transition from “abundant” to “ample” levels involves the estimation of an aggregate reserve demand curve and identifying the “kink” as the onset of reserve scarcity (Lopez-Salido & Vissing-Jorgensen (2023), Afonso et al. (2022), Acharya & Rajan (2024)). By regressing daily changes in EFFR relative to IORB on fluctuations in aggregate reserves and deposits, they trace a two-regime relationship that is essentially flat when reserves exceed a threshold and steepens once reserves dip below a certain level. We argue that this representative-bank framework is ill-suited to the problem at hand because it overlooks heterogeneity—by which we mean systematic differences across participants in constraints, objectives, and pricing (e.g., large vs. small banks, foreign vs. domestic banks, and nonbanks). Aggregating across different types of market participants blends activity which is motivated by arbitrage from that which is driven by the demand and supply of liquidity, confounding identification and the information content of fed funds rates.

Our approach is motivated by two stylized facts. First, lender composition in fed funds is heterogeneous: nonbanks (FHLBs), who do not earn IORB on their reserve balances, supply the majority of fed funds to earn the spread between EFFR and IORB (Anderson et al. 2021). FHLBs mainly lend to foreign banks, that are subject to less stringent regulations relative to domestic banks, and thus have a greater willingness to expand their balance sheet to earn the spread between EFFR and IORB to capture arbitrage. Bank lenders, in contrast, lend subject to their own reserve positions and liquidity needs of their other bank counterparties. For these bank lenders IORB, and their own liquidity considerations, are the effective opportunity cost to lend reserves into fed funds. Second, bank borrower heterogeneity is stark: only a specific subset of domestic banks—those under \$10 billion in assets—meaningfully expand their reserve holdings in response to deposit inflows, thereby putting into question the notion of a uniform aggregate demand curve. Only when these smaller banks’ demand for reserves increases, do trading volumes increase in the fed funds market.

The structure of the fed funds market poses challenges for measuring bank liquidity conditions. When transactions in the fed funds market are dominated by nonbank lending, slopes estimated on the EFFR primarily nonbanks’ incentives to supply reserves to profit

from arbitrage spreads, not a tightening in banks’ reserve management. Conversely, the interbank rate between bank borrowers and lenders moves in response to their funding needs and their willingness to deploy those funds relative earning IORB, yielding a cleaner signal of distributional frictions among banks.

In this paper, we rely on micro data to disentangle these two distinct drivers of fed funds trading activity. Specifically, we estimate the *supply elasticity* of lenders in the fed funds market, separating between non-bank and domestic bank lenders.<sup>2</sup> We show that the volume-weighted average rates offered by bank lenders vary systematically with aggregate reserves. By exploiting plausibly exogenous deposit shocks at small domestic borrowing banks as an instrumental variable for their borrowing demand, we estimate supply elasticities by lender type and find that non-bank lending remains highly elastic—consistent with pure arbitrage behavior—whereas bank lending is inelastic. We then measure both non-bank and bank supply elasticities as a function of their reserve holdings. While non-bank lending is elastic regardless of the level of reserves, domestic bank lending become more inelastic as reserves decline. In other words, as aggregate liquidity conditions tighten with the decline in aggregate reserves, domestic banks require more compensation to deploy reserves into interbank markets.

To emphasize the importance of banks’ reserve holdings even further, we also measure supply elasticity as a function of reserve holdings of banks that are the more relevant lenders in the fed funds market: *bankers’ banks*. These are specialized institutions that manage reserves for community bank customers and are the principal lenders in this market, making their reserve holdings particularly relevant to measure domestic bank lending activity (Anbil et al. 2026a). We find that domestic bank supply elasticity is particularly sensitive to bankers’ banks reserve holdings, underscoring the role of distributional frictions in affecting fed funds activity.

These insights from the fed funds market reveal that, even as the market has declined in size, it remains informative as it highlights distributional frictions that may challenge the Fed’s control of short-term interest rates and in times of heightened stress could impair monetary policy transmission. Our findings suggest that the apparent steepening of the aggregate demand curve in the existing literature most likely reflects FHLBs raising their lending rates in response to repo-market disruptions rather than evidence of genuine system-wide reserve scarcity which drive banks’ liquidity management. Crucially, we find that the rates offered by bank lenders in the fed funds market remained stable during the September 2019 repo market stress episode, showing that the turmoil likely arose from repo market

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<sup>2</sup>In our analysis we calculate a semi-elasticity which we will refer to as “supply elasticity”, for simplicity.

strains-driven by collateral shortages and settlement frictions-rather than from any shortage of bank reserves, consistent with recent findings by Anbil et al. (2024).

Taken together, these findings reframe “reserve scarcity” as a distributional, not aggregate, concept in the ample-reserves era. Our analysis demonstrates that despite the significant contraction of the fed funds market, it continues to serve as a valuable lens through which to examine distributional frictions within the financial system. By focusing on activity in the small interbank segment of the fed funds market, which is driven by banks’ trade-off between borrowing funds when their reserve balances are relatively low and their willingness to lend when their reserves are relatively high, our results underscore the importance of a well-functioning interbank market for assessing liquidity conditions among banks. These frictions, often obscured in aggregate analyses, have the potential to challenge the Fed’s ability to maintain precise control over short-term interest rates and may, at critical junctures, impede the efficient transmission of monetary policy.

Our findings offer a nuanced understanding of interbank market dynamics and challenge existing models of reserve demand. Our work has significant implications for monetary policy implementation and financial stability assessments, emphasizing the importance of accurately interpreting signals of reserve scarcity. Finally, our results speak to the scope of monetary policy implementation in an ample-reserves framework. While the framework succeeds in anchoring short-term rates with administered rates, distributional frictions can still challenge rate control and, at times, interfere with policy transmission. The small interbank fed funds market provides a lens on those frictions, making it possible to distinguish between broader stress in repo markets and genuine bank reserve tightness, and to tailor responses accordingly.

These insights are likely to become more important if there are less reserves in the banking system. In a potentially more dynamic fed funds market, the price discovery process provides valuable signals about the distribution of liquidity. As a result, interbank trading dynamics can provide early warnings of emerging liquidity pressures before aggregate measures indicate reserve tightness.

The rest of the paper is structured as follows. Section 2 provides a brief review of the existing literature and highlights the main differences with our bank-level approach. Section 3 reviews the mechanics of the fed funds market, describing the trading dynamics between borrowers and lenders, and the importance of this market relative to other short-term funding markets. Section 4 presents our empirical analysis, which unfolds in two key stages: first, we document the heterogeneity in banks’ reserve demand responses to demand deposit shocks, and then, we employ an innovative instrumental variable approach to estimate the supply elasticity of both bank and non-bank lenders. Finally, Section 5 summarizes our main findings and provides some concluding remarks.

## 2 Related Literature

Our paper contributes to several strands of research on monetary policy implementation, reserve-demand estimation, and interbank market microstructure. The earliest empirical investigations into the sensitivity of overnight rates to reserve fluctuations date back to Hamilton (1997), who identified a liquidity effect by exploiting unexpected changes in Treasury General Account balances as exogenous shocks to reserves, and Carpenter & Demiralp (2006), who documented a nonlinear liquidity effect at daily frequency using Federal Reserve forecast errors. These foundational studies identified the liquidity effect in a scarce-reserves regime, where changes in aggregate reserves directly influenced the fed funds rate.

Building on this work, a growing literature has sought to estimate the aggregate demand curve for reserves in an ample-reserves regime, typically assuming a representative bank. Lopez-Salido & Vissing-Jorgensen (2023) use changes in deposit aggregates to identify the point at which reserve demand begins to slope downward; Acharya et al. (2023) highlight asymmetries in deposit dynamics between periods of quantitative easing and tightening and their effects on the spread between EFFR and IORB; Anbil et al. (2024) structurally estimate reserve demand by incorporating repo-market capacity and emphasize the role of non-bank cash demand in determining the optimal size of the Fed’s balance sheet; and Afonso, La Spada, Mertens & Williams (2023) employ a time-varying econometric model to trace shifts in the aggregate demand slope over several decades. While these studies yield valuable benchmarks for “ample” versus “scarce” reserves, they collapse diverse institutions into a single curve and thus may conflate genuine reserve scarcity with changes in counterparty composition or trading frictions.

A parallel strand of the literature leverages payment-system data to detect the onset of reserve tightness. Afonso et al. (2024) document strategic complementarities in interbank payments—banks’ reliance on incoming flows to fund outgoing transactions—that intensify as reserves fall, and Lagos & Navarro (2023) develop a structural model of payments across bank types to infer aggregate reserve demand from payment flows. These approaches illuminate how payment patterns can reveal emerging pressures of reserves scarcity, but they do not directly address price formation in the fed funds market itself.

Theoretical models of bank liquidity management form a third nexus of related research. Poole (1968) laid the groundwork by showing how individual banks’ demand for reserves depends on the risk of intraday shortfalls, and subsequent work by Bech & Klee (2011), Afonso et al. (2019), Armenter & Lester (2017), and Kim et al. (2020) has examined how changes in the Fed’s implementation framework and balance-sheet size affect interbank trading and segmentation. More recent studies by d’Avernas et al. (2023) and d’Avernas et al.

(2024) emphasize how limits on central bank intraday credit and collateral constraints alter banks’ precautionary motives and willingness to participate in unsecured and secured funding markets.

Our approach diverges from aggregate-demand and payment-flow studies by harnessing high-frequency, bank-level data to highlight heterogeneity and microstructure in the fed funds market. We first show that only small domestic banks (assets under \$10 billion) meaningfully adjust reserves in response to deposit shocks, and we then demonstrate that changes in the volume-weighted rates offered by bank lenders on reserve fluctuations provide a coherent gauge of true reserve demand and supply, whereas regressions of the headline EFFR on aggregate reserves largely capture elastic non-bank supply. In doing so, we reveal that the familiar “kink” in the reserve-demand curve reflects shifts in counterparty composition and trading frictions—such as repo-market disruptions—rather than indicating genuine system-wide reserve scarcity.

### 3 Overview of the Fed Funds Market

In this section, we first describe the institutional structure and main incentives of the fed funds market before turning to summary statistics on borrowing and lending volumes, spreads, reserve balances, and deposit flows.

#### 3.1 Institutional Background

The fed funds market is the overnight unsecured funding venue for depository institutions, and the EFFR is calculated as a volume-weighted median of transactions reported in the FR 2420 Report of Selected Money Market Rates.<sup>3</sup> Prior to the Global Financial Crisis (GFC), aggregate reserve balances averaged around \$40 billion, and banks borrowed primarily to manage end-of-day reserve requirements, trading only to avoid excess balances. In response to the crisis, the Fed’s large-scale asset purchases expanded its balance sheet and increased reserves to nearly \$3 trillion, effectively ending daily reserve scarcity as a binding constraint on rate control (Ihrig et al. 2020).

