The Passthrough of Treasury Supply to Bank Deposit Funding

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Abstract

We demonstrate the passthrough of Treasury supply to bank deposits through bank market power. We show that a larger Treasury supply crowds out deposits with disproportionate effects in more competitive deposit markets. A larger Treasury supply further curtails bank lending and affects bank funding structure. The explanatory power of Treasury supply is not driven by other shocks to deposit demand and supply. In comparison, monetary policy rate hikes have a larger impact on deposit funding in more concentrated markets, consistent with the deposits channel of monetary policy. Our empirical findings are rationalized in a model of imperfect deposit competition.

Keywords: Treasuries, Bank deposits, Safe assets, Financial intermediation, Monetary policy

1. Introduction

From February 2007 to February 2020, the volume of marketable Treasuries almost quadrupled, followed by an additional $4.2 trillion increase during the Covid-19 pandemic. One important question arising from this rapid expansion of Treasury supply is its effect on the funding and lending capacity of the commercial banking sector. After all, one of the central roles of the banking sector is to provide liquidity (Diamond and Dybvig, 1983). Treasury securities that satisfy the demand for liquidity may thus reduce investors' demand for bank deposits. At the same time, individual banks compete with each other in local deposit markets by supplying differentiated deposit products (Drechsler et al., 2017). Such differentiation across banks gives rise to bank market power and influences the rate sensitivity of banks' aggregate deposit supply. As a result, deposit competition is a crucial determinant of the extent to which Treasury supply affects bank deposit funding.

In this paper, we examine the effect of Treasury supply on the banking sector in the presence of bank market power. We show that higher deposit competition renders the aggregate deposit supply more rate-sensitive. Thus, when an increase in Treasury supply reduces the demand for deposits, its substitute good, the contraction in deposit funding is amplified by deposit competition.

The impact of Treasury supply on bank funding is especially important to understand because surges in Treasury growth often occur during economic downturns, when investors and banks are more constrained. Empirically tracing out the impact of Treasury supply on the banking sector is challenging precisely for the same reason: Treasury supply varies with the business cycle along with other shocks to investors' demand for deposits and banks' supply of deposits. While the literature has mostly focused on time-series variation, we identify the impact of Treasury supply using cross-sectional variation in deposit rates and volumes.

Our results have several important implications. First, we demonstrate that Treasury supply affects financial stability by altering the composition of bank funding. Wholesale deposit markets are more competitive than retail deposit markets, so a larger Treasury supply disproportionately crowds out wholesale deposits. The reduced reliance on wholesale funding may, in turn, lower the likelihood of bank default because wholesale funding is more runnable than retail deposits.

Second, because deposits are an important and irreplaceable funding source for banks, Treasury growth contracts bank lending to the real economy and alters the distribution of loan supply in different geographical areas. For a one-standard-deviation increase in Treasury growth, banks at the third quartile of deposit competition experience a 159.4bps larger drop in new small business lending and a 233.3bps larger drop in on-balance-sheet new mortgage loans relative to banks at the first quartile of deposit competition.

Finally, we contrast the transmission of Treasury supply with that of monetary policy as in Drechsler et al. (2017). Our analysis jointly considers both policies and shows that more competitive deposit markets experience the most pronounced crowding out of deposits following Treasury growth while benefiting the least from the deposit expansion following policy rate cuts. These results arise because Treasury supply primarily affects investors' demand for deposits, while the policy rate primarily shifts banks' supply of deposits. We thus confirm the deposits channel of monetary policy and establish the different passthrough of Treasury supply to bank deposit funding.

We first build a simple model to shed light on the mechanisms at play. In the model, deposits are supplied by differentiated banks. When there are more banks or when deposits appear less differentiated to investors, deposit competition is stronger so that the aggregate deposit supply is more rate sensitive. Investors choose a portfolio of deposits, cash, Treasuries, and a benchmark capital market bond that is available at the monetary policy rate, i.e., the Fed funds rate. Cash earns zero interest, and therefore, the Fed funds rate is the opportunity cost of holding cash. Similarly, the opportunity cost of holding Treasuries and deposits are reflected by the Fed funds-Treasury spread and the Fed funds-deposit spread, respectively. Banks raise deposit funding to invest in loans and face a downward-sloping loan demand with respect to the loan spread.

When Treasury supply increases, the demand for deposits drops because Treasuries and deposits are substitutes in providing liquidity to investors. The drop in demand makes both the quantity and price of deposits, i.e., the deposit spread, fall. The relative impact on price versus quantity depends on the slope of the deposit supply curve, which depends on the level of deposit competition between banks. If competition is high, the deposit supply curve is relatively rate sensitive and the impact is primarily on deposit quantities. If competition is low, the deposit supply curve is relatively less rate sensitive and the impact is mainly on deposit spreads.

In contrast, increases in the Fed funds rate primarily contract the aggregate deposit supply curve. A higher Fed funds rate increases the cost of holding cash and thereby reduces the substitution away from deposits, consistent with the deposits channel of monetary policy (Drechsler et al., 2017). Therefore, banks have more deposit market power when the Fed funds rate is high, which reduces the aggregate supply of deposits and increases the Fed funds-deposit spread. When deposit competition is high, the aggregate deposit supply is relatively more rate sensitive, so the Fed funds-deposit spread increases by less.

Our model also provides insights into the effect of Treasury supply on banks' wholesale funding ratio. Institutional investors tend to be more active in searching for better deposit rates than retail investors. This renders wholesale deposits at different banks better substitutes and leads to a more rate-sensitive supply for wholesale deposits. Since a more rate-sensitive deposit supply magnifies the crowding-out effect of Treasury supply, government-supplied liquidity curbs the reliance on wholesale funding.

The aggregate time series provides preliminary evidence for our model predictions. We find that Treasury growth is negatively correlated with total deposit growth, with the negative correlation being stronger for wholesale deposits. These results are robust to controlling for Fed funds rate changes, but it could be that other macroeconomic variables comove with Treasury supply and deposit volume in the time series. For example, economic downturns may drive both an increase in Treasury issuance and a decline in firms' demand for bank loans, which reduces banks' funding needs and their supply of deposits. Further, Treasury issuance may comove with economic conditions that influence investors' demand for deposits.

To avoid the confounding effect of comoving investment opportunities, we use within-bank, across-branch variation in deposit volumes and rates to verify our model predictions. The identification assumption is that funds can be freely transferred within branches of the same bank. Hence, the remaining variation observed across branches of the same bank should be due to banks' deposit pricing strategies under different levels of local deposit competition. In the baseline specification, we use a standard Herfindahl Index (HHI) to measure deposit competition at the county level. We also control for Fed funds rate changes to clearly distinguish between the effects of monetary policy and Treasury supply.

Further, to ensure that our results are not driven by deposit demand shocks correlated with Treasury supply, we control for time-varying county-level conditions and use an instrumented specification. Our results remain robust when we control for observable county-level economic characteristics, including the percentage change in income per capita, population growth, and the change in unemployment rate. We further instrument for Treasury growth to account for unobservable deposit demand shocks. Our first instrument is based on shocks to military expenditure, where positive shocks to military expenditure increase the issuance of Treasuries but are plausibly exogenous to local economic conditions that affect county-level deposit demand. Our second instrument is based on high-frequency variation in Treasury supply associated with seasonal tax deadlines following Greenwood et al. (2015). Finally, we show that our estimates are robust to a number of alternative specifications.

Taken together, our estimation results confirm the model predictions. When Treasury supply increases, banks widen their Treasury-deposit spreads by more and experience more substantial outflows at branches located in more competitive areas. For a one-standard-deviation increase in Treasury growth, branches at the third quartile of deposit competition, i.e., the 25th percentile of HHI, experience a 43.3bps larger drop in deposit growth compared to branches of the same bank at the first quartile of deposit competition, i.e., the 75th percentile of HHI. These magnitudes are economically significant. Applying our estimates to project the overall effect of Treasury growth, we find a 140.9bps drop in deposit growth for a one-standard-deviation increase in Treasury growth.[1]

The distributional effect of Fed funds rate changes is opposite to that of Treasury growth. For a one-standard-deviation increase (decrease) in the Fed funds rate, branches at the third quartile of deposit competition experience a 32.0bps smaller decrease (increase) in deposit growth than branches of the same bank at the first quartile of deposit competition.

We find that both short-term and long-term Treasuries play a role in the crowding out of deposits. While Treasuries with less than one-year maturity, including Treasury Bills, command a higher liquidity premium than Treasuries with more than one-year maturity, the much larger volume of Treasuries with more than one-year maturity partially offsets their lower liquidity premium compared to short-term Treasuries.

Treasury supply also affects the structure of bank funding. Quantitatively, we find that the wholesale funding ratio decreases by 23.0bps following a one-standard-deviation increase in Treasury growth. At the same time, we find that a one-standard-deviation cut in the Fed funds rate lowers the wholesale funding ratio by 26.6bps. This implies that monetary easing and increased Treasury issuance during a financial downturn may jointly reduce the dependence on wholesale funding and improve the funding stability of the banking sector.

Finally, the crowding out of deposits by Treasury supply spills over to contract bank lending to the real economy and affects the distribution of loan supply. Because money is fungible across branches of the same bank, we

[1] Following Drechsler et al. (2017), we first calculate the cross-elasticities and then multiply them by the average time-series effect for Treasury-deposit spreads and Fed funds-deposit spreads. The implicit assumption is that the cross-sectional estimates can be applied to project the overall effect. Please refer to Appendix A.1.8 for details.

evaluate the effect of deposit competition at the bank level, where the bank-level exposure to deposit competition is the weighted average of branch-level deposit competition. Comparing loans to borrowers in the same county, we find that the effect of deposit competition on bank lending is economically significant and consistent with our findings on deposits. For a one-standard-deviation increase in Treasury growth, banks at the third quartile of deposit competition experience a 159.4bps larger drop in new small business lending and a 233.3bps larger drop in on-balance-sheet new mortgage loans relative to banks at the first quartile of deposit competition.

Literature Review

Our paper contributes to several strands of research. First, we build on the safe assets literature that has demonstrated an aggregate demand for money-like convenience services by Treasuries and its effect on the financial sector (Krishnamurthy and Vissing-Jorgensen, 2012, 2015; Greenwood et al., 2010, 2015). Several papers have zoomed in on demand for shorter-term debt like Treasury bills and repos (d'Avernas and Vandeweyer, 2024; Infante, 2020; d'Avernas et al., 2025), while Krishnamurthy and Li (2023) incorporate Treasuries of all maturities and shadow bank liabilities. We show that an important determinant in the crowding out of deposits by Treasuries is deposit competition between differentiated banks. Heterogeneity in deposit competition across markets and deposit types also leads to distributional effects in the cross-section of banks and influences bank funding structure.

We also contribute to a growing banking literature on deposit competition. Several papers analyze the effect of deposit competition in the transmission of conventional monetary policy (Drechsler et al., 2017; Wang et al., 2022; Whited et al., 2021) and unconventional monetary policy (Diamond et al., 2024; Albertazzi et al., 2022). We are the first to show how deposit competition affects the transmission of Treasury supply to bank funding and lending. We also confirm the effect of monetary policy on bank deposits as in Drechsler et al. (2017) while establishing the distinct and different passthrough of Treasury supply.

Finally, our findings provide insights into the effect of publicly supplied safe assets on financial stability. Gorton and Metrick (2012); Carlson et al. (2016); Sunderam (2014), and Kacperczyk et al. (2021) illustrate how the demand for safe and liquid assets fueled the expansion of shadow banks. We show that increases in the supply of Treasuries reduce banks' wholesale funding ratio. This reduced reliance on wholesale funding contributes to the funding stability of banks, consistent with the evidence from Egan et al.

(2017) that uninsured wholesale deposits are subject to runs.

This paper is organized as follows: Section 2 examines the aggregate time series. Section 3 develops a model of imperfect deposit competition to rationalize the observed trends and guide the subsequent empirical strategy. Section 4 explains the data sources used in estimating the crowding out of deposits in Section 5. In Sections 6 and 7, we estimate the effect of Treasury supply on bank lending and wholesale funding, respectively. Section 8 concludes.

2. Aggregate Trends

We begin by examining the aggregate relationship between Treasury supply and deposit funding. Figure 4 shows the overall composition of US commercial bank assets from 1980 to 2018, illustrating that loans and securities, including Treasuries, are the two dominant asset categories on bank balance sheets. Figure 1a plots the year-over-year deposit growth and the year-over-year Treasury growth from 1973 to 2019.[2] Figure 1b repeats the plot for wholesale funding ratio growth, where wholesale funding ratio is measured as large time deposits over total deposits.

The negative relationship depicted in Figure 1a is in line with Treasuries, the public safe asset, crowding out bank deposits, a privately-issued substitute for the public safe asset. The negative co-movement with Treasury growth is even more pronounced for wholesale funding. As Figure 1b shows, periods with higher Treasury growth also have lower wholesale funding growth in the banking sector.

Figure 1c plots the corresponding graph for changes in the Treasury-deposit spread, which is calculated as the difference between the three-month Treasury yield and the three-month CD rate. The relationship between Treasury growth and Treasury-deposit spread changes is noisier but overall positive. The widening of Treasury-deposit spreads as Treasury growth picks up is consistent with Treasuries crowding out deposits as a substitute good, where the price of Treasuries drops by more than that of deposits, giving rise to a higher opportunity cost of holding deposits relative to Treasuries.

[2]To measure the Treasuries available to US private investors, we calculate Treasury supply as the total supply minus foreign official holdings and intragovernmental holdings. Please see Section 4 for further details.

Another important determinant of deposit growth is monetary policy (Drechsler et al., 2017). To ensure that the observed relationship between Treasury growth and deposits is not explained away by variations in the policy rate, we first residualize both Treasury and deposit growth rates by absorbing the effect of Fed funds rate changes and then plot the binned scatter plot of year-over-year deposit growth against year-over-year Treasury growth in Figure 2a. Similarly, the corresponding plots for wholesale funding and the Treasury deposit spread are shown in Figures 2b and 2c. Overall, the binned scatter plots echo our earlier results: Treasury growth comoves negatively with deposit growth and wholesale funding growth, and increases with Treasury-deposit spread changes.

In our above analysis, the effective variation in Treasury supply may arise from a number of sources. It could be driven by government spending and borrowing targeting business cycle fluctuations that the Fed does not offset with monetary policy, government borrowing for national defense purposes, and budget changes due to shifts in the political regime. However, these events may also be correlated with other variables in the time series that affect bank deposit funding through channels other than the crowding-out effect we conjectured. To pinpoint the transmission mechanism and the effect of deposit competition, we first develop a micro-foundation for the crowding out of deposits in Section 3. Then, in Section 5, we compare how deposits at different branches of the same bank vary with Treasury supply to remove potential confounding by banks' time-varying investment opportunities in the time series. We further include time-varying county-level controls and instrument for Treasury growth to ensure that our findings are not driven by other shocks to deposit demand.

3. Model

We develop a model to understand the impact of Treasury supply on bank deposits in the presence of deposit competition. The model provides a theoretical foundation for why Treasury supply crowds out bank deposits, and how deposit competition affects this crowding-out effect. Furthermore, we model monetary policy following Drechsler et al. (2017) and compare the effect of Treasury supply on deposits with the deposits channel of monetary policy. The main predictions of the model are empirically verified in Section 5.

3.1. Model Setup

The economy lasts for one period with $N \geq 2$ banks and a representative investor. There are $N + 3$ assets to invest in: deposits D_i from bank $i \in \{1, 2, \cdots, N\}$, with return r_i^D; Treasuries, G, with return r^G; Cash, M, with return of zero; and a benchmark asset whose return is the Fed funds rate, r. The benchmark asset can be thought of as capital market securities whose returns are driven by the monetary policy rate, i.e., the Fed funds rate, and that do not provide liquidity value as bank deposits, cash, and Treasuries do. We think of cash as currency and non-interest-bearing deposits, while deposits represent liquid deposits with a positive interest rate, such as savings deposits. The opportunity costs of holding deposits of bank i, cash, and Treasuries relative to the benchmark asset can thus be expressed as the deposit spread, $s_i = r - r_i^D$, the Fed funds rate r, and the Treasury liquidity premium, $\ell = r - r^G$, respectively.

Investor Preferences. We let investor preferences for liquidity follow a multi-layer CES aggregator. The investor preference for deposits provided by differentiated banks is defined as

$$D = \left(\frac{1}{N} \sum_{i=1}^{N} D_i^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{1}$$

where η is the elasticity of substitution between individual bank's deposits. We assume $\eta > 1$ so deposits from different banks are substitutes. Each bank has mass $1/N$ and produces deposits at rate D_i. As in Drechsler et al. (2017), we normalize the mass of each bank to $1/N$ so that the total size of the banking sector is 1 regardless of N. In this way, a larger N captures the effect of deposit competition rather than the mechanical effect of a larger banking sector.

Aggregate deposits D and cash M make up near-money asset $\bar{M}$,

$$\bar{M} = \left(\delta_M M^{\frac{\epsilon-1}{\epsilon}} + (1 - \delta_M) D^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{2}$$

where ϵ is the elasticity of substitution between deposits and cash. We assume $\epsilon > 1$ so that cash and deposits are substitutes.

The investor further values the near-money asset $\bar{M}$ and Treasuries as a liquidity bundle,

$$L = \left((1 - \delta_G) \bar{M}^{\frac{\sigma-1}{\sigma}} + \delta_G G^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where σ is the elasticity of substitution between near money and Treasuries and δ_G determines the relative per unit liquidity benefit of Treasuries. The liquidity value, L, broadly represents the benefits that the investor enjoys from holding near money and Treasuries on top of her nominal consumption value.[3] Treasuries also satisfy the demand for liquidity (Krishnamurthy and Vissing-Jorgensen, 2012), so we let Treasuries and near money assets be substitutes with $\sigma > 1$.[4]

Finally, investors obtain utility from both consumption and liquidity,

$$u(C, L) = C + \frac{\rho}{\rho - 1}\beta^{\frac{1}{\rho}} L^{\frac{\rho-1}{\rho}}, \tag{4}$$

where $\rho > 0$ reflects the decreasing marginal utility in liquidity holding.[5]

We assume that the inner aggregations have stronger substitutions ($\eta > \epsilon > \sigma > \rho$). This assumption is natural. Deposits from different banks provide more similar functions to each other, like ATM withdrawals and wire transfers, than do deposits and cash. Deposits and cash both provide payment services and are better substitutes for each other than for Treasuries that cannot be used to make payments. Finally, Treasuries and near money assets both provide liquid and safe claims and are better substitutes for each other than for consumption that does not provide any convenience value. These parameter restrictions ensure well-behaved demand and supply curves, as we will elaborate in the next subsection.

Investor Decision We write the investor decision in two steps. In the first step, given any near-money asset $\bar{M}$, the investor chooses deposits $D_i, i \in \{1, 2, \cdots, N\}$, and cash M to minimize $\bar{s}$, the average opportunity cost of

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[3] These may include the benefits from having liquid assets to meet unexpected consumption needs (Diamond and Dybvig, 1983), the efficiency from having a means of payment (Kiyotaki and Wright, 1989), the convenience from holding an informationally insensitive asset (Gorton and Pennacchi, 1990), and, in the case of deposits and cash, the benefit of receiving efficient payment services. This broad notion of liquidity is also adopted by related papers in the literature, e.g., Greenwood et al. (2015), Krishnamurthy and Vissing-Jorgensen (2015), and Egan et al. (2017).

[4] Krishnamurthy and Li (2023) estimated σ using data from 1950s to 2020 and found that $\sigma > 1$.

[5] We can also allow C and L to follow another layer of CES aggregation with elasticity ρ, but this significantly complicates the theoretical results without changing the economic intuitions.

holding these liquid assets,

$$\min_{M,D_i,i=1,2,\cdots,N} \quad \underbrace{\frac{1}{\bar{M}}\left(Mr+\sum_{i=1}^{N}\frac{D_i}{N}s_i\right)}_{\equiv \bar{s}}. \tag{5}$$

In the second step, the investor chooses near money $\bar{M}$, Treasuries G, and consumption C to maximize (4), subject to the budget constraint,

$$C \leq W_0(1+r) - \bar{M}\bar{s} - G\ell, \tag{6}$$

and the liquidity bundle in (3). In the budget constraint (6), the baseline return is $1+r$ if the investor only holds the benchmark asset. If she holds more liquid assets, an opportunity cost is incurred, which is $\bar{s}$ for near money $\bar{M}$, as defined in equation (5), and ℓ for Treasuries.

We assume that the sensitivity of investors' deposit demand for individual banks D_i to deposit spread s_i is only evaluated in the first step. This assumption simplifies the model solution and allows the model to be tractable. We note that it only restricts the interaction between deposit demand for individual banks and Treasury supply, while preserving investors' substitution between aggregate deposits and Treasuries, which eventually leads to Treasuries' crowding-out effect on deposits.

Bank Decision. Each bank i raises deposit funding and invests the funds in loans. The spread between the lending rate and Fed funds rate is $b_0 - \frac{b_1}{2}D_i$, where b_0 and b_1 are both positive. In particular, the requirement of $b_1 > 0$ reflects the case when banks have a limited pool of profitable lending opportunities and thus the excess return on loans decreases with the amount of lending. Banks choose their deposit spread s_i to maximize profits

$$\max_{s_i} \underbrace{\left(r+b_0-\frac{b_1}{2}D_i\right)D_i}_{\text{loan revenue}} - \underbrace{(r-s_i)D_i}_{\text{deposit funding cost}}, \tag{7}$$

where $r + b_0 - \frac{b_1}{2}D_i$ is the lending rate and $r - s_i$ is the deposit rate.

Market Clearing. We study the symmetric equilibrium across banks, with $D_i = D_j$, for $i, j \in \{1, 2, \cdots, N\}$. This indicates that all bank-level deposit spreads, s_i, are equal in equilibrium. We impose market clearing by setting the aggregate demand for deposits equal to the aggregate supply of deposits, and the demand for Treasuries equal to the supply of Treasuries,

G_0. The market clearing condition for cash is subsumed by the Fed setting monetary policy rate r. In the model, we take G_0 to be an exogenous parameter. In practice, a larger Treasury supply may also spur government spending to crowd out private investment and reduce the demand for bank loans. We abstract away from modeling this effect because our goal is to derive comparative statics for our empirical tests, in which the estimation strategy conditions on shifts in loan demand. We derive the aggregate deposit supply, aggregate deposit demand and Treasury demand in the next subsection.