To maintain interest-rate control under abundant reserves, the Fed now adjusts two administered rates—the IORB and the ON RRP rates—in lieu of fine-tuning reserve quantities. This framework has delivered remarkably stable control of the EFFR despite unprecedented reserve levels (Clouse et al. 2025). In January 2019, the FOMC formally adopted an “ample reserves” strategy, after which active borrowing by domestic banks in the fed funds market

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<sup>3</sup>More information about the FR 2420 Report of Selected Money Market Rates can be found here.

declined sharply, even as overall trading volumes stabilized and later rose, driven largely by non-bank arbitrage activity and foreign bank participation under the new rate-control framework (FOMC 2019).<sup>4</sup>

In the current environment, non-bank entities, chiefly Federal Home Loan Banks (FHLBs), provide over 90 percent of fed funds lending. Because FHLBs cannot earn IORB on funds parked at the Fed, they lend in the fed funds market at rates below IORB in order to earn a positive return on otherwise idle balances. Their capacity to supply large volumes at these rates hinges on the scale of their regulatory liquidity buffers and the relative appeal of alternative short-term investments such as lending in the repo market (Banegas & Tase 2020).<sup>5</sup>

Borrowers split into two main groups. U.S. branches of foreign banks, which face fewer regulatory constraints, routinely borrow at rates below IORB to earn the spread between fed funds and IORB, and account for roughly 90 percent of total borrowing volume (Anderson et al. 2021). Domestic banks, by contrast, borrow mainly to address liquidity needs and typically pay spreads around IORB. Among these domestic institutions, larger banks sometimes access fed funds to optimize their Liquidity Coverage Ratio (LCR), since borrowing from FHLBs carries lower assumed outflow rates and can improve the LCR; banks reporting their LCR daily are willing to pay higher rates for this reason (Anderson et al. 2024).

A broader set of smaller domestic banks—including those with assets under \$10 billion—engage intermittently in the fed funds market to manage transient liquidity shocks. As aggregate reserves decline under quantitative tightening (QT), competition among liquidity-sensitive banks intensifies, translating into higher borrowing rates and volumes in the interbank market (Kim et al. 2020). In the next subsection, we present summary statistics on these participant groups, their trading volumes and spreads, and their reserve-deposit dynamics.

### 3.2 Borrower-Lender Activity in the Fed Funds Market

We next exploit our micro-level dataset to illustrate how heterogeneous incentives among participants shape trading volumes and rates in the federal funds market. We distinguish four counterparty pairings: domestic banks borrowing from banks, domestic banks borrowing from non-banks, foreign banks borrowing from banks, and foreign banks borrowing from non-banks.

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<sup>4</sup>Afonso, Cisternas, Gowen, Miu & Younger (2023) estimate that daily trading volumes fell from over \$150 billion (about 2 percent of commercial bank assets) before 2008 to \$60–80 billion in the 2010s, then rose to around \$110 billion (0.5 percent of assets) per day in 2023.

<sup>5</sup>See Anderson et al. (2024), Gissler & Narajabad (2017a), and Gissler & Narajabad (2017b) for a detailed analysis of the effects of FHLBs overall liquidity management on the fed funds activity.

The top panel of Figure 1 plots weekly borrowing volumes and the bottom panel shows corresponding volume-weighted spreads to IORB for each pairing over 2016–2024. Consistent with the institutional background in Section 3.1, the dominant category is foreign banks borrowing from non-bank lenders—primarily Federal Home Loan Banks (FHLBs)—at low spreads. Foreign borrowing from other banks is nearly zero, indicating that FHLBs supply large volumes at rates below IORB, exploiting the “fed arb” opportunity of pocketing the spread between fed funds and IORB (Anderson et al. 2021).

By contrast, domestic banks borrow both from non-banks and from peer banks, but at materially higher spreads. Their willingness to pay these higher rates reflects genuine liquidity needs rather than arbitrage. Notably, as QT ran from 2018 into 2019, domestic bank borrowing volumes rose alongside their spreads, suggesting that declining aggregate reserves prompted greater reliance on the fed funds market for liquidity management (Anderson & Na 2024). The bottom panel also shows an increased share of domestic borrowing from non-banks during this period.

Figure 1 therefore highlights a clear dichotomy: foreign banks borrow large volumes cheaply from non-banks, while domestic banks borrow smaller volumes at higher rates from both lender types. These patterns persist outside the zero lower bound period (shaded), when money-market spreads generally widen, underscoring that domestic banks, more so than foreign institutions, tap the fed funds market to manage liquidity.

Focusing exclusively on domestic bank activity, Figure 2 plots cumulative volume against spread for each lender type, averaging across all trading days from October 2015 to January 2024 (with each point aggregating at least seven distinct domestic borrowers).<sup>6</sup> Borrowing from non-banks (red dots) features low, flat spreads even at high volumes, indicating highly elastic supply. In contrast, borrowing from banks (blue dots) carries higher spreads that rise markedly with volume, signifying inelastic supply.

Together, these figures demonstrate that supply elasticity in the fed funds market varies sharply by lender type: non-bank lenders behave as elastic arbitrageurs, while bank lenders price their funds according to marginal spreads and aggregate liquidity conditions. This divergence in supply behavior underlies our subsequent empirical strategy for measuring true reserve scarcity.

## 4 Empirical Analysis

The evidence in Section 3.2 indicates that domestic banks—rather than foreign banks—rely on the fed funds market chiefly for liquidity management, and that the elasticity of supply

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<sup>6</sup>A parallel chart for foreign banks appears as Figure A.1 in the Appendix.

varies sharply by lender type. We therefore focus our empirical analysis on domestic bank borrowing incentives and associated price dynamics.

Figure 3, which plots the EFFR minus IORB spread against the ratio of aggregate reserve balances to total banking-sector assets, highlights the oft-cited spike on September 17, 2019—an episode many studies interpret as evidence of reserve scarcity (e.g. Lopez-Salido & Vissing-Jorgensen (2023), Afonso, La Spada, Mertens & Williams (2023)). On September 17, the EFFR printed outside the target range prompting the Fed to intervene with temporary repo operations. EFFR also increased during the onset of COVID but barely moved when Silicon Valley Bank (SVB) failed. Changes in EFFR are associated with indicators of reserve scarcity, yet, the headline EFFR conflates the behavior of heterogeneous lenders and can obscure the true drivers of rate movements.

In Figure 4, we decompose EFFR into the volume-weighted average spreads to IORB offered by non-bank lenders (chiefly FHLBs) and by bank lenders, again plotted against aggregate reserves-to-assets. The non-bank spread (purple line) remains near zero when reserves are abundant and moves only modestly as reserves contract, reflecting highly elastic arbitrage supply. By contrast, the bank-lender spread (yellow line) is much more sensitive to reserve fluctuations—rising noticeably as reserves decline—and shows little reaction to the September 2019 episode, indicating that repo-market frictions, rather than true reserve scarcity, likely drove that spike (Anbil et al. 2024). Instead, bank-lender rates surge during episodes such as the onset of COVID-19 and the SVB failure, consistent with funding constraints and credit concerns in the banking sector.

Together, these figures underscore that aggregating all lenders into the EFFR masks the distributional frictions experienced by banks when reserves dwindle. It is the pricing behavior of bank lenders that furnishes a far more informative signal of genuine reserve tightness.

To quantify these effects, we exploit plausibly exogenous weekly shocks to domestic banks’ demand deposits as an instrument for their fed funds borrowing. First, Section 4.2 documents that changes in demand deposits at small domestic banks induce corresponding adjustments in their reserve holdings, validating the use of deposit shocks to isolate reserve demand. We then use these shocks to instrument for aggregate fed funds borrowing by lender type, estimating supply elasticities separately for non-bank and bank lenders. Consistent with the price patterns in Figure 4, we find that non-bank supply is highly elastic, whereas bank supply is markedly inelastic and grows more so as the aggregate reserves-to-assets ratio falls. This two-stage approach confirms that the conventional “kink” in the aggregate reserve-demand curve captures shifts in counterparty composition and repo-market frictions rather than a systemwide shortage of reserves.

## 4.1 Data

Our empirical analysis combines two main sources: the FR 2900 (“Report of Deposits and Vault Cash”) and the FR 2420 (“Report of Selected Money Market Rates”). The FR 2900 collects daily bank-level data on reserve balances, vault cash, and deposits (including demand deposits, other liquid deposits, and small-time deposits under \$100,000), with each institution submitting one weekly filing that records its daily values. The FR 2420 data set records every overnight fed funds transaction—including the borrowing bank’s identity, transaction volume, and rate—enabling construction of the EFFR. While FR 2420 identifies the borrowing institution, it does not report specific lender identities; instead, we observe only whether lending occurs between banks or between non-banks (most of which are FHLBs).

From the merged data, we construct for each week and for each lender type (bank vs. non-bank) the total federal funds borrowing volume and the volume-weighted average spread to IORB, separately for domestic and foreign borrowers. We also compute weekly averages of each bank’s reserve balances and deposit measures from the FR 2900.

We merge FR 2900 observations to the Federal Financial Institutions Examination Council (FFIEC) Call Reports via an internal FR 2900-RSSD roadmap maintained by the Board of Governors, yielding a panel of 1,983 institutions from October 27, 2015 (the date of the first consistently clean FR 2420 data) through January 16, 2024.<sup>7</sup> Of these, 1,822 are classified as domestic banks in the Call Reports. We further categorize domestic banks into three tiers based on quarterly total assets: “small” banks with under \$10 billion (1,294 banks), “medium” banks with \$10–100 billion (156 banks), and “large” banks with over \$100 billion (31 banks).<sup>8</sup>

Table 1 summarizes these key variables. Across all 1,983 institutions, the average weekly reserve balance is \$1.3 billion, demand deposits average \$1.6 billion, and total deposits average \$2.1 billion. Restricting to the 1,822 domestic banks, average reserves fall to \$0.7 billion. Among the 78 domestic banks that borrowed in the federal funds market during our sample, the mean weekly borrowing volume is \$8.7 billion and the average spread to IORB is  $-3.4$  basis points; when borrowing specifically from peer banks, the mean weekly volume is \$2.6 billion at a spread of  $+2.3$  basis points.

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<sup>7</sup>Though the FR 2420 form began in April 2014, we restrict our sample start to October 2015 for data quality and consistency.

<sup>8</sup>Because institutions can migrate between size categories over time, the sum of banks across categories (1,481) exceeds the number of unique domestic banks in the sample (1,379).

## 4.2 Bank-level Sensitivity of Reserves to Deposits

To isolate genuine changes in reserve demand—rather than mechanical payment flows or aggregate balance-sheet effects—we exploit plausibly exogenous weekly shocks to individual banks’ demand deposits and trace their impact on each bank’s reserve holdings. This strategy follows the spirit of the representative-bank approach (e.g. Lopez-Salido & Vissing-Jorgensen (2023)), but critically relaxes its core assumption by recognizing that banks differ in their balance-sheet structure and liquidity incentives. In particular, a given deposit shock need not translate into higher reserve demand for all banks: institutions with ample excess reserves or more diversified funding sources may not adjust reserves at all, whereas smaller, deposit-dependent banks may respond aggressively.

Figure 5 illustrates this heterogeneity. The distribution of reserve-to-deposit ratios for medium and large banks is relatively flat and centered at higher values, suggesting abundant buffers, whereas small banks exhibit a tightly skewed distribution toward lower ratios, indicating greater sensitivity to deposit outflows. In light of this heterogeneity, we estimate the following panel specification for bank  $i$  in week  $t$ :

$$\begin{aligned} \Delta Reserves_{i,t} = & \alpha + \beta_1 \Delta DemandDeposits_{i,t} + \beta_2 \Delta Reserves_{i,t-1} \\ & + \theta_i + \phi_{month} + \epsilon_{i,t}. \end{aligned} \tag{1}$$

where  $\Delta DemandDeposits_{i,t}$  captures week-over-week deposit shocks, and we include lagged reserves, bank fixed effects, and month fixed effects to control for persistence and seasonality. Standard errors are clustered by bank.

Table 2 reports the results. For the full domestic-bank sample, deposit shocks and reserve holdings are positively correlated, but the effect is driven entirely by small banks: a \$100 increase in weekly deposits at small institutions is associated with a \$16 increase in reserves. Medium and large banks show a much smaller response, consistent with their higher reserve buffers. Moreover, the estimated coefficients for small banks are far below unity, ruling out a simple “payment pass-through” interpretation—if deposit changes merely reflected interbank payments, we would expect a one-for-one offset.