3.2. Model Solution

This section provides a sketch of the model solution. Detailed derivations are presented in Appendix A.1.

Household Deposit Demand Elasticity and Deposit Competition

To proceed, we define the aggregate deposit spread

$$s = \frac{1}{N}\sum_{i=1}^{N}\frac{D_i}{D}s_i. \tag{8}$$

Solving for D_i in the decision problem of (5), we obtain the deposit demand elasticity for an individual bank i,

$$\frac{\partial \log(D_i)}{\partial \log(s_i)} = -\left(\eta(1-\frac{1}{N}) + \epsilon\frac{\delta_M^{\epsilon} r^{1-\epsilon}}{\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}}\frac{1}{N}\right). \tag{9}$$

As shown in (9), the demand elasticity for an individual bank's deposits is negative, indicating that a higher deposit spread s_i reduces deposit demand D_i. The first term, $\eta(1-\frac{1}{N})$, reflects the deposit competition across banks: a higher deposit spread s_i incentivizes the investor to shift deposits at bank i to other banks $j \neq i$. The second term, $\epsilon ... \frac{1}{N}$, reflects the substitution between aggregate deposits and cash: a higher deposit spread s_i increases the aggregate deposit spread s and thus the investor shifts money from deposits to cash. When $N = 1$, the banking sector is a monopoly, so the first term that reflects within-banking deposit competition becomes zero. When $N \to \infty$, each bank is infinitesimal and does not affect the aggregate deposit spread s, and therefore, the deposit-cash substitution term becomes zero.

Bank Optimization and Aggregate Deposit Supply

Using the individual deposit demand elasticity in (9), the first-order condition to banks' problem in (7), and imposing symmetry, we obtain the aggregate deposit supply,

$$\hat{D}(s,r) = \frac{b_0}{b_1} + \frac{1}{b_1}\left(1 - \left(\eta(1-\frac{1}{N}) + \epsilon\frac{\delta_M^{\epsilon} r^{1-\epsilon}}{\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}}\frac{1}{N}\right)^{-1}\right) s. \tag{10}$$

We impose a regularity assumption $\eta(1-1/N) \geq 1$ so that the deposit supply curve in (10) is upward-sloping, i.e., $\hat{D}'_s > 0$.[6]

Two observations are in order. First, we can show that the aggregate deposit supply becomes more sensitive to deposit spread s when N and η increase. That is, when there are more banks competing for deposits and when deposits at different banks are more substitutable, each bank is facing a more rate-sensitive depositor base so that the aggregate deposit supply is more rate sensitive.

Second, the deposit supply $\hat{D}$ decreases with the relative cost of cash versus deposits, r/s. Intuitively, cash becomes more expensive as r/s increases, which incentivizes investors to hold more deposits and reduces investors' ability to substitute away from deposits. At the same time, as cash becomes more expensive, investors should substitute less between cash and deposits and rely more on substituting towards bonds and Treasuries. However, these assets are less substitutable with deposits, which further increases the market power of individual banks and reduces aggregate deposit supply.[7]

Aggregate Demand Functions

Solving the household problem gives rise to the aggregate demand functions for Treasuries and deposits,

$$G(\bar{s},\ell) = \delta_G^{\sigma}\beta \cdot s_L(\bar{s},\ell)^{\sigma-\rho}\ \ell^{-\sigma}, \tag{11}$$

$$D(\bar{s},\ell) = (1-\delta_M)^{\epsilon}(1-\delta_G)^{\sigma}\beta \cdot s_L(\bar{s},\ell)^{\sigma-\rho}\ \bar{s}^{\epsilon-\sigma}\ s^{-\epsilon}, \tag{12}$$

[6] This is not a restrictive assumption given $N \geq 2$ and $\eta > 1$. For example, Barnett (1980) estimates $\eta = 2.6$, so that $\eta(1-1/N) \geq \eta/2 > 1$.

[7] By assumption, these assets contribute zero to individual deposit demand elasticity (or more generally, only a small amount, as in Drechsler et al. (2017)) because they are excluded from consideration when investors choose between individual bank's deposits.

with aggregate liquidity cost

$$s_L(\bar{s}, \ell) = \left((1-\delta_G)^\sigma \bar{s}^{1-\sigma} + (\delta_G)^\sigma \ell^{1-\sigma}\right)^{\frac{1}{1-\sigma}}, \tag{13}$$

and near-money spread $\bar{s}$ that is an increasing function of s and r. For our main results, three properties of the demand functions are particularly important. First, total Treasury demand decreases with Treasury spread ℓ, reflecting substitution away from Treasuries when the cost of holding Treasuries increases. This property leads to equilibrium Treasury spread ℓ decreasing in Treasury supply G_0. Second, aggregate deposit demand increases with ℓ given that $\sigma > \rho$, because the substitution between near-money and Treasuries dominates when σ is large. Finally, the assumption $\epsilon > \sigma > \rho$ ensures that the term $s^{-\epsilon}$ in deposit demand function (12) dominates, leading to a downward-sloping aggregate deposit demand curve.

3.3. Impact of Treasury Supply on Deposit Markets

First, we show the effect of Treasury supply on bank deposits and its interaction with deposit competition. To be consistent with our empirical estimation, we derive our results on deposit quantities in terms of logs.[8]

Proposition 1 (Treasury Supply and Bank Deposits)**.** *The equilibrium log deposit quantity* $\log(D)$ *decreases with Treasury supply, and the magnitude of this effect increases with* N*,*

$$\frac{\partial \log(D)}{\partial G_0} < 0, \qquad \partial\left(\frac{\partial \log(D)}{\partial G_0}\right)/\partial N < 0. \tag{14}$$

The equilibrium Fed funds-deposit spread decreases with Treasury supply, and the magnitude of this effect decreases with N*,*

$$\frac{\partial s}{\partial G_0} < 0, \qquad \partial\left(\frac{\partial s}{\partial G_0}\right)/\partial N > 0. \tag{15}$$

Assuming that $|D'_s| > |D'_\ell|$ *and* $|G'_\ell| > |G'_s|$*, the equilibrium Treasury-deposit spread increases with Treasury supply, and the magnitude of this effect increases with* N*, i.e.,*

$$\frac{\partial (s-\ell)}{\partial G_0} > 0, \qquad \partial\left(\frac{\partial (s-\ell)}{\partial G_0}\right)/\partial N > 0. \tag{16}$$

[8]As discussed after (A-48) in appendix A.1.4, if our propositions hold for log deposits $\log(D)$, they also hold for the level of deposits D.

All statements in (14), (15), and (16) hold if we replace N with η.

Intuitively, Treasuries are imperfect substitutes for deposits in providing liquidity. An increase in Treasury supply lowers the cost of holding Treasuries, reflected as a lower Treasury liquidity premium ℓ, and contracts the demand for deposits (see equation (12)), i.e., $\partial \log(D)/\partial G_0 < 0$. This decreased demand for deposits also lowers the deposit spread, so we have $\partial s/\partial G_0 < 0$.

Recall that when deposit markets are more competitive, i.e., when N or η is larger, the aggregate deposit supply is more rate sensitive. Thus, the same drop in deposit demand leads to a more pronounced deposit outflow and a smaller drop in the deposit spread in more competitive deposit markets. See Figure 3 as an illustration.

The results for the Treasury-deposit spread, $s - \ell$, depend on both the deposit spread s and the Treasury spread ℓ, for which we need the additional assumption that deposit and Treasury demand respond more to their own costs than each other's costs. As we show in Appendix A.1.4, this assumption is satisfied when the Treasury supply is neither too large nor too small.[9]

3.4. The Impact of Monetary Policy on Deposit Markets

We proceed to show the effect of monetary policy on bank deposits and its interaction with deposit competition.

Proposition 2 (Monetary Policy and Deposit Spread)**.** *The equilibrium log deposit quantity* $\log(D)$ *decreases with the Fed funds rate* r *if the marginal profit of lending is positive,*

$$\frac{\partial \log(D)}{\partial r} < 0 \tag{17}$$

Moreover, the equilibrium Fed funds-deposit spread increases with the Fed funds rate r*, and the magnitude of this effect decreases with* N*,*

$$\frac{\partial s}{\partial r} > 0, \qquad \partial\left(\frac{\partial s}{\partial r}\right)/\partial N < 0. \tag{18}$$

[9] Intuitively, when the Treasury supply is too large, the Treasury spread becomes very insensitive to changes in Treasury supply so that Treasury supply may no longer predominantly affect its own spread ℓ but the deposit spread s, which may lead to $\partial(s-\ell)/\partial G_0 < 0$. When the Treasury supply is too small, changes to deposit competition may no longer predominantly affect the response of deposit spreads because the Treasury spread becomes too large and responsive. In this case, we may have $\partial\left(\frac{\partial(s-\ell)}{\partial G_0}\right)/\partial N < 0$.

Assuming $|G'_\ell| > |G'_s|$, the equilibrium Treasury-deposit spread increases with the Fed funds rate r, and the magnitude of this effect decreases with N,

$$\frac{\partial(s-\ell)}{\partial r} > 0, \qquad \partial\left(\frac{\partial(s-\ell)}{\partial r}\right)/\partial N < 0. \tag{19}$$

All statements in (18) and (19) hold if we replace N with η.

Proposition 2 echoes the results in Drechsler et al. (2017). Recall from equation (10) that the aggregate deposit supply contracts when the Fed funds rate r increases for a given s. Intuitively, this effect arises because a higher r/s renders cash more expensive and the substitution away from deposits more difficult, which gives banks more deposit market power and causes a reduction in the aggregate deposit supply. This reduction in the aggregate deposit supply shrinks the equilibrium level of deposits and increases the Fed funds-deposit spread. When deposit markets are more competitive, i.e., larger N or η, the aggregate deposit supply is more rate sensitive, which leads to a smaller change in the equilibrium deposit spread for the same change in r.

A higher r also boosts the demand for deposits by making cash more expensive, but the supply-side effect prevails as long as the marginal profit of lending is positive, i.e., $\partial((b_0 - \frac{b_1}{2}D_i)D_i)/\partial D_i > 0$. This is naturally satisfied when D_i is not too large so that the supply-side channel through individual bank's deposit market power dominates.

Finally, Proposition 2 also predicts how Treasury-deposit spread changes with r and competition. We find that the response of $s - \ell$ is mainly driven by the deposit spread component s, and therefore, the signs of (19) are the same as (18).

3.5. Effects on Bank Funding Structure

Next, we extend the model to incorporate the difference between retail and wholesale investors. Wholesale investors tend to more actively substitute among banks depending on who offers a higher rate. This willingness to switch effectively translates into a lower level of deposit differentiation and a higher elasticity of substitution across different banks for wholesale investors.

Let the elasticity of substitution for retail and wholesale investors be η_R and η_W, where $\eta_R < \eta_W$. If wholesale deposits make up α_W of total deposits, the effective elasticity of substitution among individual bank's deposits would be $\alpha_W\eta_W + (1-\alpha_W)\eta_R$. Hence, a larger fraction of wholesale deposits, α_W, renders deposit markets more competitive (see equation (10)), which according to Proposition 1 amplifies the crowding out of deposits by Treasury supply. This finding is summarized in the following proposition:

Proposition 3 (Wholesales Funding)**.** *When the fraction of wholesale funding is higher, the equilibrium Treasury crowding-out effect is stronger, i.e.,*

$$\partial \left(\frac{\partial \log(D)}{\partial G_0} \right) / \partial \alpha_W < 0. \tag{20}$$

4. Data

Before detailing the estimation strategy, we explain the data sources and the construction of the main variables.

4.1. Data Sources

Bank balance sheet data are from US Call Reports. Our sample is from 1994 to 2016 and contains quarterly data on the income statements and balance sheets of all US commercial banks. We match bank-level Call Reports to branch-level RateWatch and Federal Deposit Insurance Corporation (FDIC) data using the FDIC bank identifier.

Data on deposit volumes are from the FDIC, covering the universe of US bank branches at an annual frequency from June 1994 to June 2016. Information about branch characteristics, such as the parent bank, address, and geographic coordinates, are also available.

Data on deposit rates are from RateWatch. RateWatch collects branch-level deposit rates by product. We use quarterly-level data and focus on the most common deposit categories, including 2.5K savings accounts, 25K money market accounts, and 10K CDs with three-month, six-month, and one-year maturities from 1997 to 2016. We only include branches that actively set deposit rates to avoid duplication of observations.

Data on small business lending are from the National Community Reinvestment Coalition (NCRC). The data are annual and cover new small business loans originated at the bank-county level from 1997 to 2016.

Data on mortgages are from the Home Mortgage Disclosure Act (HMDA). The data are annual and cover new residential mortgages originated. We map HMDA identifiers to RSSD bank identifiers from Call Reports using the Avery files and include loans by bank issuers for whom a match can be found in our sample from 1997 to 2016.

Fed funds target rates and Treasury yields are from Federal Reserve Economic Data (FRED). We compute the average of the upper and lower Fed funds target rates after 2008. Treasury volumes are from the TreasuryDirect website.

Data on county characteristics are from the 2000 US Census and County Business Patterns. Relevant demographic variables include median income, the proportion of residents above 65, and the proportion of college graduates. Data on county-year characteristics are from the Bureau of Economic Analysis CAINC30 Economic Profile. Relevant variables include percentage change in income per capita, population growth, and the change in unemployment rate.

4.2. Definition of Key Variables

Branch HHI. In the baseline specifications, our proxy for local deposit market competition is the standard HHI. We assign to each bank branch the HHI of the county in which it is located and refer to it as the branch HHI. This county-level HHI is calculated by summing the squared deposit market shares of all banks that operate branches in a given county in a given year and then taking the average of that amount over all years. Figure 5a shows that the county-level HHI stays relatively constant over our sample period.

Bank HHI is calculated by first taking the weighted average of the bank's branch-level HHIs in each year, where the weights correspond to the bank's proportion of deposits in each branch, and then averaging at the bank level. Figure 5b shows the distribution of bank HHI, which is centered at around 0.2 and has almost all its weight below 0.6.

Deposit growth. Deposit growth is the log difference of bank or branch deposit volume in a year. We are limited to using annual deposit growth rates at the branch level because FDIC deposit volumes are only reported annually. We take logs of deposit volumes as in Drechsler et al. (2017) because the levels of deposit volumes are very dispersed and may skew the linear regression coefficients toward a few banks with very large deposit volumes.

Deposit spread. Deposit spread is calculated as the Treasury yield minus the deposit rate, the Fed funds rate minus the deposit rate, or the OIS swap rate minus the deposit rate in each quarter. We choose Treasury yields and OIS swap rates with maturities corresponding to each deposit category. Consistent with Drechsler et al. (2017), we use changes in deposit spreads to remove persistence in rates.

Bank lending. Bank lending is calculated as either the log of new small business loans or the log of new mortgage loans given out in a year. For mortgage loans, we further differentiate between loans that are not sold in the same calendar year and those that are sold or securitized.

Treasury growth. Treasury growth is the log difference of Treasury volume outstanding in a year. To capture Treasuries available to the US private sector, we exclude foreign official holdings, intra-governmental holdings, and Federal Reserve holdings. We treat Treasuries as homogeneous in the baseline specifications but allow for more granular breakdowns as a robustness check.

Please refer to Table 1 for summary statistics of our data.

5. Impact on Bank Deposits

This section tests our model empirically. We first explain our identification strategy and then present the estimation results.

5.1. Estimation Strategy

Because the time series suffers from potential confounding, as discussed in Section 2, we turn to verify our model predictions in the cross-section.

We begin by looking at how branches subject to different levels of deposit competition respond to changes in Treasury supply. We first divide counties into 20 bins according to their level of deposit competition. Then, we estimate the average sensitivity of branch-level deposit growth to Treasury supply, γ_h, for branches in bin h using

$$DepGrowth_{it} = \alpha_i + \gamma_h \mathbf{1}\{bin_h\} * TSYGrowth_t + \theta_t + \epsilon_{it}, \qquad (21)$$

where the dependent variable is the deposit growth of branch i at time t. We include both branch-level fixed effects, α_i, and time fixed effects, θ_t. Similarly, we obtain the sensitivities for the Treasury-time deposit spread and the Treasury-savings deposit spreads using

$$\Delta DepSpread_{it} = \alpha_i + \gamma_h \mathbf{1}\{bin_h\} * TSYGrowth_t + \theta_t + \epsilon_{it}. \qquad (22)$$

Consistent with the theory, Figure 6 shows that branches in more competitive areas experience more pronounced deposit outflows in periods of high Treasury growth. Also in line with the theory, Figure 7 confirms that branches in more competitive areas widen their Treasury-deposit spreads by more than branches in less competitive areas as Treasury growth increases.

Specifications (21) and (22) include time fixed effects to control for changes in deposit rates and volumes due to other reasons, such as banks' investment opportunities, other shocks to deposit demand, and monetary policy. However, these variables may not affect all banks in the same way, which is especially concerning if the impact is correlated with the level of deposit competition.

To this end, we rule out other deposit supply shocks such as changes in banks' investment opportunities by only comparing branches of the same bank. We illustrate our identification strategy with a simple example. Figure 8 plots the hypothetical Treasury-deposit spread of the three-month CD for two different branches of a hypothetical bank from October 2004 to April 2005. If we observe that the Treasury-deposit spread in the more competitive county, county A, increases more than that in the less competitive county, county B, as Treasury growth increases from 2004Q4 to 2005Q1, we would be able to attribute the divergence of Treasuey-deposit spreads to the level of local deposit competition, because changes in the macroeconomic environment should affect the investment opportunities of the bank as a whole. The implicit assumption here is that deposits are fungible across branches of the same bank, i.e., banks can raise a dollar of deposits at one branch and lend it at another branch until the marginal returns of lending across its branches are equalized. This assumption is empirically supported by Drechsler et al. (2017) and our findings in Section 6, which confirm that a bank's lending in a given county is not related to local deposit-market concentration. It is also corroborated by the banking literature, which shows that banks channel deposits to areas with high loan demand (Gilje et al., 2016).

To implement the estimation, we include bank-time fixed effects, δ_{jt}, and state-time fixed effects, λ_{st}, in the following specifications:

$$\begin{aligned} DepGrowth_{it} = {} & \beta_1 TSYGrowth_t * HHI_i + \beta_2 \Delta FFR_t * HHI_i + Controls_{ct} \\ & + \; Controls_{ct} * HHI_i + \alpha_i + \eta_c + \lambda_{st} + \delta_{jt} + \epsilon_{it}, \end{aligned} \tag{23}$$

$$\begin{aligned} \Delta DepSpread_{it} = {} & \beta_1 TSYGrowth_t * HHI_i + \beta_2 \Delta FFR_t * HHI_i \\ & + \alpha_i + \eta_c + \lambda_{st} + \delta_{jt} + \epsilon_{it}, \end{aligned} \tag{24}$$

where $DepGrowth_{it}$ is the annual deposit growth of branch i in year t, $\Delta DepSpread_{it}$ is the year-over-year Fed funds-deposit spread change or the year-over-year Treasury-deposit spread change in quarter t, $TSYGrowth_t * HHI_i$ is Treasury growth interacted with the HHI of branch i's county,

$\Delta FFR_t * HHI_i$ is the Fed funds rate change interacted with the HHI of branch i's county, and $Controls_{ct}$ are county-year level control variables.

The key controls in these specifications are the bank-time fixed effects, δ_{jt}, which absorb the impact of time-varying loan demand. State-time fixed effects, λ_{st}, further limit the comparison to branches in the same state to rule out confounding by state-specific regulation and geopolitical differences. We also include county fixed effects, η_c, and branch fixed effects, α_i, to control for time-invariant characteristics at the county and branch-level that are not related to Treasury supply. We do not separately include HHI_i, ΔFFR_t, and $TSYGrowth_t$ because HHI_i is absorbed by branch fixed effects α_i while ΔFFR_t, and $TSYGrowth_t$ are absorbed by bank-time fixed effects δ_{jt} and state-time fixed effects λ_{st}.

One remaining concern is county-level time-varying deposit demand shocks that are correlated with Treasury growth. To this end, we first control for observable proxies of deposit demand shocks, including the percentage change in income per capita, population growth, and the change in unemployment rate. We further control for their interactions with county-level HHI. These variables are only available at an annual frequency so we only include them for specification (23) on annual deposit growth.

To account for unobserved demand shocks, we further repeat the estimation using instrumented Treasury growth. First, we follow Ramey (2011); Ramey and Zubairy (2018); Choi et al. (2024) and use shocks to military expenditure as an instrument for Treasury supply. Military expenditure shocks affect Treasury supply through the governments' expenditure on defense and are less likely to directly affect deposit demand in the U.S. Second, we use seasonal fluctuations in tax receipts to instrument for Treasury supply following Greenwood et al. (2015). Please refer to Section 5.3 for details on the instrumental variable specifications.

5.2. Baseline Results

Table 2 reports the results for specification (23). Column (1) demonstrates that when comparing branches of the same bank in the same state, Treasury growth crowds out deposit growth to a greater extent in more competitive regions, i.e., counties with a lower HHI, consistent with the predictions in Proposition 1. The statistical and economic significance of this result remains after taking into account changes in the Fed funds rate, as indicated in column (2). Also, in column (2), notice that the coefficient for changes in the Fed funds rate interacted with HHI is negative and significant, which implies that Fed funds rate changes have the largest impact on deposit growth in the least competitive areas.

Within-bank estimation controls for time-varying investment opportunities but limits the sample to banks with two or more branches. We repeat the analysis for the full sample without bank-year fixed effects in columns (3) to (6), where columns (5) and (6) further relax the comparison from within-state branches to all branches. The sign and statistical significance of the coefficients on Treasury growth and Fed funds rate changes interacted with HHI remain unchanged, which confirms the robustness of our results. The absolute magnitude of both coefficients is larger than those in the full specification. One potential reason could be that banks with branches in more competitive markets also have larger drops in loan demand when Treasury supply increases. Table A.1 shows that the results remain robust without county-year level control variables. The coefficients are relatively larger with controls, which indicates that county-level controls helped to account for correlated deposit demand shocks to some extent.