These findings validate our use of small-bank deposit shocks as an instrument for changes in reserve demand: only those banks whose liquidity incentives are deposit-driven adjust reserves, and thus their fed funds activity, in response to deposit fluctuations. By contrast, aggregating across all banks—many of which do not react—would dilute the true variation needed to identify supply elasticities in the fed funds market.

### 4.2.1 Alternative Interpretations

An alternative view, advanced by Acharya et al. (2023), attributes the positive deposit–reserve relationship to mechanical effects of the Fed’s balance-sheet expansions: as the Fed injects reserves via LSAPs, aggregate deposits rise and banks simply hold more cash. While this channel operates in the aggregate, Figure 6 shows that during periods of rapid reserve growth only large—and to a lesser extent medium—banks expand their deposits, whereas small banks’ deposit levels remain unchanged. This non-uniform deposit response underscores that deposit shocks at small banks are not driven by Fed asset purchases, but rather by idiosyncratic funding needs, making them a valid instrument for reserve demand shocks.

Finally, one might worry that deposit changes mechanically induce reserve changes via interbank payments. Two facts mitigate this concern. First, our weekly frequency attenuates high-frequency payments noise; second, Table 1 shows that small banks participate only sparsely in fed funds. Consistent with this, Afonso et al. (2022) document that large banks account for over 75% of Fedwire Funds Service (Fedwire), implying that small-bank reserve adjustments are unlikely to be driven primarily by payment-system churn.

We nevertheless test for a payments channel. Appendix Table A.3 augments Equation 1 with an additional controls, namely  $Payments_{i,t}$  and  $Payments_{i,t-1}$ , the net Fedwire inflows (inflows minus outflows) to bank  $i$  on day  $t$  and  $t-1$ . If reserves moved mechanically one-for-one with payments, we would expect sensitivity of  $\Delta Reserves_{i,t}$  to  $Payments_{i,t}$  to be close to 1, and the coefficient on  $\Delta DemandDeposits_{i,t}$  to collapse toward zero. Instead, Appendix Table A.3 shows that while reserves respond to net payments—a 1-percentage-point increase in  $Payments_{i,t}$  is associated with a 30% increase in reserves (and decrease somewhat with an increase in  $Payments_{i,t-1}$ )—the coefficient on  $\Delta DemandDeposits_{i,t}$  remains economically large and statistically significant, across all bank cohorts. Thus, banks meaningfully adjust reserves in response to deposit changes, over and above any mechanical response to interbank payments.<sup>9</sup>

## 4.3 Supply Elasticity in the Fed Funds Market

Having documented that deposit shocks drive reserve demand chiefly among small domestic banks, we now assess how these shocks transmit into fed funds borrowing volumes and spreads, and identify which lenders facilitate price formation. Because domestic bank borrowing is motivated by liquidity management rather than arbitrage, we use weekly shocks

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<sup>9</sup>We identify each bank’s federal funds transactions in Fedwire using the algorithm of Anbil et al. (2026b) and exclude these when constructing  $Payments_{i,t}$  so that the control variable is not conflated with fed funds activity. The number of observations declines relative to the results in Table 2 because the matching algorithm only provides data between January 2018 and December 2023.

to individual banks' demand deposits as plausibly exogenous instruments for aggregate borrowing demand and then recover supply elasticities by lender type.

Figure 7 provides a stylized depiction of our empirical approach. The horizontal axis measures fed funds quantity and the vertical axis measures the spread to IORB. Non-bank lenders supply funds elastically at low spreads (red), whereas bank lenders supply more inelastically at higher spreads (blue). A deposit shock shifts the bank-reserve demand curve (black) outward, leading to changes in borrowed quantity  $\Delta Q$  and in the market spread  $\Delta(F\!F\!-\!I\!O\!R\!B)$ .

In practice, individual bank trading is too sporadic to estimate directly. Instead, for each week  $t$  and lender type  $L \in \{\text{banks}, \text{non-banks}\}$ , we regress:

$$\begin{aligned} \Delta \ln(\text{Volume}_{L,t}) &= \alpha + \gamma_1 \Delta \text{DemandDeposits}_{i,t} + \gamma_2 \Delta \ln(\text{Volume}_{L,t-1}) \\ &\quad + \gamma_3 \Delta(\text{FF}_{L,t-1} - \text{IORB}_{t-1}) + \theta_i + \phi_{\text{month}} + \epsilon_{i,t} \end{aligned} \quad (2)$$

$$\begin{aligned} \Delta(\text{FF}_{L,t} - \text{IORB}_t) &= \alpha + \gamma'_1 \Delta \text{DemandDeposits}_{i,t} + \gamma'_2 \Delta(\text{FF}_{L,t-1} - \text{IORB}_{t-1}) \\ &\quad + \gamma'_3 \Delta \ln(\text{Volume}_{L,t-1}) + \theta'_i + \phi'_{\text{month}} + \epsilon_{i,t} \end{aligned} \quad (3)$$

where  $\Delta \text{DemandDeposits}_{i,t}$  (in trillions) is the weekly change in bank  $i$ 's demand deposits, and we include bank fixed effects  $\theta_i$ , monthly fixed effects  $\phi_{\text{month}}$ , and lagged dependent variables to capture seasonality and autocorrelation. Table 3 presents two sets of OLS regressions: the top panel pools all 1,822 domestic banks, while the bottom panel restricts the sample to the 1,294 smaller banks (assets  $\leq$  \$10 billion). In the top panel, a \$10 billion increase in weekly demand deposits raises non-bank borrowing volumes (Column 5) by about 2% (significant at the 1 percent level), indicating that FHLBs absorb additional liquidity without adjusting their rates—that is, they supply elastically. In contrast, the same deposit shock widens bank-lender spreads (Column 4) by roughly 11 basis points (highly significant), despite little change in their volumes.

These effects intensify in the bottom panel, which focuses on small banks. A \$10 billion shock among small institutions boosts non-bank borrowing volumes by 141 percent (significant at the 1 percent level), while bank-lender spreads jump by approximately 16 basis points. The stark divergence—non-banks adjusting quantities and banks reacting through price increases—confirms that banks, particularly smaller ones, exhibit inelastic supply in response to reserve-demand shocks.

### 4.3.1 Instrumental Variable Approach

We now implement a two-stage instrumental-variable approach to recover the true price elasticity of fed funds supply. OLS estimates of Equations 2 and 3 separately capture how deposit shocks affect borrowing volumes and spreads, our IV strategy instead isolates how changes in borrowing volumes drive price changes. We rely on the identifying assumption that weekly shocks to small banks' demand deposits shift only reserve demand—and not supply—which, as discussed in Section 4.2.1, is most plausible for small banks.

Concretely, for each lender type  $L \in \{banks, non-banks\}$  and week  $t$ , we first instrument the change in log borrowing volume,

$$\begin{aligned} \Delta \ln(\widehat{Volume}_{L,t}) &= \alpha + \gamma_1 \Delta DemandDeposits_{i,t} \\ &\quad + \gamma_2 \Delta \ln(Volume_{L,t-1}) + \theta_i + \phi_{month} + \epsilon_{i,t} \end{aligned} \tag{4}$$

using the weekly change in bank  $i$ 's demand deposits  $\Delta DemandDeposits_{i,t}$  (in trillions). We include a lagged dependent variable, bank fixed effects  $\theta_i$ , and monthly fixed effects  $\phi_{month}$  to absorb persistence and seasonality.

In the second stage, we estimate how these instrumented volumes affect the fed funds spread:

$$\begin{aligned} \Delta(FF_{L,t} - IORB_t) &= \alpha + \gamma'_1 \Delta \ln(\widehat{Volume}_{L,t}) + \gamma'_2 \Delta(FF_{L,t-1} - IORB_{t-1}) \\ &\quad + \gamma'_3 \Delta \ln(Volume_{L,t-1}) + \theta'_i + \phi'_{month} + \epsilon_{i,t} \end{aligned} \tag{5}$$

Again, we include a lagged dependent variable, bank fixed effects  $\theta_i$ , and monthly fixed effects  $\phi_{month}$  to absorb persistence and seasonality.

Table 4 presents our two-stage IV estimates of bank and non-bank supply elasticities in the federal funds market, first for the entire sample of 1,822 domestic banks (top panel) and then restricting the instrument to deposit shocks at the 1,294 small banks (bottom panel).

In the top-panel specification, the first-stage regression instrumenting weekly fed-funds borrowing volumes with aggregate demand-deposit shocks yields an F-statistic of about 14, indicating a strong instrument. In the second stage, a one-unit increase in instrumented bank borrowing—equivalent to roughly \$10 billion—raises the volume-weighted bank-lender spread by 18 basis points, a result that is both highly statistically and economically meaningful given typical daily spread movements of just a few basis points. By contrast, the non-bank coefficient on instrumented volume is slightly negative and statistically indistin-

guishable from zero, confirming that FHLBs absorb increases in liquidity demand elastically without a significant increase in their lending rates.

When we narrow the instrument to shocks in small banks’ deposits (bottom panel), the first-stage F-statistic jumps to nearly 50, reflecting that these shocks more cleanly capture unexpected shifts in reserve demand. In this specification, the bank-lender spread response to a \$10 billion increase in borrowing rose by 20 basis points, demonstrating even stronger price sensitivity when focusing on the smallest, most liquidity-constrained institutions. The non-bank coefficient remains economically small; indeed, a \$10 billion increase in borrowing from non-banks lowered the spread by 3.5 basis points. Taken together, these results underscore that bank lenders—particularly smaller banks—adjust their pricing in response to demand shocks, whereas non-bank lenders continue to supply at essentially constant spreads.

### 4.3.2 Supply Elasticity as a Function of Reserves

To assess how fed funds supply responds to changing reserve abundance, we augment our two-stage IV specification (equation 5) by interacting the instrumented change in borrowing,  $\Delta \ln(\hat{Volume}_{L,t})$  with the system-wide reserves-to-assets ratio,  $\frac{Reserves}{BankAssets}$ .

Table 5 reports these estimates. When reserves are plentiful, bank lenders exhibit modest price sensitivity; as reserves shrink, their supply elasticity rises to about 0.37 (highly statistically significant), while non-bank lenders remain effectively price-insensitive. The negative interaction coefficient (−1.25) confirms that bank-lender spreads become markedly more responsive to volume as aggregate reserves fall, consistent with inelastic supply under tightening conditions. Assuming an average  $\frac{Reserves}{BankAssets}$  of 0.14, a \$10 billion increase in borrowing volume from banks increased spreads by 20 basis points (0.37 minus  $-1.25 \times 0.14$ ). In contrast, the supply elasticity for non-banks does not change with the reserves-to-assets ratio.

In the top panel of Figure 9, we plot the estimated supply elasticities for bank lenders (solid blue line) and non-bank lenders (solid red line) against the system-wide reserves-to-assets ratio, which ranges from roughly 8 percent to 19 percent over our sample period. The shaded areas around each line show the 95 percent confidence bands. As aggregate reserves decline with respect to bank assets, bank-lender elasticity increases. In our sample, we observe that bank lender elasticity almost doubles from 0.15 at high reserve levels to about 0.30 at the lowest observed reserve ratio, reflecting that banks become increasingly price-sensitive when liquidity is tight. By contrast, the non-bank elasticity curve remains essentially flat and statistically indistinguishable from zero across the entire range, confirming that FHLBs and other non-bank suppliers continue to supply reserves at near-constant spreads regardless

of aggregate reserve conditions. This stark divergence underscores that bank lenders drive the inelastic price response in the fed funds market as reserve levels come down.