Overall, the magnitude of coefficients reveals a strong distributional effect of Treasury growth and Fed funds rate changes. Based on the specification in column (2), branches located in counties at the third quartile of deposit competition, i.e., the 25th percentile of HHI, experience a 43.3bps larger drop in deposit growth relative to branches of the same bank located in counties at the first quartile of deposit competition, i.e., the 75th percentile of HHI, for a one-standard-deviation increase in Treasury growth. The results become more pronounced without bank-year fixed effects. From column (4), branches located in counties at the third quartile of deposit competition experience a 87.3bps larger drop in deposit growth relative to branches of the same bank located in counties at the first quartile of deposit competition for a one-standard-deviation increase in Treasury growth. In other words, regions experience significantly different degrees of deposit outflows depending on the competitiveness of their local deposit markets. In contrast, a one-standard-deviation increase (decrease) in the Fed funds rate corresponds to a 32.0bps smaller contraction (expansion) in deposit growth for branches of the same bank in counties at the third quartile of deposit competition relative to those in counties at the first quartile of deposit competition. Without bank-year fixed effects, the corresponding result is 57.6bps.

These contrasting distributional effects of Treasury supply and monetary policy are illustrated in Figures 9a and 9b. The upper panel shows the decline in deposit growth following a one-standard-deviation increase in Treasury growth for branches in each county, while the lower panel shows the corresponding result for Fed funds rate hikes. In both panels, we use the more conservative and better-identified results with bank-year fixed effects. Counties with darker shades in the upper panel suffer more pronounced deposit outflows following Treasury growth because of their more competitive deposit markets. At the same time, these counties also have the lightest shade in the lower panel because they benefit the least from deposit growth expansion following monetary easing. In contrast, more concentrated deposit markets have a lighter shade in the upper panel and a darker shade in the lower panel, indicating smaller deposit outflows following Treasury growth and larger inflows after policy rate cuts. Therefore, when financial crises and economic downturns are addressed by a combination of monetary easing and increased Treasury issuance, deposits in competitive regions contract by more than in less competitive regions.

Tables 3 and 4 present within-bank estimates for specification (24). From the results, we see that the coefficients for $TSYGrowth * HHI$ are all negative. This is consistent with Proposition 1, where the drop in the Fed funds-deposit spread is smaller and the increase in the Treasury-deposit spread is larger when deposit competition increases. Further, notice that the coefficients for $\Delta FFR * HHI$ are positive, which shows that the Fed funds-deposit spread widens more in concentrated areas with Fed funds rate hikes. This result is in line with Proposition 2 and Drechsler et al. (2017). To account for the difference in maturities between the Fed funds rate, which is overnight, and various time deposits, we reestimate specification (24) using OIS-deposit spreads, where the 3-month, 6-month, and 12-month OIS swap rates are used for calculating the deposit spreads for the 3-month, 6-month and 12-month CD. The results in Table A.2 closely resemble those in Table 4 although the effect of Treasury supply becomes marginally insignificant for longer-term CDs.[10]

To provide a ballpark estimate for the overall impact of Treasury growth, we follow Drechsler et al. (2017) by first obtaining the cross-elasticity of deposit growth with respect to the Treasury-deposit spread. This cross-elasticity is obtained by dividing the cross-sectional sensitivity of $\log(D)$

[10]OIS swap rates are only available after 2004. Before 2004, we follow Du et al. (2023) in proxying the OIS swap rates with LIBOR rates of the same maturity.

with respect to HHI and Treasury supply (column 2 of Table 2) by the cross-sectional sensitivity of the Treasury-deposit spread with respect to HHI and Treasury supply (volume-weighted average of columns 2 and 4 in Table 3). We then multiply the cross-elasticity, which is -20.49, by the sensitivity of the Treasury deposit spread to the Treasury supply over our sample period. Taken together, we find that a one-standard-deviation increase in Treasury growth corresponds to a 140.9bps drop in deposit growth. Using the same approach, a one-standard-deviation increase in the Fed funds rate leads to a 224.7bps drop in deposit growth. Therefore, when a one-standard-deviation increase in monetary easing is coupled with a one-standard-deviation increase in Treasury growth, deposit expansion will be lower by more than 60% compared to the case of monetary easing alone. Please refer to Appendix A.1.8 for details of the calculation. We note that these results implicitly assume that the cross-sectional estimates can be applied to project the overall effect, which may not perfectly apply in practice.

5.3. Instrumental Variable Analysis

One remaining concern is that unobserved deposit demand shocks that are not captured by our control variables and that comove with Treasury supply shocks are confounding our estimation. To address this concern, we isolate variation in Treasury supply that is plausibly exogenous to investors' demand for deposits. Our first instrument uses shocks to military spending following Choi et al. (2024). This instrument is based on the news series of military spending changes first constructed by Ramey (2011) and Ramey and Zubairy (2018). We then follow Choi et al. (2024) to scale this series by nominal GDP and accumulate the shocks over time to compute our military shock instrument, $MilitaryShock_t$.[11] Intuitively, military expenditure shocks increase the demand for issuing Treasuries but they are driven by military events that do not directly affect the demand for safe assets in the U.S. The exclusion restriction requires shocks to military spending to affect deposit growth at US commercial banks only through its impact on Treasury growth.

To confirm the relevance of the instrument, we perform the first stage regression specification, which includes all non-instrumented regressors in

[11]We thank Jason Choi, Rishabh Kirpalani, and Diego Perez for sharing the data with us.

specification (23):

$$TSYGrowth_t * HHI_i = \theta_1 MilitaryShock_t * HHI_i + \theta_2 \Delta FFR_t * HHI_i + Controls_{ct} * HHI_i + Controls_{ct} + \alpha_i + \eta_c + \lambda_{st} + \delta_{jt} + \epsilon_{it}. \tag{25}$$

The results in Table A.3 show that the coefficient θ_1 is positive and statistically significant at 1% across all specifications. That is, positive shocks to military expenditure interacted with HHI indeed correspond to higher Treasury growth interacted with HHI.

We then estimate (23) using the fitted value of $TSYGrowth_t * HHI_i$ from the first stage. The results of the IV specification are shown in Table 5. We observe that the coefficients on the instrumented $TSYGrowth_t * HHI_i$ remain positive and statistically significant. The magnitude of the coefficients has increased relative to those in Table 2. This may be because Treasury growth is associated with positive deposit demand shocks that attenuate the OLS coefficients, but it may also be that measurement error inflated the IV estimates. Another concern could be that military expenditure shocks are a weak instrument. However, this is less likely because the clustering-robust Kleibergen-Paap F-statistics from the first stage exceed 30 (Table A.3), which passes common tests for weak instruments. Overall, the IV results confirm that our baseline estimates in Table 2 cannot be explained away by unobserved deposit demand shocks that comove with Treasury growth.

Regarding deposit spreads, we apply the same IV approach by first regressing $TSYGrowth_t * HHI_i$ on $MilitaryShock_t * HHI_i$ and all non-instrumented regressors in specification (24). Table A.4 displays the first stage results, which confirms that positive shocks to military expenditure interacted with HHI correspond to higher Treasury growth interacted with HHI. The Kleibergen-Paap F-statistics from the first stage exceed 164, which passes common tests for weak instruments. We then estimate (24) using the fitted value of $TSYGrowth_t * HHI_i$ from the first stage and show the results in Tables 6 and 7. The results are again consistent with our baseline estimates in Tables 3 and 4.

Our second instrument is based on seasonal fluctuations in tax receipts. As shown in Greenwood et al. (2015), the supply of short-term Treasuries is expanded ahead of tax deadlines and these borrowings are then rapidly repaid following the deadlines. The assumption is that high-frequency variations in Treasury supply associated with seasonal tax deadlines are plausibly exogenous to other macroeconomic shocks that affect deposit demand.

Following Greenwood et al. (2015), we first use weekly data to construct four-week Treasury growth. Next, we regress $TSYGrowth_t * HHI_i$ against weekly dummies interacted with HHI_i and all non-instrumented regressors in specification (24). We then estimate (24) using four-week changes in deposit spreads and the fitted value of $TSYGrowth_t * HHI_i$ from the first stage. The IV estimates shown in Tables A.6 and A.7 are generally consistent with our baseline estimates in Tables 3 and 4. This IV estimation is not feasible for deposit growth, which lacks weekly data.

5.4. Heterogeneity within Treasuries

So far, we have treated government-supplied liquidity as a homogeneous quantity, whereas in reality, Treasuries of shorter remaining maturities command a higher degree of money-like premium. The use of remaining maturities for measuring convenience yield is consistent with Krishnamurthy and Vissing-Jorgensen (2012), d'Avernas and Vandeweyer (2024), and Fleckenstein and Longstaff (2024). Moreover, a large literature on the Treasury yield curve relies on remaining maturity as a fundamental variable for fitting and analyzing yield curves (Nelson and Siegel, 1987; Diebold and Li, 2006; Gürkaynak et al., 2007). One key distinction is between Treasuries of less than one-year maturity, which includes Treasury bills, and Treasuries with remaining maturity of more than one year. For example, money market funds can only hold Treasuries with less than one year in remaining maturity. Thus, we proceed to analyze the effect of Treasuries with less than one-year maturity, i.e., short-term Treasuries, versus the effect of Treasuries with more than one-year maturity, i.e., long-term Treasuries.

We first extend our baseline model to let Treasuries G be composed of short-term Treasuries, G_S, and long-term Treasuries, G_L:

$$G = (G_S^{\frac{\theta-1}{\theta}} + \delta_L G_L^{\frac{\theta-1}{\theta}})^{\frac{\theta}{\theta-1}}, \tag{26}$$

where δ_L captures the relative liquidity and θ the elasticity of substitution between short-term and long-term Treasuries. In this setting, we show in Appendix A.1.7 that the crowding-out of deposits with respect to deposit competition depends on the liquidity-premium weighted volumes of short-term and long-term Treasuries. Our estimates show that although short-term Treasuries command a higher liquidity premium than long-term Treasuries, there is a much larger volume of long-term Treasuries outstanding. Hence, the overall effect of deposit competition on the crowding-out sensitivity of short-term versus long-term Treasuries is not as pronounced as the gap in their liquidity premium. In a multivariate regression, the results further depend on the covariance between the dependent variables.

Empirically, we first re-estimate our main specification in specification (23) by including interaction terms between both short-term and long-term Treasury growth with the HHI, where short-term and long-term Treasuries are defined as Treasuries with remaining maturity of less than and more than one year, respectively. All relevant coefficients are positive and statistically significant at 1%. When changes in the Fed funds rate interacted with HHI is controlled for (column (2)), the coefficient for short-term Treasuries interacted with HHI is 0.090/0.113=0.796 times that for Treasuries with above one year maturity interacted with HHI. The relative magnitude between the coefficients for short-term and long-term Treasury growth interacted with HHI is quite close to the projected ratio in Appendix A.1.7, which range between 0.75 to 0.79.

Finally, we repeat our estimation with aggregate Treasuries in which short-term and long-term Treasuries are weighted by their relative liquidity value. Our first proxy for liquidity value is the haircut on Treasury collateral in repo transactions. We follow the haircut schedule published by the DTCC and assign Treasuries with below and above one-year maturity a haircut of 2% and 4%, respectively.[12] Our second liquidity proxy is the Resolution Funding Corporation (RefCorp)-Treasury spread. "Refcorp" stands for the government agency named "Resolution Funding Corporation". Refcorp bonds are fully guaranteed by the U.S. government but are not widely traded like Treasuries. Thus the spread between the Refcorp yield and the Treasury yield of the same maturity is a proxy for the Treasury liquidity premium of that maturity.[13] To calculate the liquidity-premium-weighted Treasury supply, we use the average 3-month and 10-year liquidity premia as weights for Treasuries with less than and more than one-year maturity.

The results are shown in columns (3) and (4) of Table 8. Observe that the coefficients for the two weighted series are 0.209 and 0.206, respectively. These are close to the sum of the coefficients on short-term and long-

[12]See https://www.dtcc.com/-/media/Files/Downloads/legal/risk-management/GSD-Haircut-Schedule-Current.pdf for the DTCC haircut schedules. We use the haircut for the 5 years to 10 years bracket for Treasuries with more than one-year maturity.

[13]Refer to Longstaff (2004) for more details about RefCorp bonds.

term Treasury growth interacted with HHI in column (2), 0.09+0.113=0.203, which is consistent with aggregate Treasury growth being a weighted sum of short-term and long-term Treasury growth.

5.5. Local Clientele and Market Power

So far, we have used the HHI as a measure for imperfect deposit competition. Nevertheless, counties may differ in other ways that influence banks' market power, which consequently determines the impact of Treasury supply. In particular, the level of sophistication among the local clientele could affect how attentive they are to changes in deposit rates and how likely they are to substitute between banks as well as between deposits and Treasuries, all of which influence banks' market power. County fixed effects can take care of the time-invariant components, but there may still be an interaction effect with changes in Treasury supply.

We repeat the analysis controlling for characteristics of the local clientele that can proxy for investor sophistication. We use county-level measures from the 2000 US Census and County Business Patterns data, including the proportion of residents over 65, the median income level, and the percentage of the population with a college degree.

Table 9 shows that the effect of imperfect competition as measured by the HHI remains after including the full set of local clientele interaction effects. The coefficients on the county characteristics also provide an additional dimension for understanding the effective market power of banks. For example, counties with an older population appear less competitive and experience more muted outflows in response to Treasury growth. The effects of higher income levels and college education seem relatively limited.

5.6. Treasuries as Collateral

Another issue is that changes in Treasury supply affect banks not only through the returns on the Treasury portion of their assets but also via the availability of collateral for repo financing. This effect is partly due to the repo activities that use Treasuries as collateral (Infante, 2019, 2020). To alleviate this concern, we purge the sample of banks that rely heavily on repo financing and repeat the analysis. Table 10 shows results excluding banks above the third quartile of repo financing as a fraction of their balance sheet size. The baseline results remain robust.

5.7. Slow-Moving Treasury Supply

Treasuries are slow-moving in nature so the statistical significance of our previous results could be driven by time-series correlation. Hence, we use non-overlapping samples to recalculate Treasury growth rates over five years as a robustness check. The results in Table 11 show that the coefficients remain statistically significant. The magnitudes appear larger but become comparable to the baseline when converting from a five-year growth rate back to an annual one. In Appendix Tables A.8 and A.9, we repeat the corresponding estimation for deposit spreads. The results for savings deposits and 3-month CDs remain statistically significant at the 1% level, while those for other deposit categories become less significant.

6. Impact on Bank Lending

This section examines the effect of Treasury supply on bank lending to firms and mortgage borrowers. On the one hand, if deposit funding is not fully substitutable with other sources of funding for commercial banks, a contraction in deposits should curtail the volume of bank loans. Eventually, real economic activity may be impacted if bank-dependent firms and mortgage borrowers cannot frictionlessly switch to other forms of funding. On the other hand, a cut in deposit funding may not spill over to affect lending if banks can flexibly tap into other funding sources or remove loans from balance sheets through asset sales.

6.1. Estimation Strategy

Consistent with deposits being fungible across bank branches, it is the average bank-level deposit competition that determines how much Treasury supply contracts bank-level deposit funding and, hence, lending. If deposits are not fully substitutable with other sources of funding, we would expect the contraction in bank lending following Treasury growth to be larger for banks subject to more deposit competition compared to banks subject to less deposit competition.

Because funds can be allocated across branches of the same bank, we can no longer use within-bank variation in deposit competition to identify our results. Instead, we compare loans made by different banks in the same county similar to Drechsler et al. (2017) to account for local investment opportunities. The assumption that investment opportunities are local is especially plausible for small business loans and mortgage lending, which are the focus of our analysis.[14] We control for the proportion of capital market securities held by banks, which is comprised of Treasury and agency securities. This control variable ensures that our results are not driven by variations in banks' securities holdings that correlate with both Treasury supply and bank HHI. Finally, we control for banks' exposure to other county-level deposit demand shocks using the bank-level average percentage change in income per capita, population growth, and the change in unemployment rate interacted with bank-level HHI.

Specifically, we estimate

$$\log(\text{NewLoans})_{it} = \delta_{jc} + \eta_{ct} + \beta_1 TSYGrowth_t * HHI_j + \beta_2 \Delta FFR_t * HHI_j + Securities_{jt} + Controls_{jt} * HHI_j + \epsilon_{it}, \tag{27}$$

where $\log(\text{NewLoans})_{it}$ is the log of new loans that bank j's branch i originates in year t, $TSYGrowth_t * HHI_j$ and $\Delta FFR_t * HHI_j$ are Treasury growth and Fed funds rate changes interacted with bank-level HHI, δ_{jc} is a bank-county fixed effect, η_{ct} is a county-time fixed effect, $Securities_{jt}$ is the proportion of the bank's Treasury and agency securities over total assets, and $Controls_{jt} * HHI_j$ are other bank-level controls interacted with bank-level HHI. δ_{jc} controls for time-invariant characteristics at the bank-county level, like reputation and service quality, while η_{ct} accounts for time-varying local investment opportunities.

As a robustness check, we estimate another specification that includes branch i's local level of competition, HHI_i, interacted with Treasury growth and Fed funds rate changes. If our assumption that bank funding is fungible across branches is valid, only bank-level HHI but not branch-level HHI would be a significant determinant of bank lending. Specifically, we estimate

$$\begin{aligned}\log(\text{NewLoans})_{it} = {} & \delta_{jc} + \beta_1 TSYGrowth_t \cdot HHI_j + \beta_2 \Delta FFR_t \cdot HHI_j \\ & + \beta_3 TSYGrowth_t \cdot HHI_i + \beta_4 \Delta FFR_t \cdot HHI_i + Securities_{jt} \\ & + Controls_{jt} + Controls_{jt} \cdot HHI_j + \epsilon_{it}\end{aligned} \tag{28}$$

[14] These are also the only types of loans for which there is location-level bank lending information. Our approach cannot be applied to syndicated loans in the Dealscan database, which tend to be less localized in nature.

6.2. Small Business Loans

We first examine the effect of Treasury growth on small business loans. Small business loans are defined as loans of $1 million or less by the Community Reinvestment Act (CRA).[15] They provide a crucial source of financing for small- and medium-sized companies that often lack capital market access. At the same time, small business loans cannot be easily sold from bank balance sheets and are dependent on bank deposit funding. In other words, they are an economically important loan category that is likely impacted by increases in Treasury supply.

We estimate specification (27) using small business loans and report the result in column (1) of Table 12. As expected, the coefficient on Treasury growth interacted with bank HHI is positive, which implies that banks operating in competitive deposit markets, i.e., banks with a lower HHI, contract small business lending more when Treasury supply increases compared to banks that operate in less competitive deposit markets, i.e., banks with a higher HHI. This effect is economically significant: when Treasury growth increases by one standard deviation, banks at the third quartile of deposit competition contract new small business lending by 159.4bps more than banks at the first quartile of deposit competition. The magnitude of the effect appears to exceed the corresponding result for deposit growth in Section 5. This may in part be because the small business loans data is based on newly originated loans rather than the stock of loans. At the same time, small business loans may also be especially contingent on deposit funding due to their relative illiquidity compared to other assets on bank balance sheets.

We then control for branch-level HHI as in specification (28). From the results in column (2) of Table 12, we see that the coefficients on branch-HHI interacted with Treasury growth and Fed funds rate changes are insignificant, which suggests that funding is indeed fungible across bank branches. The economic magnitudes of the remaining coefficients are similar to those in column (1). In both specifications, Fed funds rate cuts (hikes) crowd in (out) lending by more at banks subject to less deposit competition than at banks subject to more deposit competition. This finding implies that monetary easing can amplify the distributional effect on bank lending when

[15] The CRA mandates the reporting of small business loans for banks exceeding $1 billion in total assets while reporting by smaller banks is voluntary. As a result, large banks may be overrepresented in our sample.

adopted in tandem with an increase in Treasury supply so that areas with higher levels of deposit competition experience the largest reduction in small business lending.

6.3. Mortgages

Another important function of commercial banks is the origination of mortgage loans. However, as Buchak et al. (2024) and Buchak et al. (2018) show, only a fraction of mortgage loans are kept on bank balance sheets, while a large share is originated by banks and then sold to third parties. In our context, we expect Treasury supply to affect bank lending through banks' deposit funding capacity. Hence, Treasury supply should predominantly impact mortgages that remain on bank balance sheets rather than mortgages that are expected to be sold off.

We first estimate specification (27) using mortgages that are not expected to be sold in the same calendar year and present the results in column (3) of Table 12. Similar to small business loans, the coefficient on Treasury growth interacted with bank HHI is positive and significant. Quantitatively, the effect of Treasury supply on mortgage lending is economically significant and even larger than that for small business loans: when Treasury growth increases by one standard deviation, banks at the third quartile of deposit competition contract new mortgage loans that are expected to remain on balance sheet by 233.3bps more than banks at the first quartile of deposit competition.

Column (4) of Table 12 shows the result after controlling for branch-level HHI as in specification (28). The coefficients on the interaction terms with branch-level HHI are not statistically significant, which is again consistent with our empirical assumption that money is fungible across branches of the same bank. Also, the coefficients on Fed funds rate changes interacted with bank-HHI in both Columns (3) and (4) are negative, as expected. Similar to the case of small business loans, this negative coefficient implies that the distributional effects of monetary easing and Treasury growth add on to each other.

Finally, we repeat the estimation for mortgages purchased by third parties. Columns (5) and (6) of Table 12 present the results for specifications (27) and (28), respectively. We observe that the effect of Treasury growth on these mortgages varies negatively with bank HHI. The fact that only on-balance-sheet, deposit-funded mortgages contract with higher deposit competition is consistent with the reduction in bank lending arising through Treasury supply crowding out deposit funding. As Buchak et al. (2024) point out, on-balance-sheet mortgages are on the decline as bank balance sheet constraints tighten and shadow banks are on the rise. Our findings are complementary and suggest that the rapid expansion in Treasury supply in recent years may have also contributed to residential mortgages being increasingly sold off from bank balance sheets.

7. Impact on Bank Funding Structure

Treasury supply not only crowds out the total quantity of deposits but also influences the type of funding banks can raise and thus becomes a determinant of the composition of bank leverage. Wholesale investors respond more to changes in Treasury supply relative to retail investors. Hence, an increase in Treasury supply crowds out wholesale funding by more and reduces the ratio of wholesale funding at commercial banks, as Proposition 3 shows.

The composition of bank liabilities has important financial stability implications. In the US, deposits exceeding \$250K are not protected by the FDIC's deposit insurance. Unlike insured deposits, uninsured deposits are subject to bank runs, which was first shown by Diamond and Dybvig (1983) and empirically confirmed by Egan et al. (2017). The 2007-2008 financial crisis also illustrated how the reliance on wholesale funding increased banks' funding liquidity risks. As a result, several new regulations, such as the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR) were introduced to curb the use of runnable funding by financial institutions.

To assess the effect of Treasury supply on bank funding structure, we first estimate the sensitivities of different types of deposits to increases in Treasury growth. Because deposit volumes for different deposit types are only available at the bank level, we resort to performing our analysis at the bank-level.[16] We regress bank-level deposit growth, $DepGrowth_{jt}$, against Treasury growth, Treasury growth interacted with bank HHI, changes in the target Fed funds rate, and its interaction with bank HHI. We control for banks' exposure to other deposit demand shocks using the bank-level averages of the percentage change in income per capita, population growth,

[16] The bank-level analysis does not allow for bank-time fixed effects for identification. Nevertheless, the identification assumption is that banks' demand for different types of funding is not correlated with Treasury growth rather than the amount of bank demand for funding to be uncorrelated with Treasury growth, which is likely more plausible.

and the change in unemployment rate interacted with bank-level HHI. We also control for banks' log assets, leverage ratio, and returns on assets.

$$DepGrowth_{jt} = \delta_j + Controls_{jt} + \beta_1 TSYGrowth_t + \beta_2 TSYGrowth_t * HHI_j + \beta_3 \Delta FFR_t * HHI_j + Controls_{jt} * HHI_j + \epsilon_{jt}, \quad (29)$$

where we include bank fixed effects, δ_j, and bank-level controls.

The first three columns in Table 13 show the results for core deposits, time deposits, and wholesale funding, respectively, where wholesale funding is the sum of wholesale deposits, Fed funds, repos, and other borrowed money. From the coefficients, we observe that the sensitivity of core deposits to Treasury supply is the lowest, while the sensitivity of wholesale funding to Treasury supply is the largest at more than two times that of core deposits. This finding is consistent with our model prediction because core deposits, which include checking, savings, and small time deposits, mainly service retail depositors, while wholesale funding is mostly provided by institutional investors.

We then evaluate the effect of Treasury supply on the wholesale funding ratio, $WholesaleRatio_{jt}$, which is the ratio of wholesale funding divided by total deposits. Specifically, we estimate

$$Wholesale\ Ratio_{jt} = \delta_j + Controls_{jt} + \beta_1 TSYGrowth_t + \beta_2 TSYGrowth_t * HHI_j + \beta_3 \Delta FFR_t * HHI_j + Controls_{jt} * HHI_j + \epsilon_{jt}, \quad (30)$$

The results are shown in the last column of Table 13. The coefficient on Treasury growth is negative, which confirms that the ratio of wholesale funding on banks' balance sheets decreases with Treasury growth. Quantitatively, the wholesale funding ratio for the median-HHI bank decreases by 23.0bps following a one-standard-deviation increase in Treasury growth. Table 13 also shows a positive significant coefficient for the effect of Fed funds rate hikes on the ratio of wholesale funding. In other words, the opposite effect applies to monetary policy rate hikes: core deposits respond more than wholesale funding, leading to a higher wholesale funding ratio. Quantitatively, the wholesale funding ratio increases by 26.6bps following a one-standard-deviation increase in the Fed funds rate.

Taken together, our findings support the view that monetary tightening to contain credit booms may unintentionally lead banks to increase their reliance on wholesale funding, and concentrate growth in wholesale-reliant banks. In contrast, monetary easing and increased Treasury issuance during a financial downturn can jointly reduce the dependence on wholesale funding and improve the funding stability of the banking sector.

8. Conclusion

This paper finds that Treasury supply crowds out bank deposits with a disproportionate effect in more competitive deposit markets. To establish causality, we remove the confounding effect of time-varying investment opportunities. We empirically show that for the same bank, branches in more competitive regions experience more pronounced deposit outflows in response to Treasury growth while benefiting the least from deposit inflows following monetary policy rate cuts. We thereby complement the deposits channel of monetary policy (Drechsler et al., 2017) and establish Treasury supply as an important and distinct determinant of bank funding capacity.

Our findings have important implications for bank lending capacity and bank funding fragility. First, the crowding out of deposits spills over to curtail bank lending to the real economy. For a one-standard-deviation increase in Treasury growth, banks at the third quartile of deposit competition experience a 159.4bps larger drop in new small business lending and a 233.3bps larger drop in on-balance-sheet new mortgage loans relative to banks at the first quartile of deposit competition. Further, we find that wholesale funding is more sensitive to changes in Treasury supply than retail deposits, so the ratio of wholesale funding drops when Treasury supply increases. This reduced reliance on wholesale funding is beneficial for the funding stability of banks.

We provide a theoretical framework to microfound our empirical analysis. In our model, banks supply differentiated deposits and investors demand liquidity services provided by deposits and Treasuries. The model generates predictions in line with the empirical estimates and rationalizes the contrasting effects of Fed funds rate hikes and Treasury growth. The key intuition is that Treasury supply primarily shifts investors' demand for deposits while monetary policy primarily affects banks' supply of deposits.

This paper has focused on the effects of imperfect deposit competition. Firm borrowers tend to be more efficient at screening loan rates than depositors. However, in some markets, imperfect competition for loans is also not trivial. Future work can jointly explore the imperfect competition for both bank lending and bank deposits to understand the interplay and implications.

Another avenue for further research could be how government debt affects the composition of banks and shadow banks. Given the fast-expanding size of government debt, these issues will become increasingly important going forward.

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Table 1: Summary Statistics

This table provides summary statistics. All panels provide a breakdown by high and low HHI using the median HHI for the respective sample. Panel A presents data on deposit holdings, deposit growth, Treasury growth, Fed funds rate changes, and branch HHI from the FDIC, Treasury Direct, and FRED (June 1994 to June 2016). Panel B presents data on deposit spreads from Ratewatch (1997 to 2016). Panel C presents data on bank characteristics from Call Reports (1994 to 2016). Panel D presents data on small business loans from the NCRC from 1997 to 2016. Panel E presents data on residential mortgages from HMDA (1997 to 2016). Panel F presents data on county characteristics from the 2000 US Census and County Business Patterns. Panel G presents data on county-year level characteristics from the Bureau of Economic Analysis.

Panel A: Branch Characteristics (FDIC, Treasury Direct, FRED)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
Deposits (mill. $)	76.38	1109.99	68.19	332.11	84.46	1528.95
Deposit growth (%)	8.49	36.71	9.48	38.53	7.52	34.79
Treasury growth (%)	5.52	11.46	5.61	11.47	5.36	11.43
Δ FFR (%)	-0.23	1.45	-0.23	1.48	-0.23	1.48
Branch-HHI	0.18	0.10	0.11	0.03	0.25	0.11
Observations	1,687,658		837,756		849,902	

Panel B: Branch Characteristics (Ratewatch)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
Δ Treasury - Deposit Spread (sav)	-0.16	1.28	-0.15	1.28	-0.16	1.28
Δ Treasury - Deposit Spread (6mCD)	-0.02	0.76	-0.03	0.78	-0.03	0.78
Δ FFR - Deposit Spread (sav)	-0.17	1.40	-0.17	1.40	-0.17	1.40
Δ FFR - Deposit Spread (6mCD)	-0.04	0.87	-0.04	0.89	-0.04	0.88
Observations	474,447		235,607		238,840	

Panel C: Bank characteristics (Call Reports)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
Assets (mill. $)	1180	23900	1031	20800	1328	26700
Deposits/Liab. (%)	0.93	0.12	0.93	0.10	0.93	0.13
Branches	11.89	30.09	12.67	32.25	11.10	27.74
Bank-HHI	0.21	0.12	0.13	0.03	0.30	0.12
Observations	751,262		373,638		377,624	

Panel D: Small Business Loans (CRA)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
New loans (mill. $)	2.68	14.76	3.01	14.63	2.35	14.91
Observations	1,580,387		780,566		795,664	

Panel E: Residential Mortgages (HMDA)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
On-balance sheet mortgages (mill. $)	4.09	49.00	3.22	19.64	4.94	66.30
Observations	1,256,256		624,014		631,289	
Sold mortgages (mill. $)	5.31	50.36	4.19	31.85	6.42	63.61
Observations	922,400		459,090		462,757	

Panel F: County Characteristics (Census)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
Median income ($)	42156	9748	46313	9929	38002	7547
Over 65 (%)	14.87	4.11	14.18	3.95	15.57	4.14
College degree (%)	16.48	7.69	18.98	8.35	13.99	6.03
Observations	2,987		1,493		1,494	

Panel G: County Year Characteristics (Census)

	All		Low HHI		High HHI	
	Mean	SD	Mean	SD	Mean	SD
Δ Unemployment (%)	-0.04	1.25	-0.04	1.17	-0.05	1.33
Δ Income (%)	3.54	5.44	3.45	3.81	3.63	6.69
Δ Population (%)	0.45	1.52	0.69	1.33	0.21	1.65
Observations	63,800		31,959		31,841	

Table 2: Deposit Volume and Treasury Supply

This table estimates the effect of Treasury supply on deposit growth from 1994 to 2016. The sample for the results in columns (1) and (2) consists of all banks with branches in two or more counties. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
TSY Growth * HHI	0.166***	0.180***	0.335***	0.363***	0.195***	0.234***
	(0.043)	(0.044)	(0.035)	(0.036)	(0.042)	(0.043)
Δ FFR * HHI		-0.010***		-0.018***		-0.021***
		(0.003)		(0.002)		(0.002)
Observations	1,415,721	1,415,721	1,569,320	1,569,320	1,569,320	1,569,320
Adjusted R2	0.185	0.185	0.122	0.122	0.118	0.118
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank Year FE	Yes	Yes	No	No	No	No
State Year FE	Yes	Yes	Yes	Yes	No	No
Branch FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes

Table 3: Treasury-Deposit Spread and Treasury Supply

This table shows the effect of Treasury supply on Treasury-deposit spreads from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Spread changes for savings and money market deposits are equal to the changes in the six-month Treasury yield minus the changes in deposit rates at the branch level. Spread changes for time deposits are equal to the changes in maturity-matched Treasury yield minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ Treasury-Deposit Spread($\geq$ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-2.668***	-1.279***	-0.838***	-0.427**	-0.334**
	(0.359)	(0.299)	(0.230)	(0.185)	(0.164)
Δ FFR * HHI	0.508***	0.468***	0.308***	0.272***	0.208***
	(0.036)	(0.033)	(0.025)	(0.020)	(0.017)
Observations	186490	202175	198318	211728	211694
Adjusted R2	0.946	0.842	0.831	0.813	0.786
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table 4: Fed Funds-Deposit Spread and Monetary Policy

This table shows the effect of Treasury supply on Fed funds-deposit spreads from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the Fed funds target rate minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ FFR-Deposit Spread ($\geq$ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-2.622***	-1.180***	-0.761***	-0.333*	-0.059
	(0.378)	(0.314)	(0.255)	(0.200)	(0.186)
Δ FFR * HHI	0.554***	0.522***	0.374***	0.327***	0.308***
	(0.039)	(0.035)	(0.027)	(0.022)	(0.021)
Observations	186490	202175	198318	211728	211694
Adjusted R2	0.951	0.861	0.863	0.846	0.835
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table 5: Deposit Volume and Treasury Supply (Military Expenditure IV)

This table shows the IV estimates of the effect of Treasury supply on deposit growth from 1994 to 2016. The sample for the results in columns (1) and (2) consists of all banks with branches in two or more counties. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
TSY Growth * HHI	4.977**	4.053**	6.222***	5.631***	9.322***	8.377***
	(1.985)	(1.613)	(0.871)	(0.776)	(1.565)	(1.350)
Δ FFR * HHI		-0.034***		-0.053***		-0.085***
		(0.011)		(0.007)		(0.013)
Observations	1,415,721	1,415,721	1,569,320	1,569,320	1,569,320	1,569,320
Adjusted R2	-0.083	-0.078	-0.035	-0.029	-0.086	-0.069
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	No	No	No	No
Year FE	No	No	No	No	No	No

Table 6: Treasury-Deposit Spread and Treasury Supply (Military Expenditure IV)

This table shows the IV estimates of the effect of Treasury supply on Treasury-deposit spreads from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Spread changes for savings and money market deposits are equal to the changes in the six-month Treasury yield minus the changes in deposit rates at the branch level. Spread changes for time deposits are equal to the changes in maturity-matched Treasury yield minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ Treasury-Deposit Spread (≥ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-5.056***	-1.297**	-2.203***	-1.692***	-1.634***
	(0.787)	(0.656)	(0.581)	(0.446)	(0.386)
Δ FFR * HHI	0.446***	0.467***	0.272***	0.240***	0.175***
	(0.038)	(0.035)	(0.030)	(0.022)	(0.018)
Observations	186490	202175	198318	211728	211694
Adjusted R2	-0.184	-0.252	-0.252	-0.266	-0.275
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table 7: Fed Funds-Deposit Spread and Treasury Supply (Military Expenditure IV)

This table shows the IV estimates of the effect of Treasury supply on Fed funds-deposit spreads from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the Fed funds target rate minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ FFR-Deposit Spread (≥ 2 Counties)				
	(1) Saving	(2) MM	(3) 3m CD	(4) 6m CD	(5) 12m CD
TSY Growth * HHI	-5.454***	-1.666**	-2.664***	-2.073***	-2.272***
	(0.836)	(0.681)	(0.617)	(0.473)	(0.439)
Δ FFR * HHI	0.480***	0.510***	0.324***	0.283***	0.251***
	(0.040)	(0.037)	(0.032)	(0.024)	(0.021)
Observations	186490	202175	198318	211728	211694
Adjusted R2	-0.182	-0.246	-0.245	-0.260	-0.267
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table 8: Deposit Volume and Treasury Supply: Maturity

This table shows the effect of the maturity structure of Treasuries on deposit growth from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Deposit Growth is the log change in deposits at the branch level. Short-term TSY Growth is the log change in Treasuries with less than one-year maturity. Long-term TSY Growth is the log change in Treasuries with more than one-year maturity. TSY Growth (Haircut) is the log change in Treasury supply measured by weighing Treasuries of different maturities by one minus their repo haircuts. TSY Growth (Liquidity) is the log change in Treasury supply measured by weighting Treasuries of different maturities by their liquidity premium. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth			
	(1)	(2)	(3)	(4)
Short-term TSY Growth * HHI	0.118***	0.090***		
	(0.030)	(0.030)		
Long-term TSY Growth * HHI	0.069**	0.113***		
	(0.033)	(0.037)		
Δ FFR * HHI		-0.010***	-0.011***	-0.010***
		(0.003)	(0.003)	(0.003)
TSY Growth (Haircut) * HHI			0.209***	
			(0.045)	
TSY Growth (Liquidity) *HHI				0.206***
				(0.044)
Observations	1,363,784	1,363,784	1,363,784	1,363,784
Adjusted R2	0.185	0.185	0.185	0.185
Controls	Yes	Yes	Yes	Yes
Bank Year FE	Yes	Yes	Yes	Yes
State Year FE	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes

Table 9: Deposit Volume and Treasury Supply: Local Clientele

This table shows the effect of Treasury supply on deposit growth depending on HHI and other county characteristics from 1994 to 2016. The sample consists of all banks with branches in two or more counties. Age is the share of the county population that is aged 65 or older. Income is the natural log of county-level median household income. College is the county share of the population with a college degree. TSY Growth is the log change in Treasury supply. ΔFFR is the change in the Fed funds rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth			
	(1)	(2)	(3)	(4)
TSY Growth * HHI	0.127***	0.185***	0.195***	0.181***
	(0.043)	(0.044)	(0.046)	(0.044)
TSY Growth * Age	0.006***			0.008***
	(0.001)			(0.001)
TSY Growth * Income		0.028		0.010
		(0.020)		(0.029)
TSY Growth * College			0.001***	0.002***
			(0.001)	(0.001)
Δ FFR * HHI				-0.009***
				(0.003)
Δ FFR * Age				-0.000***
				(0.000)
Δ FFR * Income				-0.001
				(0.002)
Δ FFR * College				0.000
				(0.000)
Observations	1,413,822	1,413,822	1,413,822	1,413,822
Adjusted R2	0.185	0.185	0.185	0.185
Controls	Yes	Yes	Yes	Yes
Bank Year FE	Yes	Yes	Yes	Yes
State Year FE	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes

Table 10: Deposit Volume and Treasury Supply: Repo Funding

This table shows the effect of Treasury supply on deposit growth for banks below the third quartile of repo funding from 1994 to 2016. Deposit growth is the log change in deposits at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth	
	(1)	(2)
TSY Growth * HHI	0.282***	0.287***
	(0.075)	(0.076)
Δ FFR * HHI		-0.005
		(0.005)
Observations	451,334	451,334
Adjusted R2	0.192	0.192
Controls	Yes	Yes
Bank Year FE	Yes	Yes
State Year FE	Yes	Yes
Branch FE	Yes	Yes
County FE	Yes	Yes

Table 11: Deposit Volume and Treasury Supply: Slow-Moving Treasuries

This table shows the effect of slow-moving Treasuries on deposit growth. Data is sampled every five years, from 2000 to 2015. The sample consists of all banks with branches in two or more counties. Deposit growth is the log change in deposits at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. Standard errors are clustered by county.

	Branch-Level Deposit Growth	
	(1)	(2)
TSY Growth * HHI	0.433***	0.707***
	(0.075)	(0.096)
Δ FFR * HHI		0.085***
		(0.018)
Observations	111,726	111,726
Adjusted R2	0.185	0.185
Controls	Yes	Yes
Bank Year FE	Yes	Yes
State Year FE	Yes	Yes
Branch FE	Yes	Yes
County FE	Yes	Yes

Table 12: Treasury Supply, Small Business Loans, and Mortgages

This table shows the effect of Treasury supply on new small business lending and new mortgage lending from 1997 to 2016. For columns (1) and (2), the dependent variable is the log of small business loans originated by county per year. For the last four columns, the dependent variable is log of mortgage loans originated by county per year that is kept on balance sheet (columns (3) and (4)) and sold (columns (5) and (6)). TSY Growth is the log change in Treasury supply. County HHI measures the county-level HHI. Bank HHI measures the average market concentration of the bank's branches, where each branch takes the HHI of the county in which it is located. ΔFFR is the change in the Fed funds target rate. Securities is the ratio of Treasuries, agency, and other securities as a proportion of bank assets. Fixed effects are denoted at the bottom of the table. Control variables include bank-level changes in unemployment rate, income per capita, and population growth, and their interactions with HHI. Standard errors are clustered by county and bank.

	Small Business Loans		Mortgage Loans			
			On-balance sheet		Sold	
	(1)	(2)	(3)	(4)	(5)	(6)
TSY Growth * Bank HHI	1.808***	1.521***	2.645***	0.749***	-0.995***	-2.645***
	(0.140)	(0.136)	(0.266)	(0.226)	(0.354)	(0.326)
Δ FFR * Bank HHI	-0.320***	-0.309***	-0.155***	-0.234***	0.122***	-0.021
	(0.014)	(0.013)	(0.016)	(0.014)	(0.028)	(0.023)
TSY Growth * County HHI		0.002		-0.139		-0.110
		(0.077)		(0.096)		(0.096)
Δ FFR * County HHI		0.006		0.002		-0.004
		(0.005)		(0.006)		(0.007)
Securities	0.175***	0.127***	-0.717***	-0.758***	-0.644***	-0.600***
	(0.033)	(0.032)	(0.043)	(0.042)	(0.046)	(0.045)
Observations	921,337	893,827	699,812	680,229	463,604	454,446
Adjusted R2	0.804	0.804	0.712	0.705	0.766	0.762
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank County FE	Yes	Yes	Yes	Yes	Yes	Yes
County Year FE	Yes	No	Yes	No	Yes	No
Year FE	No	Yes	No	Yes	No	Yes

Table 13: Crowding-Out Sensitivity by Deposit Type and the Ratio of Wholesale Funding

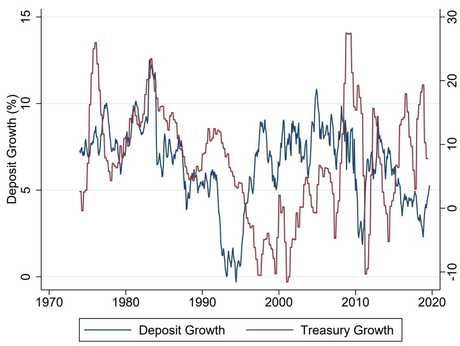
The first three columns of this table show the effect of Treasury supply on deposit growth for different types of deposits. The fourth column shows the effect of Treasury supply on changes in wholesale funding ratio. Data are at the bank-year level and cover the years 1994 to 2016. Deposit growth is the log change in deposits at the bank level. TSY Growth is the log change in Treasury supply. Bank HHI measures the average market concentration of the bank's branches, where each branch takes the HHI of the county in which it is located. Note that a larger HHI means less competition. ΔFFR is the change in the Fed funds target rate. Core Deposits are comprised of checking, savings and small time deposits (less than \$100K). Time Deposits are the sum of small and large time deposits. Wholesale Funding is comprised of wholesale deposits, Fed funds, repo borrowing, and other borrowed money. Wholesale Funding Ratio is the ratio of wholesale funding over total deposit funding. Controls include bank-level changes in unemployment rate, income per capita, and population, and their interactions with HHI. Controls also include log total assets, leverage ratio, and returns on assets. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by bank.

	Bank-Level Deposit Growth Rates			Δ Wholesale
	Core Dep.	Time Dep.	Wholesale Dep.	Funding Ratio
	(1)	(2)	(3)	(4)
TSY Growth	-0.209***	-0.275***	-0.428***	-0.027***
	(0.014)	(0.019)	(0.030)	(0.003)
TSY Growth * Bank HHI	0.504***	0.542***	0.903***	0.027***
	(0.049)	(0.067)	(0.111)	(0.010)
Δ FFR	-0.011***	0.016***	0.021***	0.002***
	(0.001)	(0.001)	(0.003)	(0.000)
Δ FFR * Bank HHI	0.000	-0.041***	-0.021**	-0.001
	(0.003)	(0.005)	(0.009)	(0.001)
Observations	651,608	649,392	648,710	652,880
Adjusted R2	0.021	0.044	0.030	0.013
Bank Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes

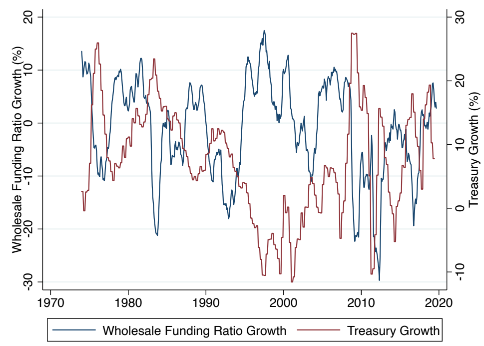
Figure 1: Treasury Supply and Bank Deposits over Time

Panel (a) plots the year-over-year growth in the total deposits of commercial banks against Treasury supply growth. Panel (b) plots the year-over-year growth in the ratio of wholesale funding and Treasury supply growth. The wholesale funding ratio is defined as large time deposits over total deposits. Panel (c) plots year-over-year changes in the spread between the 3-month Treasury yield and the three-month CD rate against Treasury supply growth. The sample period is from 1973 to 2019.