However, treating all bank lenders as a single group masks the true source of these price pressures. In practice, a small network of bankers’ banks—about a dozen U.S. cooperatives owned by community banks—serves as the principal channel through which hundreds of smaller institutions access wholesale liquidity. By law, bankers’ banks do not take retail deposits; instead, they pool their members’ balances to achieve sufficient scale and credit standing to transact directly in overnight and term money markets, including federal funds and repurchase agreements, thereby supplying reserves to community banks that lack direct market access.<sup>10,11</sup> Because the 12 bankers’ banks are the marginal lenders to banks without repo-market access, bankers’ banks hold substantially larger reserve buffers than the typical commercial bank—often two to three times higher as a share of assets—to ensure they can meet fluctuating liquidity demands.

Figure 8 plots the volume-weighted bank-lender spread against the reserve ratio of bankers’ banks,  $\frac{\text{Bankers' Banks Reserves}}{\text{Bankers Bank Assets}}$ . The correlation with bankers’-bank reserves is strikingly stronger than with the system-wide reserves ratio shown in Figure 4: as these intermediaries’ reserves fell—especially following the start of QT in mid-2022—the bank-lender spread climbed sharply, while non-bank spreads remained essentially flat.

In light of this observation, we re-estimate our IV specification with the interaction term, replacing the aggregate ratio with the bankers’ banks’ reserve ratio. In column 3, an instrumented change in borrowing volume of 1% increases the spread that bank lenders charge by 46 basis points when bankers’-bank reserves are at their mean. Crucially, the interaction between instrumented volume and the bankers’-bank reserve ratio enters at  $-0.054$ , so that as these reserves fall, each additional 1 percent increase in borrowing raises the spread by an extra 5.4 basis points. Finally, the direct effect of the bankers’-bank reserve ratio on the spread is  $-0.025$ , meaning that, holding volume constant, a lower reserve buffer at bankers’ banks increases the baseline spread by 2.5 basis points.

Taken together, these coefficients imply a total bank supply elasticity of  $\hat{\gamma}_1 + \hat{\gamma}_3 \times \frac{\text{Bankers' Bank Reserves}}{\text{Bankers' Bank Assets}} = 0.46 - .054 \times \frac{\text{Bankers' Bank Reserves}}{\text{Bankers' Bank Assets}}$ . The bottom panel of Figure 9 plots this bankers’-bank-based elasticity (solid blue curve) over the 15 percent to 60 percent range of  $\frac{\text{Bankers' Bank Reserves}}{\text{Bankers' Bank Assets}}$ , clearly illustrating its steeper decline compared to the much flatter curve based on system-wide reserves shown in the top panel.

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<sup>10</sup>12 C.F.R. § 204.121 (2025)

<sup>11</sup>Examples of current bankers’ banks are The Independent Bankers Bank or TIB and First National Bankers Bank.

Together, these findings demonstrate that true “reserve tightness” in the federal funds market does not stem from the aggregate reserve pool but from distributional frictions at bankers’ banks, the marginal suppliers whose own liquidity constraints dictate the rates paid by community and smaller banks.

## 5 Concluding Remarks

Our paper provides a novel microstructure-based framework for understanding demand and supply dynamics in the U.S. fed funds market, challenging the conventional aggregate reserve demand approach and offering crucial insights for monetary policy implementation. We show that the thin interbank segment of the fed funds market provides a window into distributional frictions in the fed funds market, and offer signals of reserve scarcity well before it manifests itself in aggregate reserve conditions. This discovery reframes the concept of “reserve scarcity” as a distributional rather than an aggregate phenomenon in the ample-reserves era.

By distinguishing between bank and non-bank lenders, we show that standard approaches to measuring reserve demand often capture non-bank supply elasticity rather than true bank demand for reserves. This finding underscores the importance of accounting for lender heterogeneity when assessing liquidity conditions in the banking system. Our innovative approach, leveraging an instrumental variable strategy based on deposit shocks, allows for the estimation of supply elasticities by lender type. These estimates reveal stark differences between the highly elastic lending behavior of non-banks and the increasingly inelastic lending by banks as aggregate reserves decline. This heterogeneity in supply elasticity has significant implications for interpreting market signals and designing effective monetary policy interventions. Crucially, our analysis distinguishes between genuine reserve scarcity and other sources of market stress. By showing that bank lenders’ rates remained stable during the September 2019 stress episode, we provide evidence that the turmoil was likely driven by repo market strains rather than a shortage of bank reserves.

Our findings emphasize the continued informational value of the fed funds market, despite its diminished size. Our work not only challenges the existing models of reserve demand but also offer a more nuanced understanding of interbank market dynamics. As the Fed continues to navigate the complexities of monetary policy implementation in an ample-reserves framework, the insights provided by our research will be instrumental in identifying and addressing distributional frictions that could impede policy transmission. These insights are likely to become more important if there are less reserves in the banking system. In a lower reserves environment interbank activity should increase, strengthening the role of

the fed funds market as a barometer for liquidity conditions and frictions related to the distribution of liquidity across the banking system.

Looking ahead, our work opens up new avenues for research into the microstructure of money markets and the role of heterogeneity in shaping market outcomes. Refining our understanding of these dynamics can enhance the effectiveness of monetary policy and contribute to greater financial stability in an ever-evolving economic landscape.

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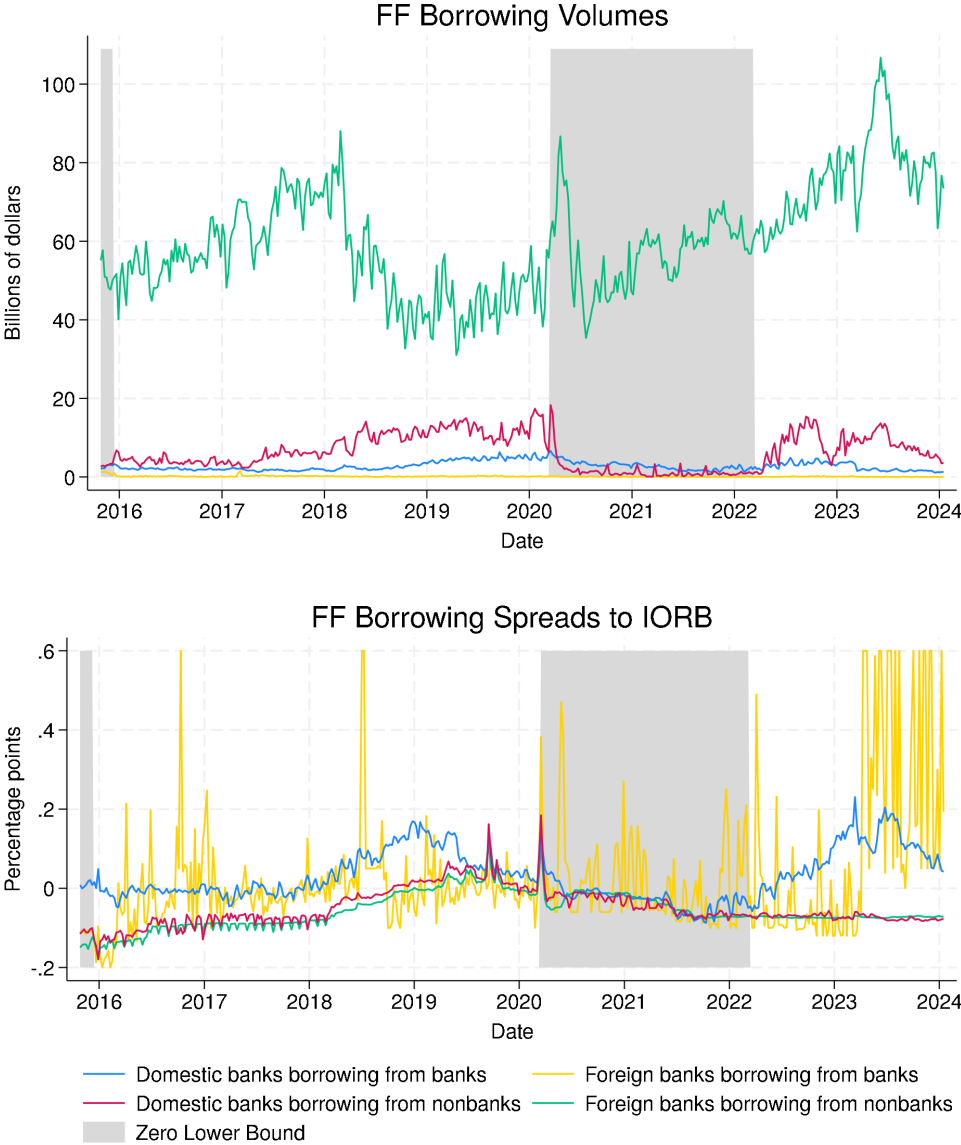
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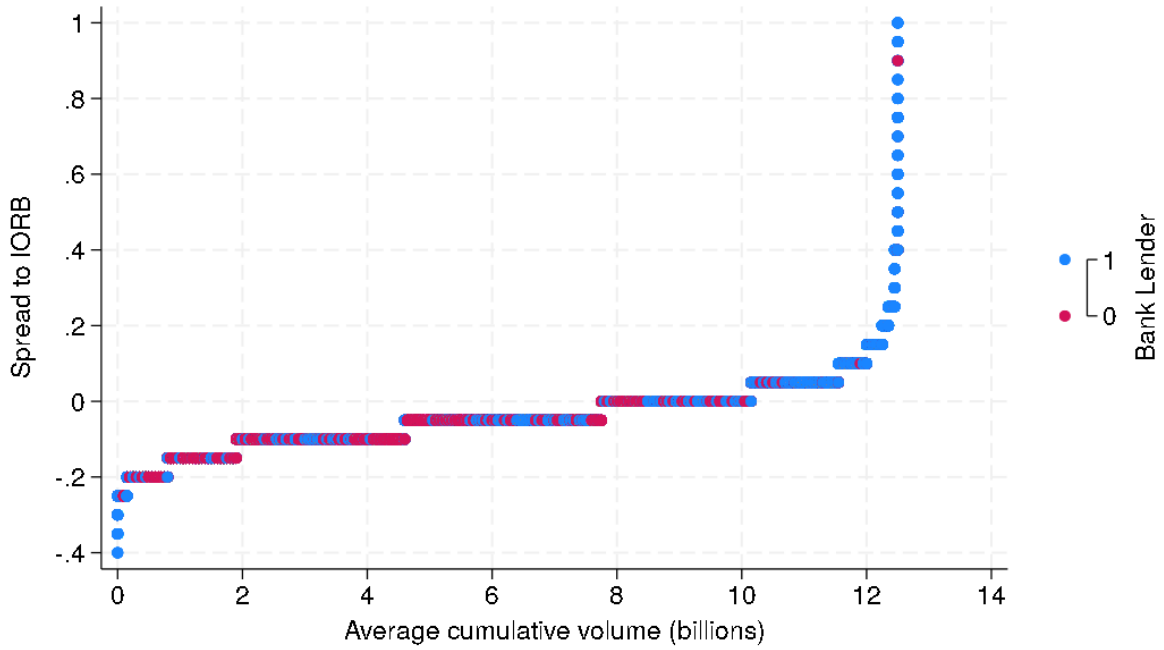
# Figures and Tables