(a) Deposit Growth



(b) Wholesale Funding Ratio



(c) Deposit Spread

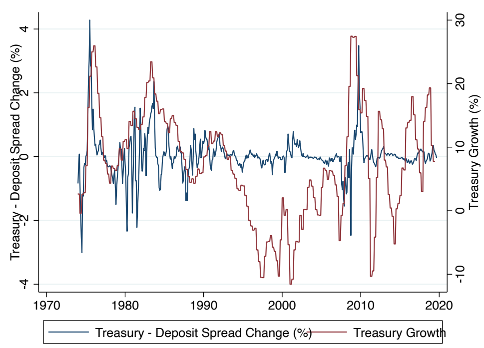
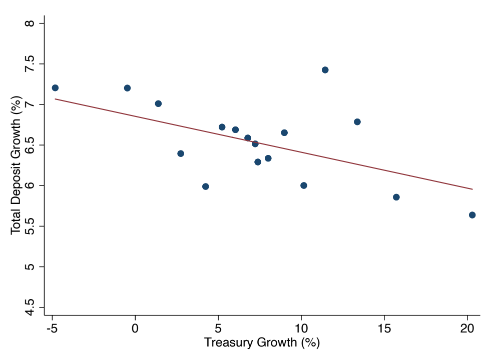


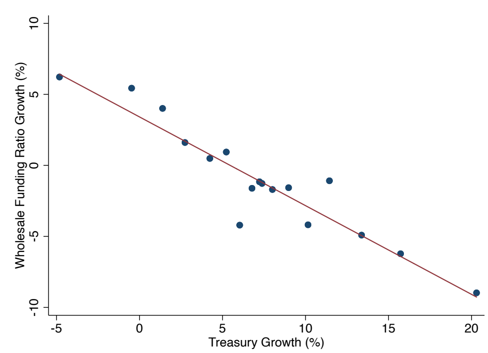
Figure 2: Treasury Supply versus Bank Deposits

Panel (a) is a binned scatterplot of year-over-year growth in the total deposits of commercial banks against Treasury supply growth. Panel (b) is a binned scatterplot of year-over-year growth in the ratio of wholesale funding and Treasury supply growth. The wholesale funding ratio is defined as large time deposits over total deposits. Panel (c) is a binned plot of year-over-year changes in the spread between the three-month Treasury yield and the three-month CD rate against Treasury supply growth. All variables are residualized by absorbing the effect of year-over-year changes in the Fed funds rate to control for the impact of monetary policy. The sample period is from 1973 to 2019.

(a) Deposit Growth



(b) Wholesale Funding Ratio



(c) Deposit Spread

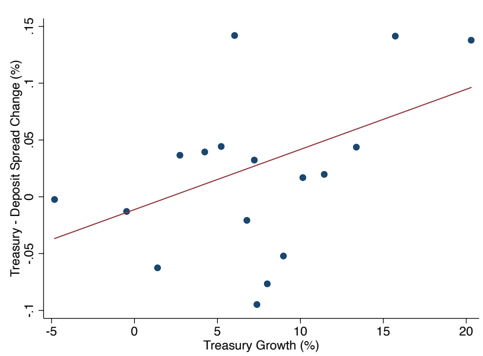


Figure 3: Illustration of the Impact of Treasury Supply on Bank Deposits

This figure illustrates the mechanism of Proposition 1. In panels (a) and (b), we illustrate the change of aggregate deposit demand and supply curves in response to the same increase of Treasury supply, under different levels of deposit competition.

(a) Less Competitive Region (b) More Competitive Region

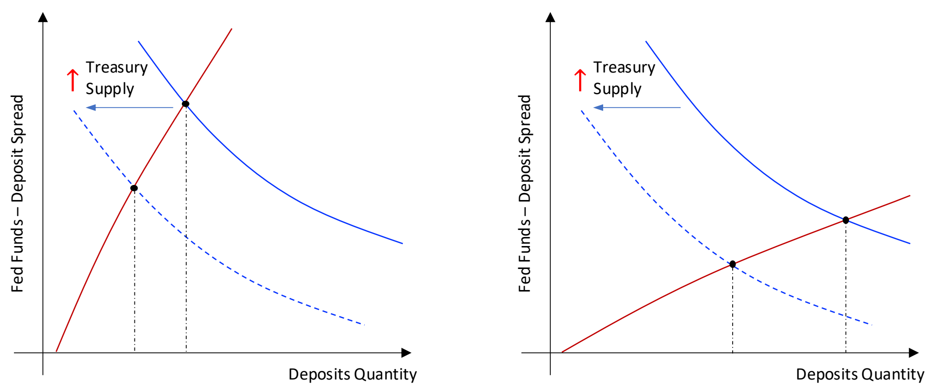


Figure 4: Composition of Bank Asset Holdings

This figure shows the asset composition of the US commercial banking sector from 1980 to 2018. Data are from the Flow of Funds.

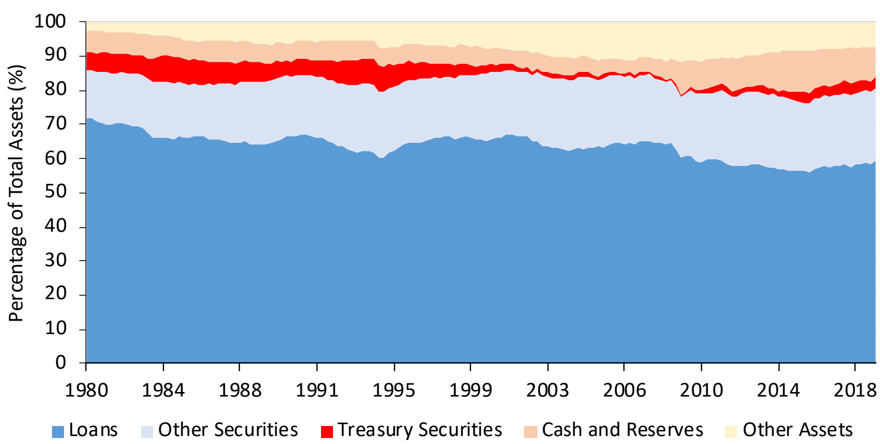
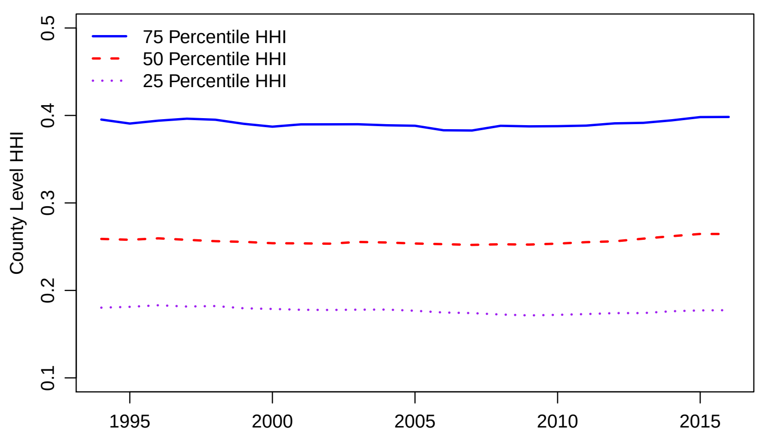


Figure 5: Deposit Competition in the US

This figure presents information on county-level and bank-level deposit competition in the US. Subfigure (a) plots the first, second, and third quartiles of county-level HHI over time from 1997 to 2016. Subfigure (b) plots the distribution of the bank-level HHI, which is measured as the weighted average of the bank's branch-level HHI. Data are from the FDIC.

(a) County-Level Herfindahl Index from 1997 to 2016



(b) Bank-Level Herfindahl Index Distribution

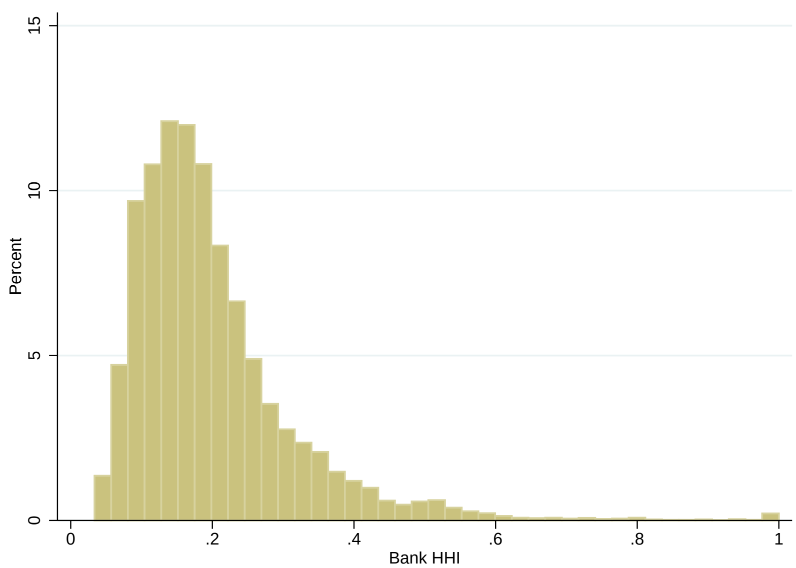


Figure 6: Sensitivity of Deposit Growth by Deposit Competition

This figure plots deposit growth sensitivities to Treasury growth against county-level HHI. Data are at the county-year level and cover 1994–2016. Counties are first divided into 20 equal-sized bins according to their HHI. Then, branch-level deposit growth is regressed against Treasury growth interacted with indicator variables for each bin and controlling for year and branch fixed effects. The coefficients on the indicator variables correspond to the average sensitivity of deposit growth to Treasury growth among bank branches located in a given region of deposit competition. The last bin is taken as the baseline for comparison. Data are from the FDIC and TreasuryDirect.

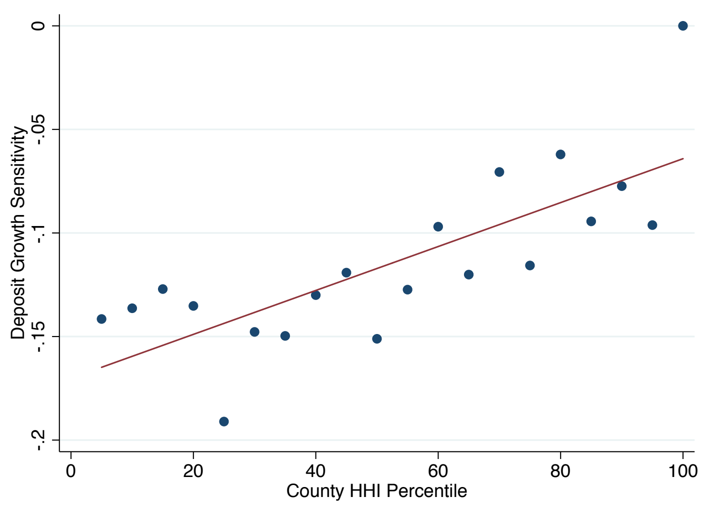
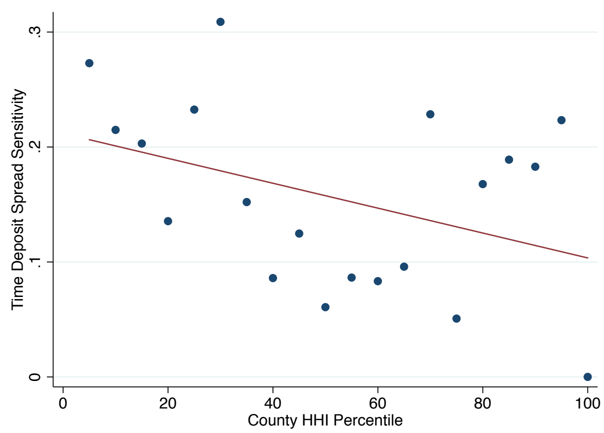


Figure 7: Sensitivity of Treasury-Deposit Spreads by Deposit Competition

This figure plots deposit spread sensitivities to Treasury growth against county-level HHI. Panels (a) and (b) show results for time and savings deposits, respectively. The data are at the branch-quarter level and cover years 1997 to 2016. Counties are first divided into 20 equal-sized bins according to their HHI. Then, branch-level deposit spread changes are regressed against Treasury growth interacted with indicator variables for each bin and controlling for year and branch fixed effects. The coefficients on the indicator variables correspond to the average sensitivity of deposit spread changes to Treasury growth among bank branches located in a given region of deposit competition. The last bin is used as the baseline for comparison. Data are from RateWatch, FDIC, and TreasuryDirect.

(a) Sensitivity of Time Deposit Spread



(b) Sensitivity of Savings Deposit Spread

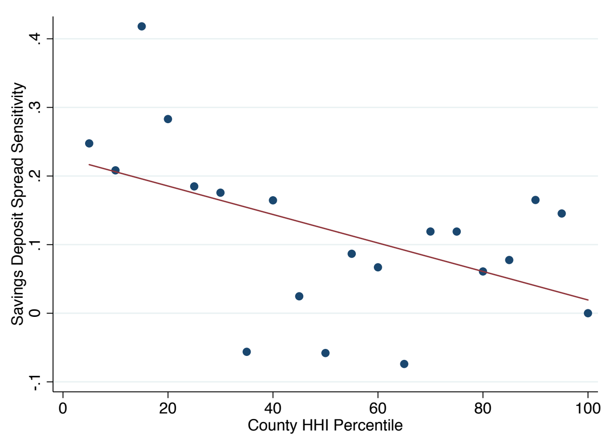


Figure 8: Illustrative Example of Deposit Spreads for Two Branches of the Same Bank

This figure plots the hypothetical spread of three-month Treasuries and three-month CDs at two branches of a hypothetical bank from October 2004 to April 2005. One branch is located in a more competitive county, county A (red), while the other is in a less competitive county, county B (blue). During this period, Treasury growth increased by 3.24% from 2004Q4 to 2005Q1. Data are from TreasuryDirect.

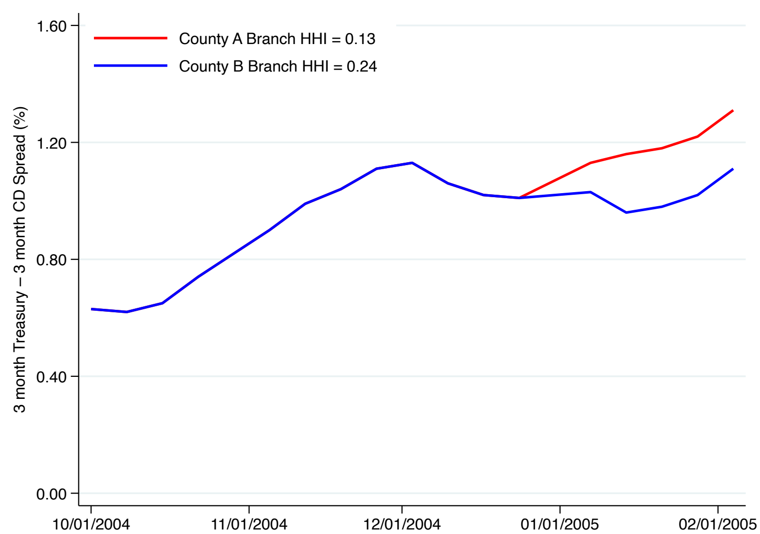
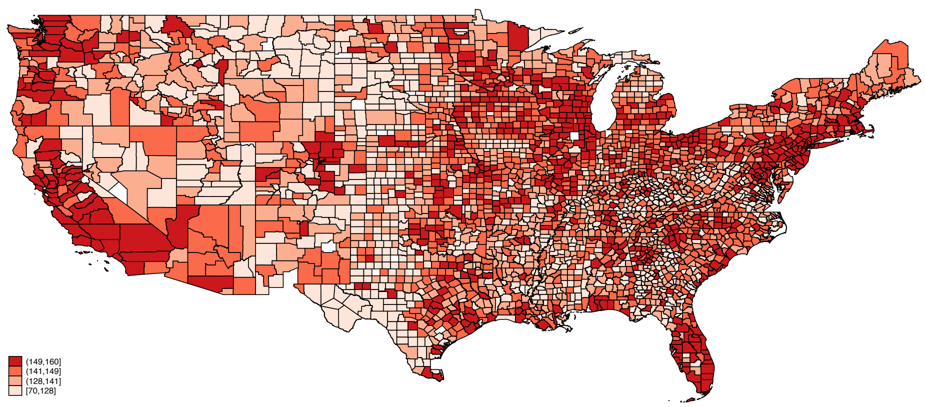


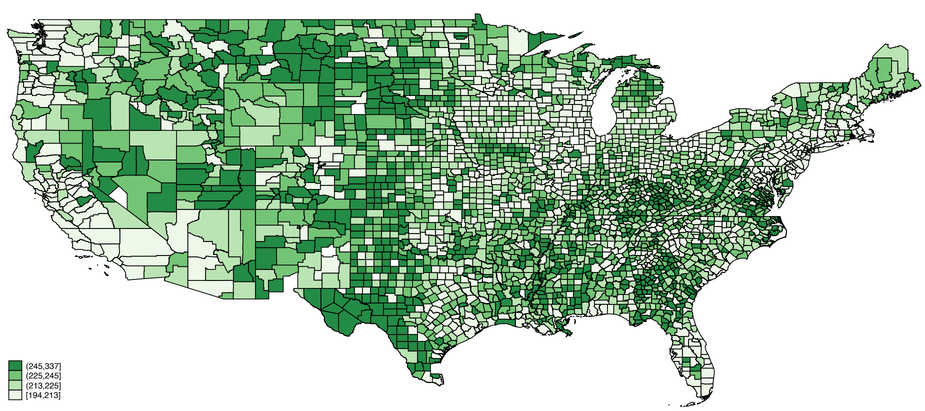
Figure 9: Passthrough of Treasury Supply and Monetary Policy to County-Level Deposits

This figure plots county-level deposit volume passthrough sensitivities to Treasury supply and monetary policy. Panel (a) shows the decrease in deposit growth (bps) due to a one-standard-deviation increase in Treasury growth for each county. Darker shades correspond to a more pronounced effect, which occurs in counties with a lower HHI, i.e., more competitive counties. Panel (b) shows the decrease in deposit growth (bps) due to a one-standard-deviation increase in the Fed funds rate for each county. Darker shades correspond to a more pronounced effect, which occurs in counties with a higher average HHI, i.e., less competitive counties. Data are from RateWatch, FDIC, and TreasuryDirect.

(a) Passthrough of Treasury Supply



(b) Passthrough of Monetary Policy



Internet Appendix to "The Passthrough of Treasury Supply to Bank Deposit Funding".

Wenhao Li, Yiming Ma, and Yang Zhao[1]

A.1. Model Derivations

This appendix contains the derivations of our main findings. For simplicity, we denote the Fed funds—deposit spread as "the deposit spread", and the Fed-funds—Treasury spread as "the Treasury spread".

A.1.1. Individual Bank's Deposit Demand Elasticity

We expand the full problem in (5) as

$$\min_{M,D_i,i=1,2,\cdots,N} \quad \frac{1}{\bar{M}}\left(Mr+\sum_{i=1}^{N}\frac{D_i}{N}s_i\right), \tag{A-1}$$

subject to

$$\left(\delta_M M^{\frac{\epsilon-1}{\epsilon}}+(1-\delta_M)D^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}=\bar{M} \tag{A-2}$$

where D is given by (1). Denote the Lagrangian multiplier on (A-2) as $\lambda_{\bar{M}}$. Then the FOC on D_i is

$$\lambda_{\bar{M}}\bar{M}^{\frac{1}{\epsilon}}(1-\delta_M)D^{-\frac{1}{\epsilon}}D^{\frac{1}{\eta}}\frac{1}{N}D_i^{-\frac{1}{\eta}}=\frac{1}{\bar{M}}\frac{1}{N}s_i. \tag{A-3}$$

Using the definition of s in (8), we can rewrite the objective function in (A-1) as

$$\min_{M,D} \quad \frac{1}{\bar{M}}\left(Mr+Ds\right), \tag{A-4}$$

subject to (A-2). Then the first-order conditions over cash and aggregate deposits are

$$\lambda_{\bar{M}}\bar{M}^{\frac{1}{\epsilon}}\delta_M M^{-\frac{1}{\epsilon}}=\frac{1}{\bar{M}}r, \tag{A-5}$$

$$\lambda_{\bar{M}}\bar{M}^{\frac{1}{\epsilon}}(1-\delta_M)D^{-\frac{1}{\epsilon}}=\frac{1}{\bar{M}}s. \tag{A-6}$$

Taking the ratio between (A-3) and (A-6), we obtain

$$\frac{D_i}{D}=\left(\frac{s_i}{s}\right)^{-\eta}. \tag{A-7}$$

[1]Wenhao Li is with USC Marshall School of Business. Yiming Ma is with Columbia Business School. Yang Zhao is with Amazon Inc.