Figure 1: Time Series of Aggregate Trading Volumes in Fed Funds Market



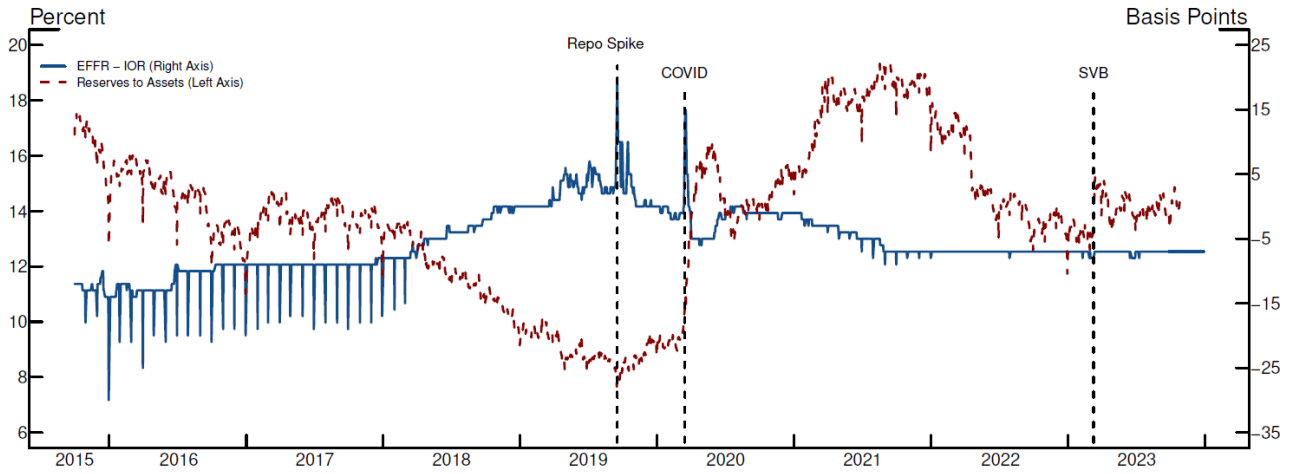
This figure displays borrowing dynamics in the fed funds market for domestic and foreign banks. Source: FR 2420 Report on Selected Money Market Rates

Figure 2: Rates and Volumes Borrowed by Domestic Bank in the Fed Funds Market



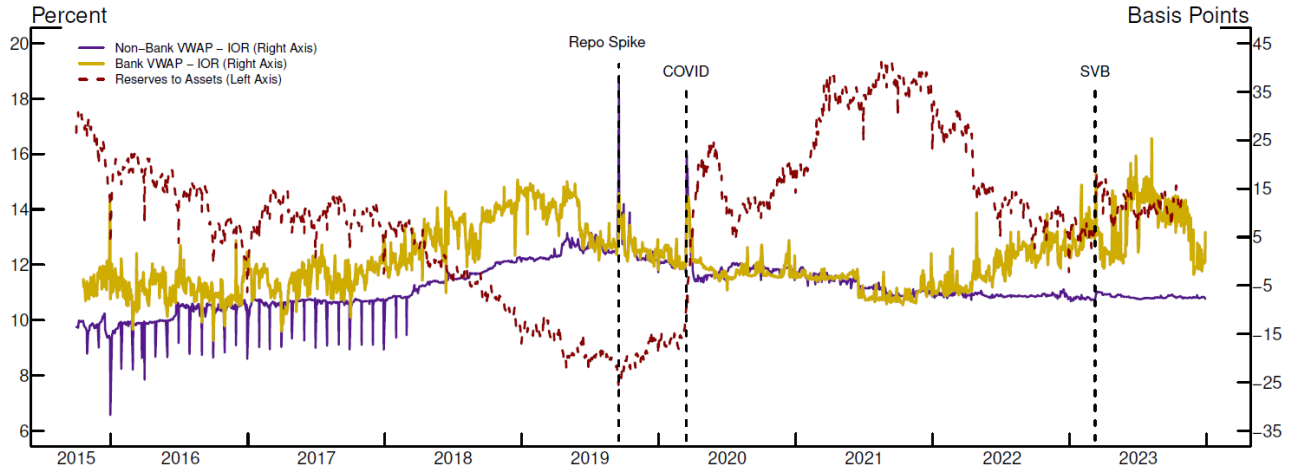
This figure displays cumulative average trading volumes and spreads in the fed funds market for domestic banks. Each volume/spread dot reflects at least 7 domestic banks' trading behavior averaged across our sample between October 2015 and January 2024. This figure does not single out trading behavior on a particular day, but represents average trading behavior between October 2015 and January 2024. Blue dots represent the cumulative trading volume lent by bank lenders. Red dots represent the cumulative trading volume lent by non-bank lenders. Source: FR 2420 Report on Selected Money Market Rates

Figure 3: EFFR and Aggregate Reserves



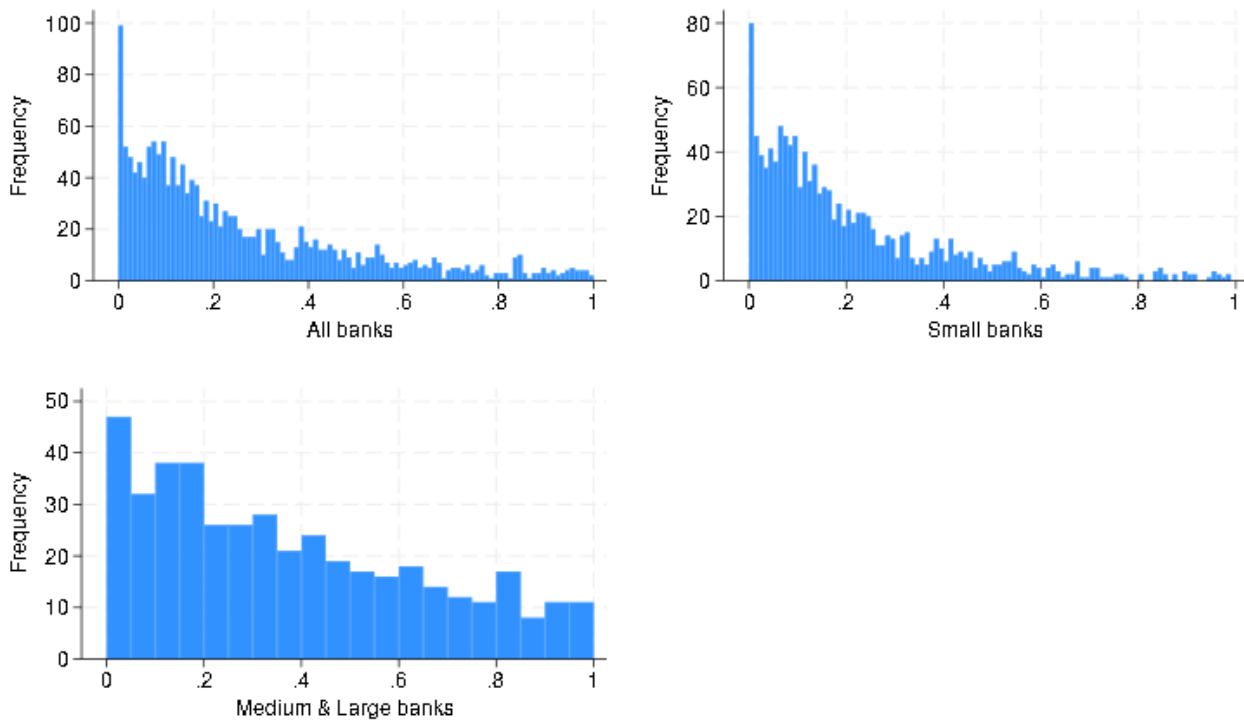
This figure displays the Effective Federal Funds Rate minus IORB and system-wide reserves divided by total banking assets in the financial system between October 2015 and January 2024. Source: Federal Reserve Bank of New York, FR H.4.1 Factors Affecting Reserve Balances, FR H.8 Assets & Liabilities of Commercial Banks in the US

Figure 4: Rates Offered by Lender Type and Aggregate Reserves



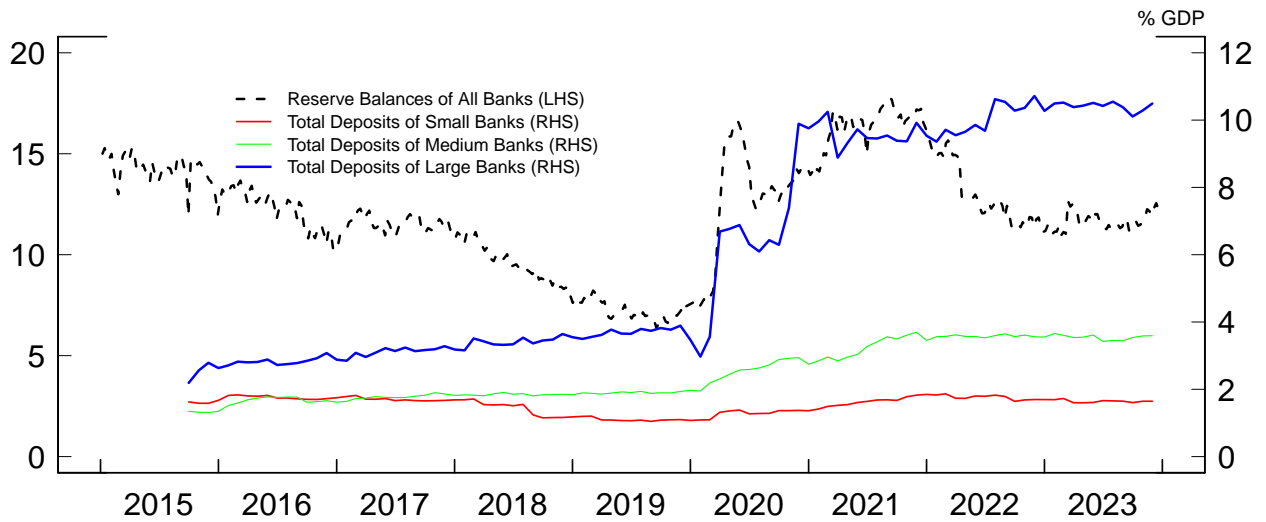
This figure displays the volume-weighted average lending rate offered by non-banks (purple line) and banks (yellow line) minus IORB, respectively, and system-wide reserves divided by total banking assets in the financial system between October 2015 and January 2024. Source: FR 2420 Selected Money Market Rates, FR H.4.1 Factors Affecting Reserve Balances, FR H.8 Assets & Liabilities of Commercial Banks in the US

Figure 5: Reserves to Deposits across Domestic Banks



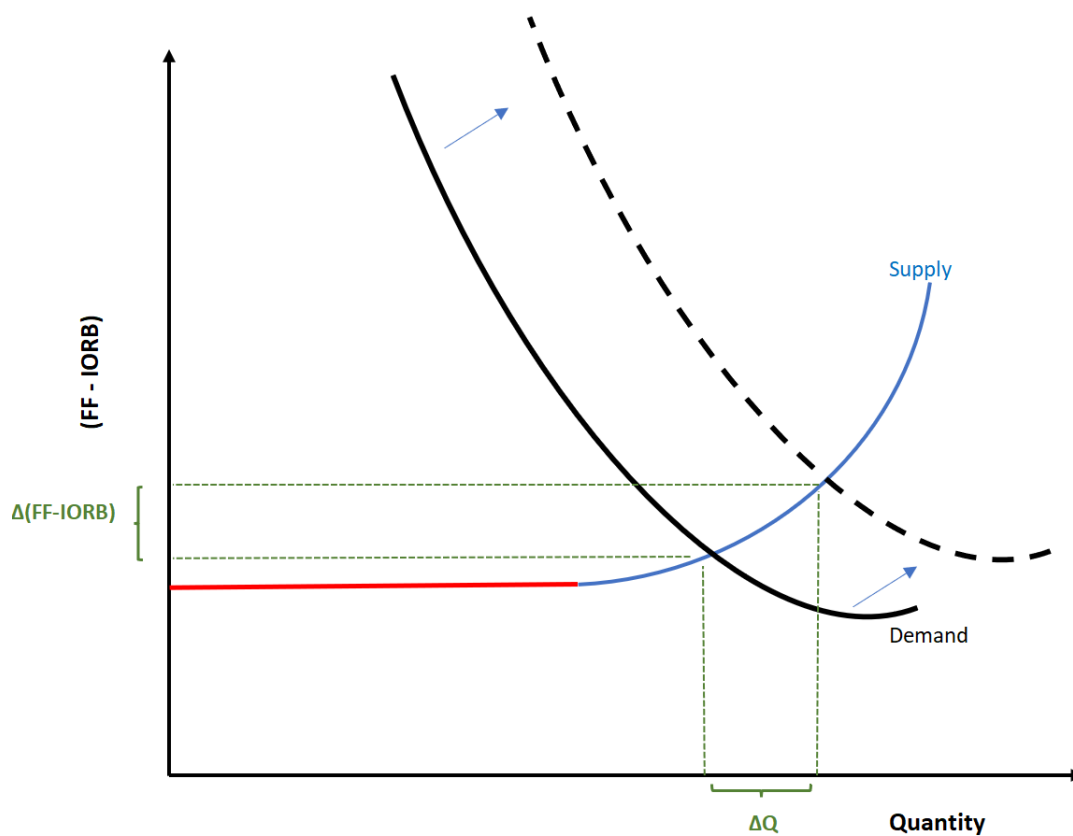
Histograms of domestic banks' reserves to deposit ratios, separated by small sized banks (less than \$10 billion in assets), and medium and large sized banks (greater than \$10 billion). Source: FR 2900 Report of Deposits and Vault Cash, internal Federal Reserve accounting records