To derive the individual bank's deposit demand elasticity, we take log on both sides of equation (A-7),

$$\log(D_i) = \log(D) - \eta \log(s_i) + \eta \log(s). \tag{A-8}$$

Next, we take the derivative over $\log(s_i)$ on both sides of (A-8).

$$\frac{\partial \log(s)}{\partial \log(s_i)} = \frac{1}{N}\frac{s_i}{s}\left(\frac{D_i}{D} + \frac{1}{D}\frac{\partial D_i}{\partial s_i}s_i + \frac{1}{D}\sum_{j\neq i}\frac{\partial D_j}{\partial s_i}s_j + \sum_{j=1}^{N} D_j s_j(-\frac{1}{D^2})\frac{\partial D}{\partial s_i}\right). \tag{A-9}$$

In (A-9), it is important to account for the impact of s_i on D and s, where s is defined in equation (8). Under a symmetric equilibrium, $s_i = s$, $D_i = D$, so we can simplify the above as

$$\frac{\partial \log(s)}{\partial \log(s_i)} = \frac{1}{N}\left(1 + \frac{\partial \log(D_i)}{\partial \log(s_i)} + \sum_{j\neq i}\frac{\partial \log(D_j)}{\partial \log(s_i)} - N\frac{\partial \log(D)}{\partial \log(s_i)}\right). \tag{A-10}$$

Using the definition of D in equation (1), we get

$$\frac{\partial D}{\partial s_i} = D^{\frac{1}{\eta}}\frac{1}{N}D_i^{-\frac{1}{\eta}}\frac{\partial D_i}{\partial s_i} + D^{\frac{1}{\eta}}\frac{1}{N}D_j^{-\frac{1}{\eta}}\sum_{j\neq i}\frac{\partial D_j}{\partial s_i}. \tag{A-11}$$

Under the symmetric equilibrium, (A-11) can be simplified as

$$N\frac{\partial \log(D)}{\partial \log(s_i)} = \frac{\partial \log(D_i)}{\partial \log(s_i)} + \sum_{j\neq i}\frac{\partial \log(D_j)}{\partial \log(s_i)}. \tag{A-12}$$

Plugging (A-12) into equation (A-10), we find that the last three terms in the bracket cancel out, so we get

$$\frac{\partial \log(s)}{\partial \log(s_i)} = \frac{1}{N}. \tag{A-13}$$

We can then take the derivative over $\log(s_i)$ in equation (A-8) to get

$$\frac{\partial \log(D_i)}{\partial \log(s_i)} = \frac{\partial \log(D)}{\partial \log(s)}\frac{1}{N} - \eta(1 - \frac{1}{N}). \tag{A-14}$$

Next, we plug (A-5) and (A-6) into (A-2) to solve for λ_M,

$$\lambda_{\bar{M}} = \bar{M}^{-1}\left(\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}} \tag{A-15}$$

Using (A-5), (A-6), and (A-15), we can simplify the objective function value in (A-4) as

$$\frac{1}{\bar{M}}(Mr + Ds) = \left(\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}} \tag{A-16}$$

By the definition of near-money holding cost $\bar{s}$ in (5), the above is exactly $\bar{s}$, so that

$$\bar{s} = \left(\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}. \tag{A-17}$$

With (A-15) and (A-17), we simplify the deposit and cash demand in (A-5) and (A-6) as

$$D = (1-\delta_M)^{\epsilon}\bar{M}\left(\frac{s}{\bar{s}}\right)^{-\epsilon}, \tag{A-18}$$

$$M = \delta_M^{\epsilon}\bar{M}\left(\frac{r}{\bar{s}}\right)^{-\epsilon}, \tag{A-19}$$

By assumption, the individual bank demand elasticity is evaluated up to the optimization problem in (5). Thus, the investor takes $\bar{M}$ as given when they substitute across individual bank deposits and cash. This leads to the $\partial\log(D)/\partial\log(s)$ component in (A-14) as an evaluation of (A-18) by keeping $\bar{M}$ fixed,

$$\begin{aligned}\frac{\partial\log(D)}{\partial\log(s)}|_{\text{fixing }\bar{M}} &= -\epsilon\left(1-(1-\delta_M)^{\epsilon}(\frac{s}{\bar{s}})^{1-\epsilon}\right)\\ &= -\epsilon\frac{\delta_M^{\epsilon}r^{1-\epsilon}}{\delta_M^{\epsilon}r^{1-\epsilon}+(1-\delta_M)^{\epsilon}s^{1-\epsilon}}.\end{aligned} \tag{A-20}$$

Combining equations (A-14) and (A-20), we obtain

$$-\frac{\partial\log(D_i)}{\partial\log(s_i)} = \eta(1-\frac{1}{N}) + \left(\epsilon-\epsilon(1-\delta_M)^{\epsilon}(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}, \tag{A-21}$$

Expanding $\bar{s}$ using equation (A-17) and using the ratio between (A-18) and (A-19), we obtain

$$\begin{aligned}-\frac{\partial\log(D_i)}{\partial\log(s_i)} &= \eta(1-\frac{1}{N}) + \epsilon\frac{\delta_M^{\epsilon}r^{1-\epsilon}}{\delta_M^{\epsilon}r^{1-\epsilon}+(1-\delta_M)^{\epsilon}s^{1-\epsilon}}\frac{1}{N}.\\ &= \eta(1-\frac{1}{N}) + \epsilon\underbrace{\frac{Mr}{Mr+Ds}}_{\text{expenditure share of cash}}\frac{1}{N}.\end{aligned} \tag{A-22}$$

As a result, the share of expenditure by cash is crucial for the magnitude of an individual bank's deposit demand elasticity. When deposits become more dominant (i.e., expenditure share of cash is lower), the individual deposit demand elasticity decreases, leading to more bank deposit market power. Note that the first line of (A-22) is exactly equation (9) in the main text.

A.1.2. Bank Optimization and Aggregate Deposit Supply

The bank optimization problem in (7) can be simplified as

$$\max_{s_i} \quad D_i\left(s_i+b_0-\frac{b_1}{2}D_i\right). \tag{A-23}$$

The first-order condition is

$$\frac{\partial D_i}{\partial s_i}\left(s_i+b_0-\frac{b_1}{2}D_i\right)+D_i\left(1-\frac{b_1}{2}\frac{\partial D_i}{\partial s_i}\right)=0, \tag{A-24}$$

which can be simplified as

$$\frac{s_i}{s_i + b_0 - b_1 D_i} = -\frac{\partial \log(D_i)}{\partial \log(s_i)}. \tag{A-25}$$

Plugging in (9), we obtain

$$\frac{s_i}{s_i + b_0 - b_1 D_i} = \eta(1 - \frac{1}{N}) + \epsilon \frac{\delta_M^\epsilon r^{1-\epsilon}}{\delta_M^\epsilon r^{1-\epsilon} + (1-\delta_M)^\epsilon s^{1-\epsilon}} \frac{1}{N}.$$

In the symmetric equilibrium, $s_i = s$ and $D_i = D$, so we obtain the aggregate deposit supply (denoted as $\hat{D}$)

$$\hat{D}(s,r) = \frac{b_0}{b_1} + \frac{1}{b_1}\left(1 - \left(\eta(1 - \frac{1}{N}) + \epsilon \frac{\delta_M^\epsilon r^{1-\epsilon}}{\delta_M^\epsilon r^{1-\epsilon} + (1-\delta_M)^\epsilon s^{1-\epsilon}} \frac{1}{N}\right)^{-1}\right) s, \tag{A-26}$$

which is equation (10) in the main text. Because

$$\epsilon \frac{\delta_M^\epsilon r^{1-\epsilon}}{\delta_M^\epsilon r^{1-\epsilon} + (1-\delta_M)^\epsilon s^{1-\epsilon}} < \eta,$$

deposit supply $\hat{D}(s,r)$ as in (A-26) increases with N. Moreover, it is straightforward to see that $\hat{D}(s,r)$ also increases with η. Finally, we can rewrite (A-26) as

$$\hat{D}(s,r) = \frac{b_0}{b_1} + \frac{1}{b_1}\left(1 - \left(\eta(1 - \frac{1}{N}) + \epsilon \frac{\delta_M^\epsilon}{\delta_M^\epsilon + (1-\delta_M)^\epsilon (\frac{r}{s})^{\epsilon-1}} \frac{1}{N}\right)^{-1}\right) s. \tag{A-27}$$

According to (A-27), $\hat{D}(s,r)$ decreases with r/s. Therefore, $\hat{D}'_r < 0$, i.e., monetary tightening reduces aggregate bank deposit supply.

Next, we evaluate the slope of the deposit supply curve,

$$\hat{D}'_s = \frac{1}{b_1}\left(1 - \frac{1}{\hat{\eta}}\right) + \frac{1}{b_1} s \frac{1}{\hat{\eta}^2} \frac{1}{N} \epsilon(\epsilon - 1)(1-\delta_M)^\epsilon (\frac{s}{\bar{s}})^{1-\epsilon}, \tag{A-28}$$

where we define

$$\hat{\eta}(\frac{r}{s}; \eta, N) \equiv \eta(1 - \frac{1}{N}) + \epsilon \frac{\delta_M^\epsilon r^{1-\epsilon}}{\delta_M^\epsilon r^{1-\epsilon} + (1-\delta_M)^\epsilon s^{1-\epsilon}} \frac{1}{N}. \tag{A-29}$$

According to the assumption $\eta(1 - 1/N) \geq 1$, we get $\hat{\eta} > 1$. Thus, both terms in (A-28) are positive. The second term is of a smaller order, because the second term involves s/N, which is very small.

More specifically, the ratio between the second term and the first term in (A-28) is

$$\mathcal{R} = \frac{s \frac{1}{N} \epsilon(\epsilon - 1)(1-\delta_M)^\epsilon (\frac{s}{\bar{s}})^{1-\epsilon}}{\hat{\eta}(\frac{r}{s}; \eta, N)(\hat{\eta}(\frac{r}{s}; \eta, N) - 1)} \tag{A-30}$$

Since $\hat{\eta}$ increases in η and N, we get that $\mathcal{R}$ decreases in η and N. To estimate an upper bound on $\mathcal{R}$, we can thus use the lowest N in the model, which is 2. In this case, the lowest η that satisfies our regularity assumption $\eta(1-1/N) \geq 1$ is 2. Moreover, since $\bar{s}$ increases in r, and $\hat{\eta}$ decreases in r, the value of $\mathcal{R}$ increases in r. We will use the highest Fed funds rate (quarterly average) in our sample period, which is 6.5%. Since $\mathcal{R}$ is not monotonic in ϵ and s, we set representative values, $\epsilon = 1.2$, and $s = 1.3\%$, which is the average savings deposit spread in our sample. To determine δ_M, we note that according to (A-18) and (A-19), the cash-to-deposit ratio is,

$$\frac{M}{D} = \left(\frac{\delta_M}{1-\delta_M}\right)^{\epsilon} (\frac{r}{s})^{-\epsilon}. \tag{A-31}$$

To measure this ratio, we treat investors in the model as households and nonprofit sectors in reality. We use the total time and savings deposits (series "HNOTSDA027N" in FRED) to represent D, and checkable deposits and currency (series "CDCABSHNO" in FRED) to represent M. We use the average ratio in the data in our main sample period, which is 0.135. This leads to $\delta_M = 0.485$. The above parametrization leads to a value of $\mathcal{R} = 0.003$, which serves as an upper bound.

On the other hand, if we use average values rather than trying to derive an upper bound of $\mathcal{R}$, we pick $N = 25$ (the average number of branches per county), $\eta = 2.66$ as in Barnett (1980), and the average Fed funds rate 2.5% in our sample period. Then we obtain $\mathcal{R} = 0.00002$.

Summarizing over the above cases, we conclude that the second term in (A-28) is of a smaller order. As a result, we approximate D'_s as

$$\hat{D}'_s \approx \frac{1}{b_1}\left(1 - \frac{1}{\hat{\eta}(\frac{r}{s};\eta,N)}\right), \tag{A-32}$$

Next, we characterize how competition affects deposit supply.

Lemma 1. *A higher N or η leads to a more elastic deposit supply curve.*

$$\hat{D}''_{s,N} > 0, \quad \hat{D}''_{s,\eta} > 0,$$

Moreover, a higher N or η weakens the shrinking effect of monetary policy r on deposit supply (note that $\hat{D}'_r < 0$),

$$\hat{D}''_{r,N} > 0, \quad \hat{D}''_{r,\eta} > 0.$$

Proof. According to (A-29), $\hat{\eta}$ increases in both η and N. As a result, (A-32) implies that $\hat{D}'_s$ increases in both η and N, leading to $\hat{D}''_{s,N} > 0$ and $\hat{D}''_{s,\eta} > 0$.

Next, we consider the impact of competition on $\hat{D}'_r$. Taking derivative over r in (A-26), we get

$$\hat{D}'_r = \frac{1}{b_1}\frac{-\epsilon(\epsilon-1)(1-\delta_M)^{\epsilon}s^{2-\epsilon}\bar{s}^{\epsilon-2}}{\hat{\eta}(\frac{r}{s};\eta,N)^2}\frac{\partial\bar{s}}{\partial r}, \tag{A-33}$$

where $\frac{\partial \bar{s}}{\partial r} > 0$ according to (A-17). Consequently, $\hat{D}'_r < 0$. Moreover, a higher N or η increases the denominator in (A-33) and reduces the magnitude of $|\hat{D}'_r|$. Thus, we get $\hat{D}''_{r,N} > 0$ and $\hat{D}''_{r,\eta} > 0$. □

A.1.3. Aggregate Demand Functions

Next, we derive the aggregate demand functions, including the demand for Treasuries and deposits. Following the usual approach in solving CES demand problems, we decompose the problem of solving $\bar{M}$, G, and consumption C to maximize (4) into two steps. First, given liquidity holding L, the decision between near money and Treasury can be formulated as

$$\begin{aligned} &\min_{M,D} \bar{M}\bar{s} + \ell G \\ &s.t. \left((1-\delta_G)\left(\bar{M}\right)^{\frac{\sigma-1}{\sigma}} + \delta_G G^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} = L. \end{aligned} \tag{A-34}$$

This leads to

$$\bar{M} = (1-\delta_G)^{\sigma} L \left(\frac{\bar{s}}{s_L}\right)^{-\sigma}, \tag{A-35}$$

$$G = \delta_G^{\sigma} L \left(\frac{\ell}{s_L}\right)^{-\sigma}, \tag{A-36}$$

where s_L is defined as

$$s_L = \left((1-\delta_G)^{\sigma}(\bar{s})^{1-\sigma} + (\delta_G)^{\sigma}\ell^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{A-37}$$

Using (A-35), (A-36), and (A-37), we obtain

$$\begin{aligned} \frac{\bar{M}\bar{s} + \ell G}{L} &= \frac{s_L^{\sigma}}{L}\left((1-\delta_G)^{\sigma} L \bar{s}^{1-\sigma} + \delta_G^{\sigma} L \ell^{1-\sigma}\right) \\ &= s_L^{\sigma} \cdot s_L^{1-\sigma} \\ &= s_L \end{aligned} \tag{A-38}$$

Consequently, we can interpret s_L as the average holding cost per unit of liquidity L, which is the interpretation that we use when we set up the expression $s_L(\bar{s}, \ell)$ in equation (13).

Second, given the aggregate liquidity holding cost s_L, we can equivalently write the decision problem between consumption and liquidity at the highest level of liquidity aggregation,

$$\begin{aligned} \max_{C,L} \quad & u(C, L) = C + \frac{\rho}{\rho-1}\beta^{\frac{1}{\rho}} L^{\frac{\rho-1}{\rho}} \\ s.t. \quad & C = W_0(1+r) - s_L L, \end{aligned}$$

which leads to the first-order condition

$$L = \beta s_L^{-\rho}. \tag{A-39}$$

Combining (A-18), (A-35), and (A-39), we get

$$\begin{aligned} D &= (1-\delta_M)^{\epsilon} \bar{M} \left(\frac{s}{\bar{s}}\right)^{-\epsilon} \\ &= (1-\delta_M)^{\epsilon}(1-\delta_G)^{\sigma}\beta s_L^{-\rho}\left(\frac{\bar{s}}{s_L}\right)^{-\sigma}\left(\frac{s}{\bar{s}}\right)^{-\epsilon} \\ &= (1-\delta_M)^{\epsilon}(1-\delta_G)^{\sigma}\beta s_L^{\sigma-\rho}\,(\bar{s})^{\epsilon-\sigma}\,(s)^{-\epsilon}, \end{aligned} \tag{A-40}$$

which gives rise to (12).

Aggregate Treasury demand can be obtained by combining (A-36) and (A-39),

$$G = \delta_G^{\sigma} \beta s_L^{-\rho} \left(\frac{\ell}{s_L} \right)^{-\sigma} = \delta_G^{\sigma} \beta s_L^{\sigma-\rho} (\ell)^{-\sigma}, \tag{A-41}$$

which gives rise to (11). Therefore, both the deposit and Treasury demand will depend on r, s, and ℓ.

Next, we show the properties of aggregate demand functions in the following lemma.

Lemma 2. *Treasury and deposit demand both decrease with respect to their own spread but increase with respect to the other spread and the Fed funds rate, i.e.,*

$$D'_s < 0, D'_r > 0, D'_\ell > 0,$$

$$G'_\ell < 0, G'_r > 0, G'_s > 0.$$

Proof. Taking the derivative over s in (A-40) and multiplying it by s/D, we get the partial derivative of $\log(D)$ over $\log(s)$,

$$\frac{\partial \log(D)}{\partial \log(s)} = \frac{s}{D} D'_s = (\sigma - \rho) \frac{(1-\delta_G)^{\sigma} \bar{s}^{1-\sigma}}{s_L^{1-\sigma}} \frac{(1-\delta_M)^{\epsilon} s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} + (\epsilon - \sigma) \frac{(1-\delta_M)^{\epsilon} s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} - \epsilon.$$

We note that

$$\frac{(1-\delta_G)^{\sigma} \bar{s}^{1-\sigma}}{s_L^{1-\sigma}} = \frac{(1-\delta_G)^{\sigma} \bar{s}^{1-\sigma}}{(1-\delta_G)^{\sigma} (\bar{s})^{1-\sigma} + (\delta_G)^{\sigma} \ell^{1-\sigma}} < 1,$$

$$\frac{(1-\delta_M)^{\epsilon} s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} = \frac{(1-\delta_M)^{\epsilon} s^{1-\epsilon}}{\delta_M^{\epsilon} r^{1-\epsilon} + (1-\delta_M)^{\epsilon} s^{1-\epsilon}} < 1.$$

As a result,

$$\frac{s}{D} D'_s < (\sigma - \rho) + (\epsilon - \sigma) - \epsilon = -\rho < 0,$$

which implies

$$D'_s < 0.$$

Next,

$$\frac{s}{D} D'_r = (\sigma - \rho) \frac{(1-\delta_G)^{\sigma} \bar{s}^{1-\sigma}}{s_L^{1-\sigma}} \frac{\delta_M^{\epsilon} r^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} + (\epsilon - \sigma) \frac{\delta_M^{\epsilon} r^{1-\epsilon}}{(\bar{s})^{1-\epsilon}},$$

$$= \frac{\delta_M^{\epsilon} r^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} \left((\sigma - \rho) \frac{(1-\delta_G)^{\sigma} \bar{s}^{1-\sigma}}{s_L^{1-\sigma}} + (\epsilon - \sigma) \right).$$

Since $\sigma - \rho > 0$ and $\epsilon - \sigma > 0$, we get

$$\frac{s}{D} D'_r > 0.$$

Similarly,

$$\frac{\ell}{D}D'_\ell = (\sigma-\rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}} > 0.$$

The proofs for $G(s,r,\ell)$ are similar. Taking the derivatives over $G(s,r,\ell)$ in (A-41), we get

$$\frac{\ell}{G}G'_\ell = (\sigma-\rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}} - \sigma < \sigma-\rho-\sigma < 0,$$

$$\frac{s}{G}G'_s = (\sigma-\rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} > 0,$$

$$\frac{r}{G}G'_r = (\sigma-\rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{\delta_M^\epsilon r^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} > 0.$$

□

A.1.4. Proof of Proposition 1

Next, we analyze the effect of Treasury supply. We first show that Treasury supply crowds out deposits in both level and log terms. Then, we show that deposit competition amplifies the crowding-out effect in both levels and logs.

We evaluate the following market clearing conditions of deposits and Treasuries,

$$\begin{aligned}\hat{D}(s,r) &= D(s,r,\ell),\\ G_0 &= G(s,r,\ell).\end{aligned} \tag{A-42}$$

The Crowding-Out Effect of Treasury Supply on Deposits

Taking the derivative over G on both sides of the market clearing condition (A-42), we obtain

$$\begin{aligned}\hat{D}_s s'_G &= D'_s s'_G + D'_\ell \ell'_G,\\ 1 &= G'_s s'_G + G'_\ell \ell'_G.\end{aligned}$$

Then, in equilibrium, the sensitivities of the deposit and Treasury spread with respect to Treasury supply are

$$s'_G = \frac{1}{G'_\ell}\frac{1}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}}, \tag{A-43}$$

$$\ell'_G = \frac{1}{G'_\ell}\frac{\frac{\hat{D}_s}{D'_\ell} - \frac{D'_s}{D'_\ell}}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}}. \tag{A-44}$$

Hence, we have the equilibrium crowding-out effect,

$$\frac{\partial D}{\partial G_0} = -\frac{1}{-G'_\ell}\frac{\hat{D}'_s}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}}. \tag{A-45}$$

To determine the sign of the denominator in the RHS of equation (A-45), we first evaluate the sign of $\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell}$, which in turn depends on whether the ratio $\frac{D'_s}{D'_\ell}\frac{G'_\ell}{G'_s}$ is above or below 1. We confirm that this ratio is above one in the following lemma.

Lemma 3. *Treasuries and deposits demand are, on average, more responsive to their own spread than to the spread of their substitute asset, i.e.,*

$$|\frac{D'_s}{D'_\ell}| \cdot |\frac{G'_\ell}{G'_s}| > 1. \tag{A-46}$$

Proof. Taking logs of the expressions of $G(s, r, \ell)$ and $D(s, r, \ell)$ in (A-40) and (A-41), we get

$$\log(D) = \text{constant} + (\sigma - \rho)\log(s_L) + (\epsilon - \sigma)\log(\bar{s}) - \epsilon \log(s),$$

$$\log(G) = \text{constant} + (\sigma - \rho)\log(s_L) - \sigma \log(s).$$

Taking derivatives over s and ℓ in the above expressions, we get

$$\frac{s}{D}D'_s = (\sigma - \rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} + (\epsilon - \sigma)\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} - \epsilon,$$

$$\frac{\ell}{D}D'_\ell = (\sigma - \rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}},$$

$$\frac{s}{G}G'_s = (\sigma - \rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}},$$

$$\frac{\ell}{G}G'_\ell = (\sigma - \rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}} - \sigma.$$

Finally, we obtain

$$\begin{aligned}
\frac{D'_s}{D'_\ell}\frac{G'_\ell}{G'_s} &= \frac{\frac{s}{D}D'_s}{\frac{\ell}{D}D'_\ell} \cdot \frac{\frac{\ell}{G}G'_\ell}{\frac{s}{G}G'_s} \\
&= \frac{(\sigma - \rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} + (\epsilon - \sigma)\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} - \epsilon}{(\sigma - \rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}}} \cdot \frac{(\sigma - \rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}} - \sigma}{(\sigma - \rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}}} \\
&= \left(\frac{\sigma}{(\sigma - \rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}}} - 1\right) \cdot \left(\frac{\epsilon - (\epsilon - \sigma)\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}}}{(\sigma - \rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}}} - 1\right).
\end{aligned}$$

By assumption, $\sigma > \rho > 0$, so we have $\frac{\sigma}{\sigma-\rho} > 1$. Therefore,

$$
\begin{aligned}
\frac{D'_s}{D'_\ell}\frac{G'_\ell}{G'_s} &> \left(\frac{1}{\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}}} - 1\right) \cdot \left(\frac{\sigma \frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}}}{(\sigma-\rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}}} - 1\right) \\
&> \left(\frac{1}{\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}}} - 1\right) \cdot \left(\frac{1}{\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}} - 1\right) \\
&= \frac{s_L^{1-\sigma} - \delta_G^\sigma \ell^{1-\sigma}}{\delta_G^\sigma \ell^{1-\sigma}} \frac{s_L^{1-\sigma} - (1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}} \\
&= \frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{\delta_G^\sigma \ell^{1-\sigma}} \frac{\delta_G^\sigma \ell^{1-\sigma}}{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}} \\
&= 1.
\end{aligned}
$$

which implies

$$|\frac{D'_s}{D'_\ell}| \cdot |\frac{G'_\ell}{G'_s}| > 1.$$

□

We note that Lemma 3 is a natural property of the CES demand function: on average, the demand for one good is more responsive to its own cost than the other.