Figure 6: Aggregate Reserves and Deposits per Bank Size to GDP



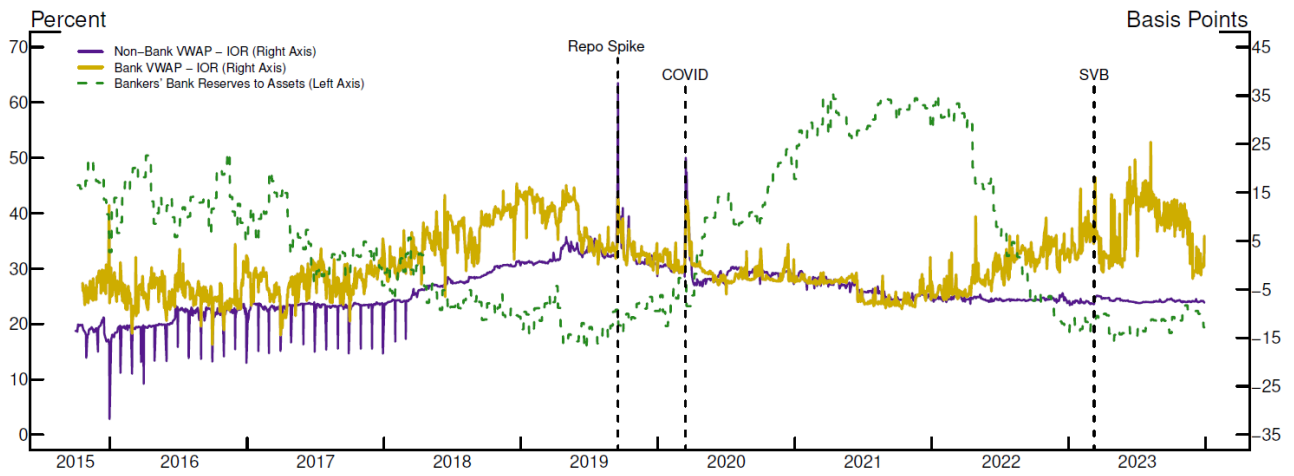
This figure displays aggregate reserves balances as a fraction of GDP and aggregate deposits of banks by bank size to GDP. Small banks are banks with less than \$10 billion in assets. Large banks have assets greater than \$100 billion in assets. Source: FR 2900 Report of Deposits and Vault Cash, FFIEC Call Reports, FR H.4.1 Factors Affecting Reserve Balances, internal Federal Reserve accounting records

Figure 7: Theoretical Demand and Supply Curves in the Fed Funds Market



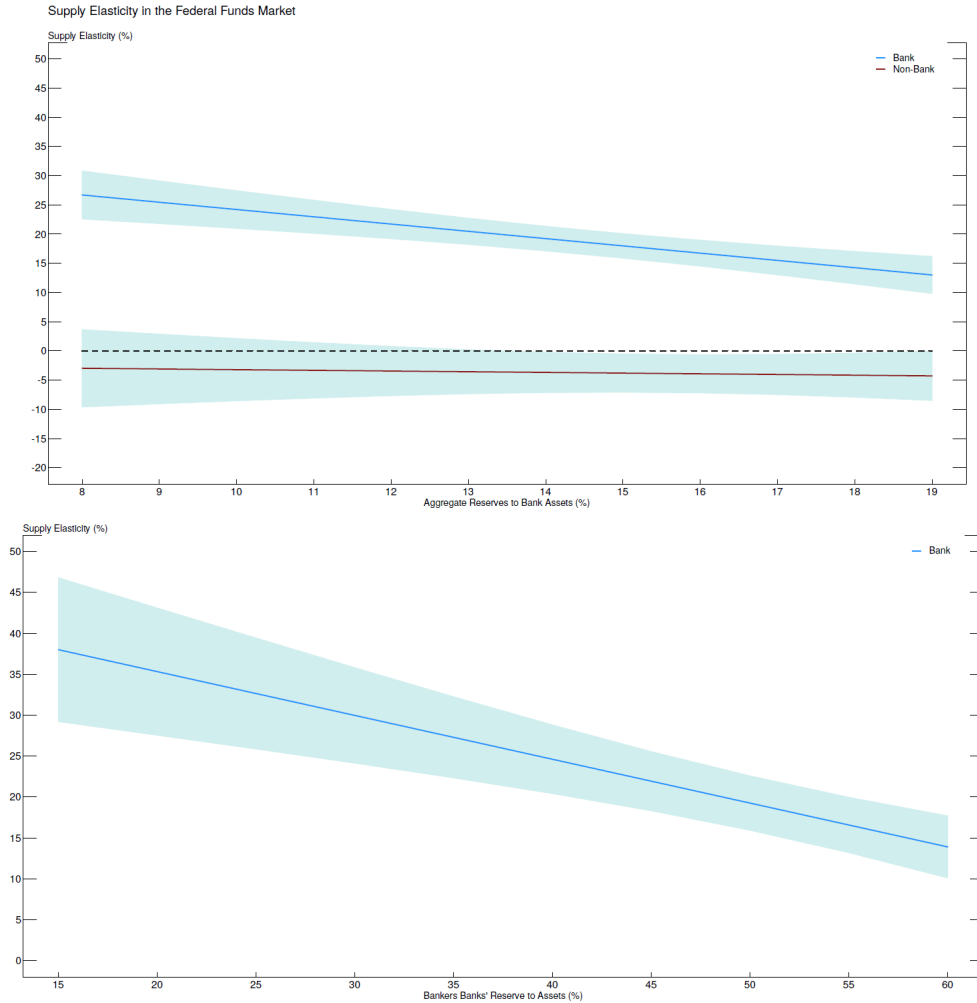
Vertical axis is spread of fed funds rate to IORB, horizontal line is trading volumes in the fed funds market. Red and blue lines depict supply in the fed funds market by non-bank and banks, respectively. Black solid line depicts demand in the fed funds market, dashed black lines depicts demand after a deposit shock.

Figure 8: Rates Offered by Lender Type and Bankers' Bank Reserves



This figure displays the volume-weighted average lending rate offered by non-banks (purple line) and banks (yellow line) minus IORB, respectively, and system-wide reserves divided by total banking assets in the financial system between October 2015 and January 2024. Source: FR 2420 Selected Money Market Rates, FFIEC Call Reports.

Figure 9: Estimate of Supply Elasticity for Small Domestic Banks as a Function of Reserves to Bank Assets



This figure illustrates how reserve ratios influence our estimated supply elasticity from the two-stage IV regression of equation 5. In the top panel, the blue line shows the total bank-lender elasticity  $\gamma'_1 + \gamma'_3 \frac{Reserves}{BanksAssets_t}$  plotted over the range of the aggregate reserve-to-assets ratio  $\frac{Reserves}{BanksAssets_t}$ . These curves use the coefficients from Table 5 for both banks and non-bank lenders. In the bottom panel, we replace the aggregate ratio with the bankers' banks reserve ratio  $\frac{Bankers' Banks Reserves}{Bankers' Banks Assets_t}$ , again plotting the sum of the baseline elasticity and its interaction term using the point estimates from Table 6. This panel highlights that bank supply elasticity is far more sensitive to bankers' banks' reserves than to system-wide reserves, while non-bank elasticity remains essentially flat. The shaded area illustrates the confidence intervals of our elasticity measure at the 95th percentile. Source: FR 2420 Report of Selected Money Market Rates, FR 2900 Report of Deposits and Vault Cash, FR H.4.1 Factors Affecting Reserve Balances, FR H.8 Assets & Liabilities of Commercial Banks in the US, FFIEC Call Reports, internal Federal Reserve accounting records.

<b>Variable</b>	<b>No. of Banks</b>	<b>Mean</b>	<b>Median</b>	<b>Std. Dev.</b>
<i>All Banks</i>				
<i>Reserves</i> (in billions)	1,983	1.3	0.06	8.4
<i>DemandDeposits</i> (in billions)	1,983	1.6	0.07	19.0
<i>TotalDeposits</i> (in billions)	1,983	2.1	0.26	20.4
<i>Assets</i> (in billions)	1,543	14.4	2.0	90.6
<i>Domestic Banks</i>				
<i>Reserves</i> (in billions)	1,822	0.7	0.04	7.1
<i>DemandDeposits</i> (in billions)	1,822	1.9	0.25	18.6
<i>Assets</i> (in billions)	1,379	13.0	1.8	91.4
$FF_{all} - IORB$ (in bps)	78	-3.4	-4.6	4.0
$FF_{bank} - IORB$ (in bps)	78	2.3	0.4	5.7
$FF_{non-bank} - IORB$ (in bps)	78	-5.7	-6.9	4.6
<i>Volume<sub>all</sub></i> (in billions)	78	8.7	7.3	4.7
<i>Volume<sub>bank</sub></i> (in billions)	78	2.6	2.2	1.1
<i>Volume<sub>non-bank</sub></i> (in billions)	78	6.1	5.2	4.1
<i>Small Banks</i>				
<i>Reserves</i> (in millions)	1,294	105.2	32.7	212.4
<i>DemandDeposits</i> (in millions)	1,294	288.1	110.4	523.5
<i>Assets</i> (in billions)	1,294	2.4	1.7	2.2
$FF_{all} - IORB$ (in bps)	21	-3.5	-4.7	4.1
$FF_{bank} - IORB$ (in bps)	21	2.1	0.2	5.5
$FF_{non-bank} - IORB$ (in bps)	21	-5.8	-6.9	4.7
<i>Volume<sub>all</sub></i> (in billions)	21	8.7	7.3	4.6
<i>Volume<sub>bank</sub></i> (in billions)	21	2.6	2.2	1.1
<i>Volume<sub>non-bank</sub></i> (in billions)	21	6.1	5.1	4.1

Table 1: Summary Statistics.

This table presents summary statistics about the independent and dependent variables in our analysis between October 27, 2015 and January 26, 2024.  $FF_L - IORB$  where  $L$  refers to the type of lender and  $FF_L$  with  $L \in \{all, banks, non-banks\}$  is the volume-weighted average rate in the fed funds market across for lender type  $L$ .  $Volume_L$  is the summed borrowed volume in the fed funds market from lender type  $L$ . Total deposits are equal to the sum of demand deposits, other liquid deposits, and small-time deposits. Small banks are banks with assets less than \$10 billion during their last Call Report quarter. Source: FR 2900 Report of Deposits and Vault Cash, FFIEC Call Reports, FR 2420 Report on Selected Money Market Rates, internal Federal Reserve accounting records

	(1)	(2)	(3)	(4)
	All Domestic	Large	Medium	Small
$\Delta DemandDeposits_{i,t}$	0.031*** (3.00)	0.029*** (2.80)	0.072*** (2.63)	0.16*** (4.95)
$\Delta Reserves_{i,t-1}$	0.15 (1.31)	0.14 (1.21)	0.017 (0.46)	-0.024 (-0.37)
Observations	455287	8496	38356	291010
Adjusted $R^2$	0.0270	0.0386	0.0143	0.0347
Month FE?	Yes	Yes	Yes	Yes

Table 2: The Effect of Deposits on Reserves for Domestic Banks.

This table shows the results of equation (1). All columns show the estimates from a weekly panel regression between October 27, 2015 and January 26, 2024 examining the effects of the change in deposits on the change in reserves. Column 1 shows the results for 1,822 domestic banks, Column 2 shows for small banks, Column 3 shows for medium banks, and Column 4 shows for large banks. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) internal Federal Reserve accounting records

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln(\text{Volume}_{\text{all},t})$	$\Delta(\text{FF}_{\text{all},t} - \text{IORB}_t)$	$\Delta \ln(\text{Volume}_{\text{banks},t})$	$\Delta(\text{FF}_{\text{banks},t} - \text{IORB}_t)$	$\Delta \ln(\text{Volume}_{\text{non-banks},t})$	$\Delta(\text{FF}_{\text{non-banks},t} - \text{IORB}_t)$
$\Delta \text{DemandDeposits}_{i,t}$	1.11*** (3.69)	0.039*** (3.42)	0.62*** (3.76)	0.11*** (4.01)	2.00*** (3.57)	-0.0043 (-0.39)
Observations	455287	455287	453900	453900	453900	453900
Adjusted $R^2$	0.1496	0.1052	0.1417	0.1733	0.1769	0.0990
Month FE?	Yes	Yes	Yes	Yes	Yes	Yes
Lagged LHS?	Yes	Yes	Yes	Yes	Yes	Yes

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln(\text{Volume}_{\text{all},t})$	$\Delta(\text{FF}_{\text{all},t} - \text{IORB}_t)$	$\Delta \ln(\text{Volume}_{\text{banks},t})$	$\Delta(\text{FF}_{\text{banks},t} - \text{IORB}_t)$	$\Delta \ln(\text{Volume}_{\text{non-banks},t})$	$\Delta(\text{FF}_{\text{non-banks},t} - \text{IORB}_t)$
$\Delta \text{DemandDeposits}_{i,t}$	107.7*** (4.87)	2.29*** (2.75)	76.6*** (6.97)	16.2*** (7.53)	140.5*** (3.25)	-4.27*** (-4.76)
Observations	291010	291010	291010	289980	291010	289980
Adjusted $R^2$	0.1381	0.1057	0.1388	0.1516	0.1743	0.0952
Month FE?	Yes	Yes	Yes	Yes	Yes	Yes
Lagged LHS?	Yes	Yes	Yes	Yes	Yes	Yes

Table 3: The Effect of Deposit Shocks on Fed Funds Trading.

This table shows the results from estimating equation (2) and (3), separately, using demand deposit shocks to all and small domestic banks. The results of a panel regression between October 27, 2015 and January 26, 2024, with Panel A using deposit shocks to all 1,822 domestic banks and Panel B using shocks to 1,294 small domestic banks (banks with total assets last quarter less than \$10 billion USD). The dependent variables are  $\Delta \ln(\text{Volume}_{L,t})$ , the total trading volume in the fed funds market, and  $\Delta(\text{FF}_{L,t} - \text{IORB}_t)$ , the aggregate volume-weighted average borrowing rate in the fed funds market minus IORB, where  $L$  refers to the type of lender and  $L \in \{\text{all}, \text{banks}, \text{non-banks}\}$ . The independent variable is  $\Delta \text{DemandDeposits}_{i,t}$ , weekly changes in individual bank demand deposits, expressed in trillions. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) internal Federal Reserve accounting records

	$\Delta(FF_{all,t} - IORB_t)$		$\Delta(FF_{banks,t} - IORB_t)$		$\Delta(FF_{non-banks,t} - IORB_t)$	
	(1) First Stage	(2) Second Stage	(3) First Stage	(4) Second Stage	(5) First Stage	(6) Second Stage
$\Delta \ln(Volume_{all,t})$		0.035*** (6.20)				
$\Delta \ln(Volume_{banks,t})$				0.18*** (6.00)		
$\Delta \ln(Volume_{non-banks,t})$						-0.0022 (-0.37)
$\Delta DemandDeposits_{i,t}$	1.11*** (3.69)		0.62*** (3.76)		2.00*** (3.57)	
Observations	455287	455287	453900	453900	453900	453900
First-Stage F statistic		13.7		14.1		12.7
Month FE?		Yes		Yes		Yes
Lagged LHS?		Yes		Yes		Yes

	$\Delta(FF_{all,t} - IORB_t)$		$\Delta(FF_{banks,t} - IORB_t)$		$\Delta(FF_{non-banks,t} - IORB_t)$	
	(1) First Stage	(2) Second Stage	(3) First Stage	(4) Second Stage	(5) First Stage	(6) Second Stage
$\Delta \ln(Volume_{all,t})$		0.026*** (4.61)				
$\Delta \ln(Volume_{banks,t})$				0.20*** (17.06)		
$\Delta \ln(Volume_{non-banks,t})$						-0.035** (-2.27)
$\Delta DemandDeposits_{i,t}$	93.0*** (4.42)		76.4*** (6.94)		122.7*** (2.92)	
Observations	291010	291010	289980	289980	289980	289980
First-Stage F statistic		19.5		48.1		8.50
Month FE?		Yes		Yes		Yes
Lagged LHS?		Yes		Yes		Yes

Table 4: Supply Elasticity in the Fed Funds Market for Banks and Non-Banks.

This table shows our instrumental variable approach estimate supply elasticity using equation 5, using demand deposit shocks to all (top panel) and small domestic banks (bottom panel). The results of a weekly IV panel regression between October 27, 2015 and January 26, 2024, with Panel A using shocks to 1,822 all domestic banks in our sample and Panel B using shocks to 1,294 small domestic banks in our sample (banks with total assets last quarter less than \$10 billion USD), to examine the elasticity of supply in the fed funds market. Columns 1, 3, and 5 show the results of the first stage regression where we regress  $\Delta \ln(Volume_{L,t})$  where  $L$  refers to the type of lender and  $L \in \{all, banks, non-banks\}$  on  $\Delta DemandDeposits_{i,t}$ , expressed in trillions. The dependent variable,  $\Delta(FF_{L,t} - IORB_t)$  is the aggregate volume-weighted average borrowing rate to lender type  $L$  in the fed funds market on day  $t$  minus IORB. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) internal Federal Reserve accounting records

	$\Delta(FF_{all,t} - IORB_t)$			$\Delta(FF_{banks,t} - IORB_t)$			$\Delta(FF_{non-banks,t} - IORB_t)$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	First Stage	First Stage	Second Stage	First Stage	First Stage	Second Stage	First Stage	First Stage	Second Stage
$\Delta \ln(Volume_{all,t})$			0.32*** (7.13)						
$\Delta \ln(Volume_{banks,t})$						0.37*** (8.82)			
$\Delta \ln(Volume_{non-banks,t})$									-0.020 (-0.32)
$\Delta \ln(Volume_{all,t}) \times \frac{Reserves}{BankAssets_t}$			-1.93*** (-6.24)						
$\Delta \ln(Volume_{banks,t}) \times \frac{Reserves}{BankAssets_t}$						-1.25*** (-4.52)			
$\Delta \ln(Volume_{non-banks,t}) \times \frac{Reserves}{BankAssets_t}$									-0.12 (-0.30)
$\frac{Reserves}{BankAssets_t}$	-3.73*** (-60.21)	-0.58*** (-55.13)	-0.22*** (-5.57)	-2.51*** (-32.42)	-0.33*** (-27.40)	-0.53*** (-16.86)	-5.37*** (-49.85)	-0.90*** (-51.21)	0.11 (1.14)
$\Delta DemandDeposits_{i,t}$	20.0 (0.29)	-10.4 (-0.81)		189.4*** (4.99)	12.1*** (2.60)		-251.9 (-1.29)	-55.3 (-1.52)	
$\Delta DemandDeposits_{i,t} \times \frac{Reserves}{BankAssets_t}$	485.7 (0.85)	165.2 (1.52)		-784.4*** (-3.32)	-9.99 (-0.29)		2527.7 (1.57)	511.0* (1.71)	
Observations	291010	291010	291010	289980	289980	289980	289980	289980	289980
First-Stage F statistic			18.6			26.8			9.43
Month FE?			Yes			Yes			Yes
Lagged LHS?			Yes			Yes			Yes

Table 5: How Aggregate Reserves Affects Supply Elasticity in the Fed Funds Market.

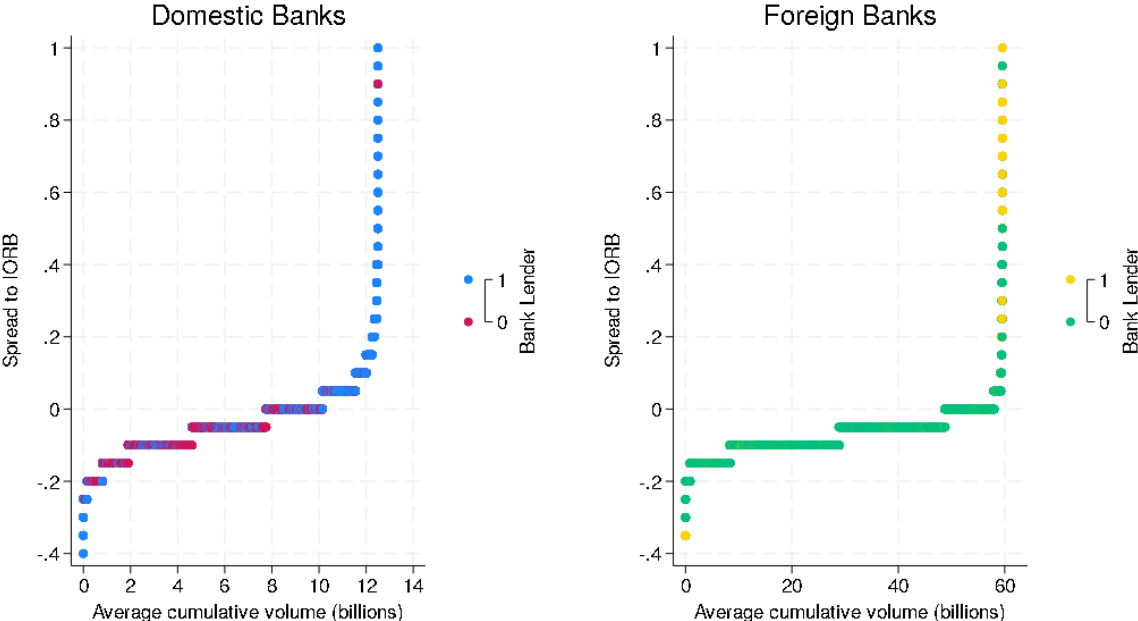
This table reports instrumental variable estimates of supply elasticity in the fed funds market for small domestic banks (assets  $\leq$  \$10 billion USD) using equation 5 using weekly panel data from October 27, 2015 and January 26, 2024 for 1,294 small domestic banks. In the “First Stage” (columns 1, 3, 5) we regress  $\Delta \ln(Volume_{L,t})$  for each lender type  $L \in \{all, banks, non-banks\}$  on weekly shocks to  $\Delta DemandDeposits_{i,t}$  (in trillions), controlling for lagged volume, bank fixed effects, and month fixed effects. In the “Second Stage” (columns 2, 4, 6), we regress  $\Delta(FF_{L,t} - IORB_t)$  on the instrumented volume, interacting it with  $\frac{Reserves}{BankAssets_t}$ , the ratio of total reserves held at the Fed to total domestic bank assets. All regressions include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) FR H.4.1 Factors Affecting Reserve Balances; (5) FR H.8 Assets & Liabilities of Commercial Banks in the US; (6) internal Federal Reserve accounting records