With Lemma 3 and Lemma 2, we get

$$\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} > 0.$$

Furthermore, the deposit supply curve is upward-sloping (i.e., $\hat{D}'_s > 0$). Taken together, the denominator in the RHS of equation (A-45) is positive, i.e.,

$$\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell} > 0. \tag{A-47}$$

Since $-G'_\ell > 0$ and $\hat{D}'_s > 0$, we have that Treasury supply crowds out deposits in levels, i.e.,

$$\frac{\partial D}{\partial G_0} < 0.$$

The log crowding-out effect immediately follows,

$$\frac{\partial \log(D)}{\partial G_0} = \frac{1}{D}\frac{\partial D}{\partial G_0} < 0.$$

The Effect of Competition

The effect of competition on the crowding-out of deposits can be expressed as

$$\begin{aligned}
&\partial\left(\frac{\partial\log(D)}{\partial G_0}\right)/\partial N \\
=&\frac{1}{D}\frac{\partial\left(\frac{\partial D}{\partial G_0}\right)}{\partial N}-\frac{1}{D^2}\frac{\partial D}{\partial G_0}\frac{\partial D}{\partial N} \\
=&\frac{1}{D}\left(\underbrace{\frac{\partial\left(\frac{\partial D}{\partial G_0}\right)}{\partial N}}_{\text{level effect}}-\underbrace{\frac{1}{D}\frac{\partial D}{\partial G_0}\frac{\partial D}{\partial N}}_{\text{log adjustment}}\right).
\end{aligned} \tag{A-48}$$

In equation (A-48), the first term in the bracket, $\partial(\frac{\partial D}{\partial G_0})/\partial N$, is the impact of competition on the level-crowding-out effect, and the second term in the bracket, $\frac{1}{D}\frac{\partial D}{\partial G_0}\frac{\partial D}{\partial N}$, is the log adjustment. Because Treasuries crowd out deposits ($\partial D/\partial G_0 < 0$) and more competition increases deposits ($\partial D/\partial N > 0$), the log adjustment term is negative. As a result, the impact of competition on the log crowding-out effect ($\partial(\partial\log(D)/\partial G_0)/\partial N < 0$) is a sufficient condition for the impact of competition on the level crowding-out effect ($\partial(\partial D/\partial G_0)/\partial N < 0$). Intuitively, the log adjustment factor reflects a decreasing marginal impact on the percentage change in deposits, because higher N leads to larger equilibrium deposit quantity and thus lower marginal effect of Treasury supply on log deposits, counteracting with the main result that competition reinforces the Treasury crowding-out effect.

In what follows, we will first examine the level effect and then combine the level effect with the log adjustment to evaluate the sign of the whole expression.

We take the first-order derivative over N on both the market clearing conditions for Treasuries and deposits in (A-42),

$$(D'_s s'_N + D'_\ell \ell'_N) = \hat{D}_s s'_N + \hat{D}'_N, \tag{A-49}$$

$$G'_s s'_N + G'_\ell \ell'_N = 0, \tag{A-50}$$

which imply

$$\left(D'_s - \hat{D}_s - D'_\ell \frac{G'_s}{G'_\ell}\right) s'_N = \hat{D}'_N,$$

$$s'_N = -\frac{1}{D'_\ell}\frac{\hat{D}'_N}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}} < 0. \tag{A-51}$$

Then we have the following result.

Lemma 4. *In equilibrium, $\partial D/\partial N > 0$.*

Proof. From equation (A-50), we know that

$$\ell'_N = -\frac{1}{G'_\ell} G'_s s'_N.$$

Thus,

$$\begin{aligned}\frac{\partial D}{\partial N} &= \frac{\partial D(s,\ell)}{\partial N} \\ &= D'_s s'_N + D'_\ell \ell'_N \\ &= s'_N \left(D'_s - \frac{G'_s}{G'_\ell} D'_\ell \right).\end{aligned}$$

According to Lemma 3 and equation (A-51), we obtain $\frac{\partial D}{\partial N} > 0$. □

To simplify notations, we denote

$$\frac{\partial D}{\partial G_0} = \frac{\hat{D}'_s / G'_\ell}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}} \equiv \frac{x}{y},$$

where x denotes the numerator and y denotes the denominator. Then the cross-partial derivative is

$$\begin{aligned}\partial \left(\frac{\partial D}{\partial G_0} \right) / \partial N =& \frac{x'_N y - x y'_N}{y^2} \\ =& \frac{1}{G'_\ell} \frac{\hat{D}''_{sN}}{y} - \frac{x}{y} \frac{y'_N}{y} \\ =& \left(\frac{\hat{D}''_{sN}}{\hat{D}'_s} - \frac{y'_N}{y} \right) \frac{x}{y}.\end{aligned}$$

We are going to show that the above expression is negative.

Since we have already proved that $\frac{\partial D}{\partial G_0} < 0$, we only need to know the sign of $\frac{1}{N} - \frac{y'_N}{y}$. By definition,

$$\frac{y'_N}{y} = \frac{\frac{\hat{D}''_{sN}}{D'_\ell}}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}} = \frac{1}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}} \frac{\hat{D}''_{sN}}{D'_\ell}. \tag{A-52}$$

$$s'_N = -\frac{1}{D'_\ell} \frac{\hat{D}'_N}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}}.$$

Plugging (A-51) into equation (A-52), we obtain

$$\frac{y'_N}{y} = -\frac{s'_N}{\hat{D}'_N} \hat{D}''_{sN} = -\frac{\hat{D}''_{sN}}{\hat{D}'_N} s'_N.$$

Thus, we get

$$\partial\left(\frac{\partial D}{\partial G_0}\right)/\partial N = (\frac{\hat{D}''_{sN}}{\hat{D}'_s} - \frac{y'_N}{y})\frac{x}{y} \tag{A-53}$$

$$= (\frac{\hat{D}''_{sN}}{\hat{D}'_s} + \frac{\hat{D}''_{sN}}{\hat{D}'_N}s'_N)\frac{\partial D}{\partial G_0} \tag{A-54}$$

$$= \frac{\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N}(\hat{D}'_N + \hat{D}'_s s'_N)\frac{\partial D}{\partial G_0}. \tag{A-55}$$

Using

$$\frac{\partial D}{\partial N} = \frac{\partial \hat{D}}{\partial N} = \hat{D}'_s s'_N + \hat{D}'_N, \tag{A-56}$$

we get

$$\partial\left(\frac{\partial D}{\partial G_0}\right)/\partial N = \frac{\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N}\frac{\partial D}{\partial N}\frac{\partial D}{\partial G_0}. \tag{A-57}$$

With Lemma 4 and (A-57), we obtain

$$\partial\left(\frac{\partial D}{\partial G_0}\right)/\partial N < 0.$$

Regarding the effect of competition on the crowding-out effect in logs, we further simplify equation (A-48) using equation (A-53) and (A-56) as

$$\begin{aligned}\frac{\partial\left(\frac{\partial \log D}{\partial G_0}\right)}{\partial N} &= \frac{1}{D}\left(\frac{\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N}\frac{\partial D}{\partial N}\frac{\partial D}{\partial G_0} - \frac{1}{D}\frac{\partial D}{\partial G_0}\frac{\partial D}{\partial N}\right)\\ &= \frac{1}{D^2}\frac{\partial D}{\partial N}\frac{\partial D}{\partial G_0}\left(\frac{D\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N} - 1\right).\end{aligned} \tag{A-58}$$

Using the expression of $\hat{D}'_s$ in equation (A-32), we get

$$\hat{D}'_s = \frac{1}{b_1}\left(1 - \frac{1}{\eta(1-\frac{1}{N}) + \left(\epsilon - \epsilon(1-\delta_M)^\epsilon(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}}\right).$$

Thus,

$$\frac{D}{\hat{D}'_s} = \frac{\frac{b_0}{b_1} + \frac{1}{b_1}\left(1 - \frac{1}{\eta(1-\frac{1}{N})+\left(\epsilon-\epsilon(1-\delta_M)^\epsilon(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}}\right)s}{\frac{1}{b_1}\left(1 - \frac{1}{\eta(1-\frac{1}{N})+\left(\epsilon-\epsilon(1-\delta_M)^\epsilon(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}}\right)} > s.$$

Moreover,

$$\frac{\hat{D}''_{sN}}{\hat{D}'_N} = \frac{\frac{1}{b_1}\left(\frac{1}{\left(\eta(1-\frac{1}{N})+\left(\epsilon-\epsilon(1-\delta_M)^\epsilon(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}\right)^2}\right)}{\frac{1}{b_1}\frac{1}{\left(\eta(1-\frac{1}{N})+\left(\epsilon-\epsilon(1-\delta_M)^\epsilon(\frac{s}{\bar{s}})^{1-\epsilon}\right)\frac{1}{N}\right)^2}s} = \frac{1}{s}.$$

Therefore,

$$\frac{D\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N} - 1 > s\frac{1}{s} - 1 = 0.$$

In summary,

$$\frac{\partial\left(\frac{\partial \log D}{\partial G_0}\right)}{\partial N} = \frac{1}{D^2}\frac{\partial D}{\partial N}\frac{\partial D}{\partial G_0}\left(\frac{D\hat{D}''_{sN}}{\hat{D}'_s\hat{D}'_N} - 1\right) < 0,$$

which implies that the log crowding-out effect holds.

Finally, replacing N with η, all the above results will go through, so the log crowding-out effect also holds for η.

The Fed Funds-Deposit Spread

Next, we prove (15) of Proposition 1. Equation (A-43) together with Lemma 2 imply that $s'_G < 0$, so that a larger Treasury supply reduces the deposit spread. Moreover, the impact of competition on this response is

$$\frac{\partial}{\partial N}\left(s'_G\right) = -\frac{1}{G'_\ell}\frac{1}{\left(\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}\right)^2}\frac{\hat{D}''_{sN}}{D'_\ell} > 0,$$

where the sign of $\hat{D}''_{sN}$ is given by Lemma 1. Thus, the magnitude of the s'_G effect decreases with N. The same proof goes through if we replace N with η.

The Treasury-Deposit Spread

The Treasury-deposit spread is

$$r^G - r^D = (r - r^D) - (r - r^G) = s - \ell.$$

Note that the Treasury-deposit spread depends on both the deposit spread, s, and the Treasury spread, ℓ. The effect of Treasury supply thus depends on its relative effect on s and ℓ. For this reason, additional assumptions are required to ensure that Treasury supply is not overly large or overly small. We state and discuss this assumption in our derivations below.

The effect of Treasury supply on the Treasury–deposit spread is

$$s'_G - \ell'_G = \frac{1}{G'_\ell D'_\ell}\frac{D'_\ell - \hat{D}'_s + D'_s}{\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}}. \tag{A-59}$$

To show that $s'_G - \ell'_G > 0$, we need the extra assumption that $|D'_\ell| < |D'_s|$. This assumption essentially ensures that Treasury supply primarily affects its own opportunity cost, ℓ, rather than the opportunity cost of deposits s, so that the sign of the net effect of Treasury supply on $s'_G - \ell'_G$ is the same as that of $-\ell'_G$. This assumption is satisfied unless when ℓ is too small compared to s so the deposit demand sensitivity to ℓ is much larger. Such a violation happens when Treasury supply G_0 is too large because at the far end of the Treasury demand curve, the sensitivity of the Treasury spread ℓ to a given change in Treasury supply becomes very low, so $|s'_G|$ could dominate $|\ell'_G|$ and lead to $s'_G - \ell'_G < 0$. Our assumption exactly avoids this corner case.

With the assumption $|D'_\ell| < |D'_s|$ and demand-function properties $D'_\ell > 0$, $D'_s < 0$, $G'_\ell < 0$, and $\hat{D}_s > 0$, we have

$$s'_G - \ell'_G > 0.$$

Finally, we want to prove that

$$\frac{\partial}{\partial N}\left(s'_G - \ell'_G\right) > 0.$$

We note that the cross-partial derivative of $s - \ell$ with respect to G_0 and N is

$$\frac{\partial}{\partial N}\left(s'_G - \ell'_G\right) = -\frac{1}{G'_\ell}\frac{1}{\left(\frac{G'_s}{G'_\ell} - \frac{D'_s}{D'_\ell} + \frac{\hat{D}'_s}{D'_\ell}\right)^2}\frac{1}{D'_\ell}\hat{D}''_{sN}\left(1 + \frac{G'_s}{G'_\ell}\right). \tag{A-60}$$

To show that

$$\frac{\partial}{\partial N}\left(s'_G - \ell'_G\right) > 0,$$

we need to assume that $|G'_s| < |G'_\ell|$. This assumption ensures that deposit competition N predominantly affects the response in deposit spread, s, so that $\frac{\partial}{\partial N}s'_G$ dominates $\frac{\partial}{\partial N}\ell'_G$. Intuitively, we expect deposit competition to have a first-order effect on how the deposit spread reacts. This result holds unless Treasury supply is very small. At this point of the Treasury demand curve, ℓ becomes too large and too responsive to changes in deposit competition, thus dominating the deposit spread effect and overturning the sign of $\frac{\partial}{\partial N}\left(s'_G - \ell'_G\right)$. Furthermore, a large ℓ also implies that Treasury demand has a smaller sensitivity to the Treasury spread ℓ than the deposit spread s. This situation is avoided by the assumption $|G'_s| < |G'_\ell|$.

Summarizing the above proof, assuming that $|D'_\ell| < |D'_s|$ and $|G'_s| < |G'_\ell|$, we get $s'_G - \ell'_G > 0$ and $\frac{\partial}{\partial N}\left(s'_G - \ell'_G\right) > 0$.

Next, we discuss the assumptions $|D'_\ell| < |D'_s|$ and $|G'_s| < |G'_\ell|$. It is informative to evaluate the ratio of the value,

$$\left|\frac{\frac{s}{D}D'_s}{\frac{\ell}{D}D'_\ell}\right| = \left|\frac{(\sigma-\rho)\frac{(1-\delta_G)^\sigma \bar{s}^{1-\sigma}}{s_L^{1-\sigma}}\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} + (\epsilon-\sigma)\frac{(1-\delta_M)^\epsilon s^{1-\epsilon}}{(\bar{s})^{1-\epsilon}} - \epsilon}{(\sigma-\rho)\frac{\delta_G^\sigma \ell^{1-\sigma}}{s_L^{1-\sigma}}}\right|. \tag{A-61}$$

For intuition, let's consider the simpler case where $\delta_M = 0$ so that $\bar{s} = s$. In this case, we can further simplify (A-61) as

$$
\begin{aligned}
|\frac{\frac{s}{D}D'_s}{\frac{\ell}{D}D'_\ell}| &= \frac{\sigma s_L^{1-\sigma} - (\sigma-\rho)(1-\delta_G)^\sigma s^{1-\sigma}}{(\sigma-\rho)\delta_G^\sigma \ell^{1-\sigma}} \\
&= \frac{\sigma((1-\delta_G)^\sigma(\bar{s})^{1-\sigma} + (\delta_G)^\sigma \ell^{1-\sigma}) - (\sigma-\rho)(1-\delta_G)^\sigma s^{1-\sigma}}{(\sigma-\rho)\delta_G^\sigma \ell^{1-\sigma}} \\
&= \frac{\rho(1-\delta_G)^\sigma (s)^{1-\sigma} + \sigma(\delta_G)^\sigma \ell^{1-\sigma}}{(\sigma-\rho)\delta_G^\sigma \ell^{1-\sigma}} \\
&= \frac{\rho(1-\delta_G)}{(\sigma-\rho)\delta_G^\sigma}(\frac{s}{\ell})^{1-\sigma} + \frac{\sigma}{\sigma-\rho}.
\end{aligned}
$$

Thus,

$$
|\frac{D'_s}{D'_\ell}| = \frac{\rho(1-\delta_G)}{(\sigma-\rho)\delta_G^\sigma}(\frac{s}{\ell})^{-\sigma} + \frac{\sigma}{\sigma-\rho}(\frac{s}{\ell})^{-1}.
$$

We note that this ratio will be small if s/ℓ is too large, which is the case when G_0 is large. Consequently, restricting $|D'_s/D'_\ell|$ to be bigger than 1 is requiring G_0 not to be too large so that the ratio s/ℓ is not too high. On the other hand, $|G'_\ell/G'_s| > 1$ requires s/ℓ not to be too small, which is satisfied when G_0 is not too small. In summary, we require G_0 to be neither too large nor too small.

A.1.5. Proof of Proposition 2

We first prove the impact of monetary policy rate r on Fed funds-deposit spread and then the impact on Fed funds-Treasury spread. Finally, we prove the impact on deposit quantity.

Fed Funds-Deposit Spread

Taking derivative over r on market clearing conditions in (A-42), we obtain

$$
\begin{aligned}
\hat{D}_s s'_r + \hat{D}'_r &= D'_s s'_r + D'_r + D'_\ell \ell'_r, \\
0 &= G'_s s'_r + G'_r + G'_\ell \ell'_r.
\end{aligned} \tag{A-62}
$$

To solve for s'_r, we need to substitute out ℓ'_r. This leads to

$$
\begin{aligned}
\hat{D}_s s'_r + \hat{D}'_r &= D'_s s'_r + D'_r - \frac{G'_s s'_r + G'_r}{G'_\ell} D'_\ell, \\
\left(\hat{D}_s - D'_s\right) s'_r + \hat{D}'_r &= D'_r - \frac{G'_s s'_r + G'_r}{G'_\ell} D'_\ell, \\
\left(\hat{D}_s - D'_s + \frac{G'_s}{G'_\ell} D'_\ell\right) s'_r + \hat{D}'_r &= D'_r - \frac{G'_r}{G'_\ell} D'_\ell, \\
s'_r &= \frac{D'_r - \hat{D}'_r - \frac{G'_r}{G'_\ell} D'_\ell}{\hat{D}_s - D'_s + \frac{G'_s}{G'_\ell} D'_\ell}.
\end{aligned} \tag{A-63}
$$

Lemma 1 and Lemma 2 imply that $\hat{D}'_r < 0$, $\hat{D}_s > 0$, $D'_s < 0$, $D'_r > 0$, $D'_\ell > 0$, $G'_\ell < 0$, and $G'_r > 0$. Therefore, the numerator in (A-63) is positive. Moreover, given Lemma 3, the denominator in (A-63) is also positive. Thus, we have $s'_r > 0$.

According to Lemma 1, $\hat{D}''_{r,N} > 0$ and $\hat{D}''_{s,N} > 0$. This implies that a larger N reduces s'_r (note that N does not affect demand derivatives, such as D'_ℓ). The same argument applies to η. Consequently, s'_r decreases with competition, driven by either a higher N or larger η.

Fed Funds-Treasury Spread

Using (A-62), we solve for ℓ'_r, which leads to

$$s'_r - \ell'_r = (1 + \frac{G'_s}{G'_\ell})s'_r. \tag{A-64}$$

We have already shown that $s'_r > 0$, so the sign of $s'_r - \ell'_r$ depends on the term $1 + G'_s/G'_\ell$, which is positive by assumption $|G'_\ell| > |G'_s|$. Therefore, we get

$$s'_r - \ell'_r > 0.$$

Next, the cross-partial derivative is

$$\frac{\partial\left(s'_r - \ell'_r\right)}{\partial N} = (1 + \frac{G'_s}{G'_\ell})s''_{rN}.$$

Previously, we have already proved that s'_r decreases with competition. Therefore,

$$\frac{\partial\left(s'_r - \ell'_r\right)}{\partial N} < 0.$$

The same argument applies if we replace N with η.

Deposits Crowding-Out

Given that a higher monetary policy rate r shrinks aggregate deposit supply but increases aggregate deposit demand, the prediction on deposit quantity is more challenging to prove. For that purpose, we follow the same strategy as Drechsler et al. (2017) to use the optimality conditions of bank decision together with evaluations of implicit functions.