	$\Delta(FF_{banks,t} - IORB_t)$		
	(1) First Stage	(2) First Stage	(3) Second Stage
$\Delta \ln(\text{Volume}_{banks,t})$			0.46*** (7.55)
$\Delta \ln(\text{Volume}_{banks,t}) \times \frac{\text{Bankers' Banks Reserves}_t}{\text{Bankers' Banks Assets}_t}$			-0.054*** (-4.72)
$\frac{\text{Bankers' Banks Reserves}_t}{\text{Bankers' Banks Assets}_t}$	0.16*** (211.79)	0.58*** (201.49)	-0.025*** (-6.46)
$\Delta \text{DemandDeposits}_{i,t}$	43.0*** (3.07)	-79.9 (-1.31)	
$\Delta \text{DemandDeposits}_{i,t} \times \frac{\text{Bankers' Banks Reserves}_t}{\text{Bankers' Banks Assets}_t}$	1.72 (0.43)	73.6*** (3.09)	
Observations	289,980	289,980	289,980
First-Stage F statistic			22.5
Month FE?			Yes
Lagged LHS?			Yes

Table 6: How Bankers' Bank Reserves Affects Supply Elasticity in the Fed Funds Market. This table reports instrumental variable estimates of supply elasticity in the fed funds market for small domestic banks (assets  $\leq$  \$10 billion USD) using equation 5 using weekly panel data from October 27, 2015 and January 26, 2024 for 1,294 small domestic banks. In the "First Stage" (columns 1, 2) we regress  $\Delta \ln(\text{Volume}_{bank,t})$  on weekly shocks to  $\Delta \text{DemandDeposits}_{i,t}$  (in trillions), controlling for lagged volume, bank fixed effects, and month fixed effects. In the "Second Stage" (column 3), we regress  $\Delta(FF_{bank,t} - IORB_t)$  on the instrumented volume, interacting it with  $\frac{\text{Bankers' Banks Reserves}_t}{\text{Bankers' Banks Assets}_t}$ , the ratio of total reserves held at the Fed by bankers' banks to total domestic bank assets. All regressions include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) FR H.4.1 Factors Affecting Reserve Balances; (5) FR H.8 Assets & Liabilities of Commercial Banks in the US; (6) internal Federal Reserve accounting records

# Appendix

Figure A.1: Rates and Volumes Borrowed by Domestic and Foreign Bank in the Fed Funds Market.



This figure displays cumulative average trading volumes and spreads in the fed funds market for domestic banks (left) and foreign banks (right). Each volume/spread dot on the left panel for domestic banks reflects at least 7 banks’ trading behavior averaged across our sample between October 2015 and January 2024. Each volume/spread dot on the right panel for foreign banks reflects at least 5 banks’ trading behavior averaged across our sample between October 2015 and January 2024. Both panels do not single out trading behavior on a particular day but represent average trading behavior between October 2015 and January 2024. Blue and yellow dots represent the cumulative trading volume lent by bank lenders. Red and green dots represent the cumulative trading volume lent by non-bank lenders. Source: FR 2420 Report on Selected Money Market Rates

	$\Delta(FF_{all,t} - IORB_t)$		$\Delta(FF_{banks,t} - IORB_t)$		$\Delta(FF_{non-banks,t} - IORB_t)$	
	(1)	(2)	(3)	(4)	(5)	(6)
	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
$\Delta \ln(Volume_{all,t})$		0.035*** (6.30)				
$\Delta \ln(Volume_{banks,t})$				0.18*** (6.15)		
$\Delta \ln(Volume_{non-banks,t})$						-0.0023 (-0.39)
$\Delta TotalDeposits_{i,t}$	1.10*** (3.69)		0.62*** (3.75)		1.99*** (3.57)	
Observations	454829	454829	453446	453446	453446	453446
First-Stage F statistic		13.6		14.1		12.8
Month FE?		Yes		Yes		Yes
Lagged LHS?		Yes		Yes		Yes

	$\Delta(FF_{all,t} - IORB_t)$		$\Delta(FF_{banks,t} - IORB_t)$		$\Delta(FF_{non-banks,t} - IORB_t)$	
	(1)	(2)	(3)	(4)	(5)	(6)
	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
$\Delta \ln(Volume_{all,t})$		0.025*** (4.19)				
$\Delta \ln(Volume_{banks,t})$				0.19*** (17.01)		
$\Delta \ln(Volume_{non-banks,t})$						-0.036** (-2.32)
$\Delta TotalDeposits_{i,t}$	89.0*** (4.48)		73.6*** (7.12)		116.6*** (2.93)	
Observations	290719	290719	289691	289691	289691	289691
First-Stage F statistic		20.0		50.7		8.56
Month FE?		Yes		Yes		Yes
Lagged LHS?		Yes		Yes		Yes

Table A.1: Elasticity of Supply in the Fed funds Market Using Total Deposits.

This table shows the two stage strategy to estimate supply elasticity, first using equation (2) and then equation (3), using total deposit shocks to all and small domestic banks. The results of a weekly IV panel regression between October 27, 2015 and January 26, 2024, with Panel A using shocks to 1,822 all domestic banks in our sample and Panel B using shocks to 1,294 small domestic banks in our sample (banks with total assets last quarter less than \$10 billion USD), to examine the elasticity of supply in the fed funds market. Columns 1, 3, and 5 show the results of the first stage regression where we regress  $\Delta \ln(Volume_{L,t})$  where  $L$  refers to the type of lender and  $L \in \{all, banks, non-banks\}$  on  $\Delta TotalDeposits_{i,t}$ , expressed in trillions. The dependent variable,  $\Delta(FF_{L,t} - IORB_t)$  is the aggregate volume-weighted average borrowing rate to lender type  $L$  in the fed funds market on day  $t$  minus IORB. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) internal Federal Reserve accounting records

	$\Delta(FF_{all,t} - IORB_t)$			$\Delta(FF_{banks,t} - IORB_t)$			$\Delta(FF_{non-banks,t} - IORB_t)$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	First Stage	First Stage	Second Stage	First Stage	First Stage	Second Stage	First Stage	First Stage	Second Stage
$\Delta \ln(Volume_{all,t})$			0.30*** (6.73)						
$\Delta \ln(Volume_{banks,t})$						0.39*** (9.90)			
$\Delta \ln(Volume_{non-banks,t})$									0.052 (0.69)
$\Delta \ln(Volume_{all,t}) \times \frac{Reserves}{BankAssets_t}$			-1.84*** (-5.94)						
$\Delta \ln(Volume_{banks,t}) \times \frac{Reserves}{BankAssets_t}$						-1.43*** (-5.38)			
$\Delta \ln(Volume_{non-banks,t}) \times \frac{Reserves}{BankAssets_t}$									-0.54 (-1.15)
$\frac{Reserves}{BankAssets_t}$	-3.73*** (-60.20)	-0.58*** (-55.13)	-0.22*** (-5.69)	-2.51*** (-32.46)	-0.33*** (-27.43)	-0.59*** (-19.17)	-5.37*** (-49.83)	-0.90*** (-51.21)	-0.14 (-1.40)
$\Delta TotalDeposits_{i,t}$	14.8 (0.22)	-10.7 (-0.84)		172.8*** (4.97)	10.3** (2.35)		-239.9 (-1.25)	-53.0 (-1.48)	
$\Delta TotalDeposits_{i,t} \times \frac{Reserves}{BankAssets_t}$	497.0 (0.87)	163.9 (1.52)		-691.1*** (-3.11)	-0.82 (-0.02)		2416.5 (1.52)	490.6* (1.68)	
Observations	290719	290719	290719	289691	289691	289691	289691	289691	289691
First-Stage F statistic			20.8			28.9			10.4
Month FE?			Yes			Yes			Yes
Lagged LHS?			Yes			Yes			Yes

Table A.2: How Elasticity of Supply in the Fed funds Market Using Total Deposits Changes With Aggregate Reserves.

This table shows the two stage strategy to estimate supply elasticity, first using equation (2) and then equation (3), using total deposit shocks to small domestic banks; augmented by including an interaction term of the level of aggregate reserves to total bank deposits. This table shows the results of a weekly IV panel regression between October 27, 2015 and January 26, 2024 for 1,294 small domestic banks (banks with total assets last quarter less than \$10 billion USD). Columns 1, 3, and 5 show the results of the first stage regression where we regress  $\Delta \ln(Volume_{L,t})$  where  $L$  refers to the type of lender and  $L \in \{all, banks, non-banks\}$  on  $\Delta TotalDeposits_{i,t}$ , expressed in trillions. The dependent variable,  $\Delta(FF_{L,t} - IORB_t)$  is the aggregate volume-weighted average borrowing rate to lender type  $L$  in the fed funds market on day  $t$  minus IORB.  $\frac{Reserves}{BankAssets_t}$  is the ratio of all reserve balances held at the Fed to total domestic bank assets. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) FR 2420 Report on Selected Money Market Rates; (4) FR H.8; (5) internal Federal Reserve accounting records

	(1)	(2)	(3)	(4)
	All Domestic	Large	Medium	Small
$\Delta Demand Deposits_{i,t}$	0.039*** (3.58)	0.038*** (3.45)	0.075*** (3.07)	0.17*** (4.46)
$\Delta Reserves_{i,t-1}$	0.21 (1.62)	0.19 (1.54)	-0.011 (-0.31)	0.032 (0.58)
$Payments_{i,t}$	0.30*** (3.17)	0.29*** (3.09)	0.90*** (3.17)	1.18*** (2.75)
$Payments_{i,t-1}$	-0.16** (-2.27)	-0.15** (-2.34)	0.39* (1.76)	-0.14 (-0.57)
Observations	280817	6894	30338	167458
Adjusted $R^2$	0.0656	0.0792	0.1119	0.1606
Month FE?	Yes	Yes	Yes	Yes

Table A.3: The Effect of Deposits on Reserves for Domestic Banks Controlling for Payment Flows.

This table shows the results of equation (1) with an additional control variables of net payments ( $Payments_{i,t}$  and  $Payments_{i,t-1}$ ).  $Payments$  equals Fedwire Funds Received - Fedwire Funds Sent - (Federal Funds Received - Federal Funds Sent). We control for federal funds payment flows in  $t$  and  $t - 1$  to ensure that payment flows do not affect the sensitivity of deposit shocks on changes in reserves. All columns show the estimates from a weekly panel regression between January 2, 2018 and December 26, 2023 examining the effects of the change in deposits on the change in reserves. Column 1 shows the results for 1,822 domestic banks, Column 2 shows for small banks, Column 3 shows for medium banks, and Column 4 shows for large banks. We include bank and month fixed effects. Standard errors are clustered at the bank level.  $t$  statistics are shown in parentheses. Statistical significance: \*\*\*  $p \leq .01$ , \*\*  $p \leq .05$ , \*  $p \leq .10$ . Source: (1) FR 2900 Report of Deposits and Vault Cash; (2) FFIEC Call Reports; (3) internal Federal Reserve accounting records