Denote the bank profit as

$$\max_{D_i} \Pi_i(r, D_i) = (b_0 - \frac{b_1}{2}D_i + s_i)D_i,$$

where $s_i = s_i(r, D_i)$ is expressed as a function of deposit quantity D_i and the Fed funds rate r. The FOC can be written as

$$\frac{\partial \Pi_i(r, D_i)}{\partial D_i} = b_0 - b_1 D_i + s_i(r, D_i)(1 + \frac{\partial s_i(r, D_i)}{\partial D_i}\frac{D_i}{s_i(r, D_i)}) = 0. \tag{A-65}$$

Since $D_i = 0$ cannot be an equilibrium, we must have $D_i > 0$, so that the problem gives rise to an interior solution. To evaluate $\partial D_i/\partial r$, we will use the first- and second-order conditions at the interior optimum,

$$\frac{\partial \Pi_i(r, D_i)}{\partial D_i} = 0, \quad \text{and} \quad \frac{\partial^2 \Pi_i(r, D_i)}{\partial D_i^2} < 0. \tag{A-66}$$

Differentiating the above with respect to r and noting that D_i itself is a function of r, we obtain

$$0 = \frac{\partial}{\partial r}\left(\frac{\partial \Pi_i(r, D_i)}{\partial D_i}\right) = \frac{\partial^2 \Pi_i(r, D_i)}{\partial r \partial D_i} + \frac{\partial^2 \Pi_i(r, D_i)}{\partial D_i^2}\frac{\partial D_i}{\partial r}. \tag{A-67}$$

The first term is

$$\frac{\partial^2 \Pi_i(r, D_i)}{\partial r \partial D_i} = \frac{\partial s_i(r, D_i)}{\partial r}(1 + \frac{\partial s_i(r, D_i)}{\partial D_i}\frac{D_i}{s_i(r, D_i)}) + s_i(r, D_i)\frac{1}{\hat{\eta}(r/s;\eta, N)^2}\frac{\partial \hat{\eta}(r/s;\eta, N)}{\partial r}. \tag{A-68}$$

We have already proved that, in equilibrium, the deposit spread increases in r, so that $\frac{\partial s_i(r,D_i)}{\partial r} > 0$. Moreover, by assumption, the marginal profit of loans is positive, so that

$$\frac{\partial\left((b_0 - \frac{b_1}{2}D_i)D_i\right)}{\partial D_i} > 0,$$

which implies $b_0 - b_1 D_i > 0$, so that the first bracket term in (A-68) is negative according to equation (A-65). The second term in (A-68) involves how demand elasticity changes with r and we have proved that $\hat{\eta}$ decreases in r, which is the origin of higher market power when the Fed funds rate rises. As a result, we obtain

$$\frac{\partial^2 \Pi_i(r, D_i)}{\partial r \partial D_i} < 0. \tag{A-69}$$

Using (A-66) and (A-69), we can conclude from equation (A-67) that

$$\frac{\partial D_i}{\partial r} < 0,$$

which also leads to the log crowding-out effect,

$$\frac{\partial \log(D_i)}{\partial r} = \frac{1}{D_i}\frac{\partial D_i}{\partial r} < 0.$$

Since $D = D_i$ in equilibrium, we conclude that log deposit quantity $\log(D)$ decreases with higher Fed funds rate r.

A.1.6. Proof of Proposition 3

For bank i with wholesale deposits D_i^W and retail deposits D_i^R, the elasticity of its deposit demand is

$$\frac{\partial \log(D_i^W + D_i^R)}{\partial \log(s_i)} = \frac{D_i^W}{D_i^W + D_i^R}\frac{\partial \log(D_i^W)}{\partial \log(s_i)} + \frac{D_i^R}{D_i^W + D_i^R}\frac{\partial \log(D_i^R)}{\partial \log(s_i)}. \tag{A-70}$$

Applying symmetry and denoting the deposit market share of wholesale depositors W as α_W, we have

$$\frac{\partial \log(D_i^W + D_i^R)}{\partial \log(s_i)} = -\left((\alpha_W \hat{\eta}_W + (1-\alpha_W)\hat{\eta}_R)(1 - \frac{1}{N}) + \epsilon\left(1 + \frac{(1-\delta_M)^\epsilon}{\delta_M^\epsilon}(\frac{r}{s})^{\epsilon - 1}\right)^{-1}\frac{1}{N}\right), \tag{A-71}$$

where we assume that both the wholesale deposit spread and the retail deposit spread are s for simplicity. Define $\eta^* = \alpha_W \hat{\eta}_W + (1-\alpha_W)\hat{\eta}_R$. Then we get the equilibrium impact of α_W on the crowding-out effect as

$$\frac{\partial}{\partial \alpha_W}\left(\frac{\partial \log(D)}{\partial G_0}\right) = \frac{\partial \eta^*}{\partial \alpha_W}\cdot\frac{\partial}{\partial \eta^*}\left(\frac{\partial \log(D)}{\partial G_0}\right) = \hat{\eta}^W \frac{\partial}{\partial \eta^*}\left(\frac{\partial \log(D)}{\partial G_0}\right).$$

According to Proposition 1,

$$\frac{\partial}{\partial \eta^*}\left(\frac{\partial \log(D)}{\partial G_0}\right) < 0.$$

As a result,

$$\frac{\partial}{\partial \alpha_W}\left(\frac{\partial \log(D)}{\partial G_0}\right) < 0.$$

A.1.7. Heterogeneity within Treasuries

In this subsection, we provide details on the crowding out of deposits when the Treasury supply is made up of long-term (above 1Y) and short-term (below 1Y) Treasuries. Specifically, we let Treasuries G be composed of short-term Treasuries G_S and long-term Treasuries G_L in a CES aggregation:

$$G = (G_S^{\frac{\theta-1}{\theta}} + \delta_L G_L^{\frac{\theta-1}{\theta}})^{\frac{\theta}{\theta-1}}.$$

Then, denoting the liquidity premium of short-term Treasuries and long-term Treasuries as ℓ_S and ℓ_L, we obtain from the investor's first order conditions that

$$\ell_S = \frac{\partial G}{\partial G_S} = \delta M^{\frac{1}{\sigma}-1} G^{-\frac{1}{\sigma}} G^{\frac{1}{\theta}} G_S^{-\frac{1}{\theta}},$$

$$\ell_L = \frac{\partial G}{\partial G_L} = \delta M^{\frac{1}{\sigma}-1} G^{-\frac{1}{\sigma}} G^{\frac{1}{\theta}} \delta_L G_L^{-\frac{1}{\theta}}.$$

Thus, the ratio of the above two liquidity premia is

$$\frac{\ell_S}{\ell_L} = \frac{\partial G}{\partial G_S}/\frac{\partial G}{\partial G_L} = \frac{G_S^{-\frac{1}{\theta}}}{\delta_L G_L^{-\frac{1}{\theta}}}.$$

To compare the crowding out of deposits by short-term and long-term Treasuries, we derive that

$$\begin{aligned} & \frac{\partial^2 \log(D)}{\partial \log(G_S)\partial N}/\frac{\partial^2 \log(D)}{\partial \log(G_L)\partial N} \\ = \quad & \frac{\partial \log(G)}{\partial \log(G_S)}/\frac{\partial \log(G)}{\partial \log(G_L)} \\ = \quad & \frac{\partial G}{\partial G_S}/\frac{\partial G}{\partial G_L}\cdot\frac{G_S}{G_L} \\ = \quad & \frac{\ell_S}{\ell_L}\cdot\frac{G_S}{G_L}, \end{aligned} \qquad \text{(A-72)}$$

which is the ratio between short-term liquidity premium times volume and long-term liquidity premium times volume. In other words, it is the relative liquidity-premium-weighted volume that determines the relative crowd-out sensitivities.

To estimate the ratio in (A-72), we obtain yearly volumes of short-term Treasuries and long-term Treasuries for the main sample period from 1994 to 2016, and calculate the fraction of short-term Treasuries over long-term Treasuries year by year. The average of this fraction is 0.543, i.e., $G_S/G_L = 0.543$.

Then, we measure the liquidity premium for short-term Treasuries and long-term Treasuries using the spread between Refcorp yields and Treasury yields following Longstaff (2004). "Refcorp" stands for the government agency named "Resolution Funding Corporation". Refcorp bonds are fully guaranteed by the U.S. government but are not widely traded like Treasuries. Thus the spread between the Refcorp yield and the Treasury yield of the same maturity is a proxy for Treasury liquidity premium of that maturity. We obtain daily data on Refcorp STRIPs (zero coupon bonds) and Treasury STRIPs from Bloomberg for our main sample period from 1994 to 2016. In the table below, we show the average liquidity premia by maturity in basis points.

Average Treasury Liquidity Premium by Remaining Maturity

	Refcorp-Treasury Spread by Maturity		
Maturity	3M	10Y	20Y
Spread (bps)	37.6	27.2	26.0
# of Observations	6000	6000	6000

From the table, we see that the ratio between the liquidity premia of Treasuries with 3-month and 10-year remaining maturity is

$$\frac{\ell_S}{\ell_L} = \frac{37.6}{27.2} = 1.38,$$

whereas the ratio between the liquidity premia of Treasuries with 3-month and 20-year remaining maturity is

$$\frac{\ell_S}{\ell_L} = \frac{37.6}{26.0} = 1.45.$$

For the former ratio, we have

$$\frac{\partial^2 \log(D)}{\partial \log(G_S)\partial N} \Big/ \frac{\partial^2 \log(D)}{\partial \log(G_L)\partial N} \approx 1.38 * 0.543 = 0.75,$$

and for the latter ratio, we have

$$\frac{\partial^2 \log(D)}{\partial \log(G_S)\partial N} \Big/ \frac{\partial^2 \log(D)}{\partial \log(G_L)\partial N} \approx 1.45 * 0.543 = 0.79,$$

On average, we have

$$\frac{\partial^2 \log(D)}{\partial \log(G_S) \partial N} / \frac{\partial^2 \log(D)}{\partial \log(G_L) \partial N} \approx 0.77. \tag{A-73}$$

In comparison, according to column (2) of Table 8, the ratio between the coefficients on the interaction between short-term Treasury growth and HHI and the interaction between long-term Treasury growth and HHI is

$$0.090/0.113 = 0.796 \tag{A-74}$$

Thus, the model-implied ratio in (A-73) and the regression coefficient ratio in (A-74) are very close, confirming that our model mechanism is consistent with the data.

A.1.8. Estimating the Aggregate Effect

We follow Drechsler et al. (2017) to infer the aggregate effect of Treasury supply and monetary policy on deposits. We use full precision of underlying data to do all computations but all reported numerical values are rounded to two decimal places for clarity and readability. Consequently, intermediate steps may exhibit slight discrepancies.

We first obtain the sensitivity of deposit growth with respect to the Treasury-deposit spread by dividing (a) the cross-sectional elasticity of $\log(D)$ with respect to HHI and Treasury supply by (b) the cross-sectional elasticity of the Treasury-deposit spread with respect to HHI and Treasury supply.

For part (a), the cross-section elasticity of $\log(D)$ with respect to HHI and Treasury supply is 18.00 (in percentage points) according to column (2) of Table 2. For part (b), we calculate the cross-sectional elasticity of the Treasury-deposit spread with respect to HHI and Treasury supply as the average response from time and savings deposits, as in Drechsler et al. (2017). We use the results for MMs and 6m CDs in columns (2) and (4) of Table 3 to proxy for time and savings deposits and weigh them by the ratio of their overall volumes. That is, we have $(-1.279) * 0.53 + (-0.427) * 0.47 = -0.879$. Taken together, we have the sensitivity of deposit growth with respect to the Treasury-deposit spread, i.e. (a)/(b), equal to -20.49.

Finally, we multiply the sensitivity of deposit growth with respect to the Treasury-deposit spread by the sensitivity of Treasury-deposit spread to Treasury supply, which is 0.601 bps for a 1 % increase in Treasury growth. Thus, for a one-standard-deviation increase in Treasury growth during our sample period, which is 11.45%, the overall effect on deposit growth is

$$-20.49 * 0.601/100 * 11.45 * 100 = -140.9\text{bps}.$$

We use the same approach to calculate the effect of the Fed funds rate on deposits. We first obtain the sensitivity of deposit growth with respect to the Fed funds-deposit spread by dividing (a) the cross-sectional elasticity of $\log(D)$ with respect to HHI and the Fed funds rate by (b) the cross-sectional elasticity of the Fed funds-deposit spread with respect to HHI and the Fed funds rate.

For part (a), the cross-section elasticity of $\log(D)$ with respect to HHI and the Fed funds rate is -1 (in percentage points) according to column (2) of Table 2. For part (b), we calculate the cross-sectional elasticity of the Fed funds-deposit spread with respect to HHI and the Fed funds rate as the average response from time and savings deposits, as in Drechsler et al. (2017). We use the results for MMs and 6m CDs in columns (2) and (4) of Table 4 to proxy for time and savings deposits and weigh them by the ratio of their overall volumes. That is, we have $0.522 * 0.53 + 0.327 * 0.47 = 0.430$. Taken together, we have the sensitivity of deposit growth with respect to the Fed funds-deposit spread, i.e. (a)/(b), equal to -2.32.

Finally, we multiply the sensitivity of deposit growth with respect to the Fed funds-deposit spread by the sensitivity of the Fed funds-deposit spread to the Fed funds rate, which is 63.48 bps for a 100 bps increase in the Fed funds rate. Thus, for a one-standard-deviation increase in the Fed funds rate during our sample period, which is 152.3 bps, the overall effect on deposit growth is

$$-2.32 * 63.48/100 * 152.3 = -224.7\text{bps}.$$

A.2. Additional Empirical Results

Table A.1: Deposit Volume and Treasury Supply

This table estimates the effect of Treasury supply on deposit growth from 1994 to 2016. The sample for the results in columns (1) and (2) consists of all banks with branches in two or more counties. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. ΔFFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by county.

	Branch-Level Deposit Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
TSY Growth * HHI	0.086**	0.084**	0.265***	0.265***	0.150***	0.150***
	(0.039)	(0.039)	(0.031)	(0.031)	(0.036)	(0.036)
Δ FFR * HHI		-0.007***		-0.015***		-0.017***
		(0.003)		(0.002)		(0.002)
Observations	1,503,852	1,503,852	1,661,279	1,661,279	1,661,279	1,661,279
Adjusted R2	0.184	0.184	0.122	0.122	0.117	0.117
Controls	No	No	No	No	No	No
Bank Year FE	Yes	Yes	No	No	No	No
State Year FE	Yes	Yes	Yes	Yes	No	No
Branch FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes

Table A.2: OIS-Deposit Spread and Treasury Supply

This table shows the effect of Treasury supply on OIS-deposit spreads from 1997 to 2016. The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the maturity-matched OIS swap rates minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. Branch HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ OIS-Deposit Spread (≥ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-2.503***	-1.036***	-0.596**	-0.206	-0.209
	(0.395)	(0.331)	(0.271)	(0.223)	(0.210)
Δ FFR * HHI	0.584***	0.559***	0.414***	0.364***	0.314***
	(0.041)	(0.037)	(0.029)	(0.024)	(0.022)
Observations	186490	202175	198318	211728	211694
Adjusted R2	0.949	0.869	0.876	0.874	0.881
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table A.3: First Stage: Deposit Volume and Treasury Supply (Military Expenditure IV)

This table shows the first stage results for the effect of Treasury supply on deposit growth from 1994 to 2016 using military expenditure shocks as IV. The sample for the results in columns (1) and (2) consists of all banks with branches in two or more counties. TSY Growth is the log change in Treasury supply. Military shock is the shock to military expenditure as in Choi et al. (2024). HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of the table. Control variables include the change in unemployment rate, income per capita, and population, and their interactions with HHI. The Kleibergen-Paap F-statistic jointly tests for weak identification of the instruments and is robust to clustering. Standard errors are clustered by county.

	TSY Growth * HHI					
	(1)	(2)	(3)	(4)	(5)	(6)
Military Shock * HHI	0.066***	0.077***	0.124***	0.133***	0.094***	0.102***
	(0.012)	(0.012)	(0.011)	(0.011)	(0.014)	(0.014)
Δ FFR * HHI		0.006***		0.007***		0.008***
		(0.000)		(0.000)		(0.000)
Observations	1,415,721	1,415,721	1,569,320	1,569,320	1,569,320	1,569,320
Adjusted R2	0.912	0.912	0.863	0.865	0.826	0.829
Kleibergen-Paap F-statistics	30.448	43.136	130.997	155.155	45.558	52.723
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank Year FE	Yes	Yes	No	No	No	No
State Year FE	Yes	Yes	Yes	Yes	No	No
Branch FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes

Table A.4: First Stage: Deposit Spreads and Treasury Supply (Military Expenditure IV)

This table shows the first stage results for the effect of Treasury supply on deposit spreads from 1997 to 2016 using military expenditure shocks as IV. The sample consists of all banks with branches in two or more counties. TSY Growth is the log change in Treasury supply. Military shock is the shock to military expenditure as in Choi et al. (2024). HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. The Kleibergen-Paap F-statistic jointly tests for weak identification of the instruments and is robust to clustering. Standard errors are clustered by county.

	TSY Growth * HHI				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
Military Shock * HHI	0.814***	0.934***	0.840***	0.938***	0.938***
	(0.063)	(0.066)	(0.049)	(0.064)	(0.064)
Δ FFR * HHI	-0.028***	-0.027***	-0.028***	-0.027***	-0.027***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	186490	202175	198318	211728	211694
Adjusted R2	0.813	0.815	0.816	0.811	0.810
Kleibergen-Paap F-statistics	164.984	201.018	299.928	213.700	213.404
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table A.5: OIS-Deposit Spread and Treasury Supply (Military Expenditure IV)

This table shows the IV estimates of the effect of Treasury supply on OIS-deposit spreads from 1997 to 2016. The instrument is based on shocks to military spending following Choi et al. (2024). The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the maturity-matched OIS swap rates minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ OIS-Deposit Spread (≥ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-5.744***	-1.955***	-2.979***	-2.365***	-2.388***
	(0.864)	(0.693)	(0.633)	(0.499)	(0.452)
Δ FFR * HHI	0.499***	0.536***	0.351***	0.309***	0.258***
	(0.042)	(0.038)	(0.033)	(0.025)	(0.022)
Observations	186490	202175	198318	211728	211694
Adjusted R2	-0.185	-0.244	-0.243	-0.258	-0.267
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table A.6: Treasury-Deposit Spread and Treasury Supply (Tax Seasonality IV)

This table shows the IV estimates of the effect of Treasury supply on Treasury-deposit spreads from 1997 to 2016. The instrument is based on seasonality in tax receipts following Greenwood et al. (2015). The sample consists of all banks with branches in two or more counties. Spread changes for savings and money market deposits are equal to the changes in the six-month Treasury yield minus the changes in deposit rates at the branch level. Spread changes for time deposits are equal to the changes in maturity-matched Treasury yield minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. The Kleibergen-Paap F-statistic jointly tests for weak identification of the instruments in the first stage and is robust to clustering. Standard errors are clustered by county.

	Δ Treasury-Deposit Spread				
	Saving	MM	3m CD	6m CD	12m CD
	(1)	(2)	(3)	(4)	(5)
TSY Growth * HHI	-0.96***	-0.70***	-0.50**	-0.46	-0.16
	(0.18)	(0.24)	(0.23)	(0.33)	(0.19)
Δ FFR * HHI	1.7***	1.3***	0.80***	0.62***	0.44***
	(0.12)	(0.09)	(0.06)	(0.05)	(0.04)
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Kleinbergen-Paap F-stat (1st stage)	2,472.8	2,660.0	2,575.9	2,678.8	2,674.4
Adjusted R2	0.70	0.36	0.53	0.47	0.50
Observations	6,501,694	6,742,293	6,504,669	7,044,057	7,054,232

Table A.7: Fed Funds-Deposit Spread and Treasury Supply (Tax Seasonality IV)

This table shows the IV estimates of the effect of Treasury supply on Fed funds-deposit spreads from 1997 to 2016. The instrument is based on seasonality in tax receipts following Greenwood et al. (2015). The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the Fed funds target rate minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. The Kleibergen-Paap F-statistic jointly tests for weak identification of the instruments in the first stage and is robust to clustering. Standard errors are clustered by county.

	Δ FFR-Deposit Spread				
	Saving	MM	3m CD	6m CD	12m CD
	(1)	(2)	(3)	(4)	(5)
TSY Growth * HHI	-1.0***	-0.81***	-0.59***	-0.55*	-0.31
	(0.19)	(0.24)	(0.23)	(0.33)	(0.19)
Δ FFR * HHI	1.9***	1.5***	1.0***	0.80***	0.76***
	(0.13)	(0.10)	(0.07)	(0.06)	(0.05)
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap F-stat (1st stage)	2,472.8	2,661.9	2,577.8	2,680.4	2,676.0
Adjusted R2	0.68	0.27	0.35	0.31	0.32
Observations	6,501,702	6,748,005	6,510,269	7,050,039	7,060,212

Table A.8: Treasury-Deposit Spread and Treasury Supply: Slow-Moving Treasuries

This table shows the effect of Treasury supply on Treasury-deposit spreads. Data is sampled every five years, from 2000 to 2015. The sample consists of all banks with branches in two or more counties. Spread changes for savings and money market deposits are equal to the changes in the six-month Treasury yield minus the changes in deposit rates at the branch level. Spread changes for time deposits are equal to the changes in maturity-matched Treasury yield minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. Branch HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ Treasury-Deposit Spread (≥ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-1.528***	-0.716	-1.441**	-0.709	-0.758
	(0.483)	(0.713)	(0.579)	(0.526)	(0.540)
Δ FFR * HHI	0.789***	0.579***	0.346***	0.350***	0.382***
	(0.096)	(0.099)	(0.063)	(0.058)	(0.060)
Observations	3430	3304	3283	3457	3449
Adjusted R2	0.666	0.388	0.321	0.450	0.368
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table A.9: Fed Funds-Deposit Spread and Treasury Supply: Slow-Moving Treasuries

This table shows the effect of Treasury supply on Fed funds-deposit spreads. Data is sampled every five years, from 2000 to 2015. The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the Fed funds target rate minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. Branch HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ FFR-Deposit Spread ($\geq$ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-1.498***	-0.682	-1.562***	-0.679	-0.718
	(0.480)	(0.711)	(0.589)	(0.519)	(0.534)
Δ FFR * HHI	0.824***	0.615***	0.398***	0.385***	0.405***
	(0.099)	(0.100)	(0.067)	(0.058)	(0.059)
Observations	3430	3304	3283	3457	3449
Adjusted R2	0.670	0.390	0.406	0.436	0.383
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Table A.10: OIS-Deposit Spread and Treasury Supply: Slow-Moving Treasuries

This table shows the effect of Treasury supply on OIS-deposit spreads. Data is sampled every five years, from 2000 to 2015. The sample consists of all banks with branches in two or more counties. Spread changes are equal to the changes in the maturity-matched OIS swap rates minus the changes in deposit rates at the branch level. TSY Growth is the log change in Treasury supply. Branch HHI measures market concentration in the county where a branch is located. Δ FFR is the change in the Fed funds target rate. Fixed effects are denoted at the bottom of each panel. Standard errors are clustered by county.

	Δ OIS-Deposit Spread (≥ 2 Counties)				
	(1)	(2)	(3)	(4)	(5)
	Saving	MM	3m CD	6m CD	12m CD
TSY Growth * HHI	-1.810***	-1.006	-1.679***	-0.988*	-1.182**
	(0.517)	(0.740)	(0.601)	(0.553)	(0.582)
Δ FFR * HHI	0.874***	0.665***	0.431***	0.435***	0.478***
	(0.105)	(0.106)	(0.070)	(0.065)	(0.070)
Observations	3430	3304	3283	3457	3449
Adjusted R2	0.713	0.489	0.436	0.561	0.553
Bank Time FE	Yes	Yes	Yes	Yes	Yes
State Time FE	Yes	Yes	Yes	Yes	Yes
Branch FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes