Deposit Funding Shocks and Credit Supply: Bank-Level IV Estimates and Heterogeneous Responses

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1 Introduction

Rapid tightening since March 2022 has renewed interest in how monetary policy transmits through banks to the real economy. A rising strand emphasizes the deposit channel: when policy rates increase, deposit spreads widen, deposit growth slows, and banks partly replace core deposits with more expensive wholesale liabilities, which still leaves assets and loan supply lower (Drechsler et al. 2016). This perspective fits within the broader credit-channel research program that tighter policy raises banks' funding costs and tightens loan supply (Bernanke and Gertler 1995). Following Drechsler et al. (2016), a large body of recent work documents substantial cross-sectional variation in deposit rate pass-through and deposit outflows, shaped by factors such as bank size and depositor sophistication. The foundational branch-level evidence on the "deposit channel" showed that when policy rates rise, banks in less competitive deposit markets raise rates more slowly and lose fewer deposits, while others face larger outflows and higher funding costs. Later studies questioned how well such local designs capture bank-level behavior. Evidence that large institutions price deposits uniformly across geographies raises concerns about county-level identification and suggests strong liability substitution at the largest banks(Begenau and Stafford 2023; Begenau and Stafford 2024). Related work shows depositor composition matters for pass-through and outflows and concentration indexes largely proxy deposit composition rather than market power, shifting attention from local market structure to who the depositors are. Against this backdrop, much less is known about the subsequent impact of higher funding costs on how much credit banks supply (Narayanan and Ratnadiwakara 2024).

The deposit channel rests on three testable premises. First, deposits are imperfect substitutes for other liabilities at the margin, so policy rate hikes raise both marginal and average funding costs for a meaningful subset of banks (Bernanke and Gertler 1995; Drechsler et al. 2016). Second, higher marginal funding costs shift banks' loan-supply schedules inward rather than being fully offset by repricing, fees, or operating adjustments (Bernanke and Gertler 1995). Third, borrowers face frictions in replacing relationship lenders, so bank-level supply contractions translate into lower aggregate credit availability (Erel et al. 2023). Each premise is contestable. Large banks can reoptimize liability structures at relatively low cost, dampening the effective increase in funding costs (Begenau and Stafford 2023). On the second premise in particular, the mapping from funding-cost shocks to bank credit supply remains underdeveloped in both theory and evidence; two canonical frameworks motivate quantity (and terms) tightening without one-for-one price pass-through: credit-rationing logic, where higher loan rates worsen selection and incentives, making nonprice and quantity restrictions optimal (Stiglitz and Weiss 1981), and bank-capital models, where lower net interest margins slow retained-earnings accumulation and raise the likelihood of binding capital constraints (Van den Heuvel 2002). This paper does not attempt to identify these microfoundations; it estimates the reduced-form, bank-level local average treatment effect of policy-induced increases in effective funding costs on credit supply.

The paper estimates the bank-level local average treatment effect of policy-induced changes in deposit funding conditions on credit supply for the set of banks whose funding is shifted by the instrument. Identification uses a bank-level 2SLS design with instruments that interact predetermined, pre-2021 exposures with quarterly changes in the federal funds rate. Working at the bank rather than branch level and instrumenting both funding costs and outflows—while absorbing local demand with deposit-weighted region-by-quarter fixed effects and controlling for time-invariant heterogeneity with bank fixed effects—directly addresses uniform-pricing and aggregability critiques. The analysis reports elasticities for total and portfolio-level lending and examines size heterogeneity to test whether small and community banks contract credit more for a comparable policy-driven shift in funding conditions. The contribution is direct, reduced-form causal evidence on the linkage from policy-induced bank-specific deposit funding conditions to bank credit supply, without committing to a specific micro-mechanism.

2 Literature Review

The "standard interest-rate channel" is the textbook mechanism in which a policy-induced increase in the federal funds rate passes through to borrowing rates, raising the user cost of credit and reducing interest-sensitive spending (Bernanke and Gertler 1995). An earlier alternative emphasized a "reserve channel," under which the central bank's control of bank reserves and a stable reserve multiplier constrained loan supply (Bernanke and Blinder 1988; Balbach 1981). In practice, that mechanism weakened or had never been effective as financial innovation, regulatory change, and modern operating procedures decoupled lending from contemporaneous reserve quantities: banks reconfigured liability mixes and reserve requirements became less binding, while central banks accommodated aggregate reserve demand in order to target the overnight policy rate (Minsky 1957; Moore 1991). In the early 1990s, the discussion was recast as a "credit channel" comprising a balance-sheet channel—tightening weakens borrower cash flow and collateral, raising external-finance premia—and a bank-lending channel—reserve drains or funding-cost increases reduce core deposits and, when nondeposit liabilities are imperfect or costly substitutes, shift banks' loan-supply schedules inward, tightening bank credit supply (Bernanke and Gertler 1995; Kashyap and Stein, n.d.).

A complementary bank-capital channel traces how capital requirements and payout rules shape lending. Since Basel I (1988), risk-weighted capital standards have tied balance-sheet growth to capital; Basel II increased risk sensitivity, and Basel III added conservation and countercyclical buffers (Basel Committee on Banking Supervision 1988, 2011). Early credit-crunch evidence showed that thinly capitalized banks slowed loan growth as they adjusted to standards (Bernanke and Lown 1991; Hancock and Wilcox 1994). Quasi-experimental work finds that tighter, bank-specific capital requirements contract lending at affected banks, with some migration to less-regulated lenders (Aiyar et al. 2014). Risk-sensitive rules can be procyclical: in downturns, higher measured default probabilities and losses given default raise required capital just as earnings weaken, amplifying credit retrenchment (Kashyap and Stein 2004; Gordy and Howells 2006; Heid 2007; Repullo and Suárez 2013). Importantly, banks need not be at regulatory minima to pull back: when margins compress, value-maximizing banks may conserve capital and smooth dividends, raising the shadow cost of capital and shifting loan supply inward even without a binding constraint (Van den Heuvel 2002).

The modern deposit channel begins with Drechsler et al. (2016), which builds on classic evidence that deposit pricing is sluggish and more so where banks face less competition (Hannan and Berger 1997; Neumark and Sharpe 1992). In DSS, a policy-rate increase lifts outside short rates; with search frictions and deposit-market power, deposit rates adjust only partially, widening the funds–deposit spread and inducing households to shift out of checking and savings. The gradients are strongest where competition is weak: spreads rise more and deposit growth falls more in high-HHI counties, a price–quantity pattern that identifies a supply shift rather than demand. They establish causality with a within-bank design that interacts policy moves with county HHI under bank-time fixed effects, relying on internal capital markets that equalize marginal lending returns across branches so branch lending is independent of local deposit taking. A weekly event study shows spreads step up at FOMC enactment with no pre-trends, and expected and unexpected rate changes have similar effects, ruling out Fed-information stories. Aggregation follows from funding arithmetic: core deposits, which are about four-fifths of bank liabilities, fall on net, banks only partly substitute into wholesale or large time deposits, total liabilities mirror the core-deposit decline, and assets and loans contract. Because deposits are households' primary liquid claim, the systemwide shrinkage raises the liquidity premium, a macro link they document via the tight comovement between the aggregate deposit spread and the T-bill liquidity premium.

A newer wave refines mechanism and magnitudes. On mechanics, retail deposits provide a built-in duration hedge: when deposit rates adjust only slowly to policy, the deposit franchise behaves like a negative-duration asset. Banks pair that hedge with long-duration, fixed-rate assets, keeping NIM and ROA relatively stable around rate moves; as a result, tightening transmits mainly through funding-quantity pressure and the liquidity premium rather than large net-worth swings (Drechsler et al. 2021). If imperfect passthrough causes core deposit outflow and banks could not substitute deposit with similar duration liabilties with low friction or cost, then this could cause banks to reduce duration risk taking. On magnitudes, a decomposition of bank valuations shows that liability "productivity" explains most cross-bank value; for the median bank roughly two-thirds of value is attributable to deposit productivity, and a one-standard-deviation increase in deposit productivity raises market-to-book by roughly 0.2–0.8 points; savings-deposit capability is the tightest link to value (Egan et al. 2021). Deposit betas are state-dependent, rising with the level of rates, which shortens effective deposit duration and amplifies balance-sheet sensitivity in hiking cycles (Greenwald et al. 2023). Market structure and technology shift the first stage: online/national banks pass through more and attract inflows, while smaller institutions face sharper outflows, reallocating credit supply across balance sheets (Erel et al. 2023; d'Avernas et al. 2023). Outside the U.S., the 2022–23 cycle shows that larger deposit outflows map into quantity rationing—especially for fixed-rate, longer-maturity loans—and the effect is stronger at banks entering with larger duration gaps (Bank 2024). Dynamic models microfound deposit demand and market power through search frictions, implying that reductions in frictions or better outside options weaken transmission (Choi and Rocheteau 2021). Finally, structural estimates link the deposits and capital channels: deposit-market power shapes pass-through to lending and interacts with capital requirements, potentially delivering a low "reversal rate" when cuts erode equity (Wang et al. 2020).

There are some important critiques for the deposit channel. A first set concerns uniform pricing: large networks often post near-uniform retail deposit rates across geographies, so pricing is effectively national rather than local. If so, county concentration (HHI) is a weak proxy for deposit-market power and within-bank cross-county designs risk attributing pass-through and outflows to "local competition" when they largely reflect head-office rate sheets (Begenau and Stafford 2023; d'Avernas et al. 2023). A related specification critique emphasizes depositor composition: who the customers are, not where they bank, predicts pass-through and run-off in 2022–23 (Narayanan and Ratnadiwakara 2024). The deeper challenge is aggregation: the mechanism has macro bite only if substitution from core deposits into time deposits and non-deposit debt is incomplete; asset-weighted analyses suggest that at the largest institutions substitution is ample, so cross-sectional gradients may reallocate intermediation across balance sheets rather than contract it in the aggregate (Begenau and Stafford 2023). Even so, distributional effects remain first order: if bank-dependent borrowers cannot easily substitute away from relationship lending, such as small businesses, or if smaller banks face higher marginal costs of wholesale replacement, policy can still tighten credit where those relationships bind, producing partial aggregation on the small-business margin (Erel et al. 2023; Kashyap and Stein, n.d.; d'Avernas et al. 2023).

The main gap is a clean mapping from policy-induced, bank-specific changes in funding conditions to lending. A substantial literature offers cross-sectional explanations of deposit-rate pass-through and deposit outflows, but far fewer papers quantify how a given bank-level increase in funding costs or a standardized deposit outflow translates into credit supply; even flagship contributions relate deposit movements to lending in reduced form rather than recovering a causal elasticity with instruments (Drechsler et al. 2016; Narayanan and Ratnadiwakara 2024). This paper addresses that gap with a bank-level 2SLS design: predetermined, pre-2021 exposures to deposit-rate sensitivity and to deposit-flow sensitivity are interacted with quarterly federal funds rate changes to instrument, respectively, each bank's change in its effective deposit rate and its deposit outflow; deposit-weighted region-by-quarter fixed effects absorb local demand and common shocks, and bank fixed effects absorb time-invariant heterogeneity. The second stage maps the instrumented funding-cost shock and the instrumented outflow into total and portfolio-level lending, delivering a bank-level LATE for the credit-supply response. By construction, the design speaks to uniform-pricing and aggregability critiques by shifting identification away from county concentration and by reporting size-split elasticities that test whether substitution at large institutions mutes macro transmission (Begenau and Stafford 2023).

3 Data and methodology

3.1 Data sources and sample construction

The empirical analysis uses a quarterly panel of U.S. commercial banks constructed from regulatory Call Reports and the FDIC Summary of Deposits (SOD), merged with county-level demographic and financial data. Call Reports provide bank-level balance sheet and income information, including interest expenses and outstanding balances on deposits, which are used to construct effective deposit rates and deposit quantities. Throughout the paper, all Call Report variables used are restricted to **domestic** offices: interest expense on deposits refers to domestic deposits only, and deposit balances are domestic deposit balances only.

SOD contains branch-level domestic deposits and branch locations, which are aggregated up to the bank level to measure branch density and local deposit-market concentration. County-level socio-economic and tax data (such as income, education, age structure, internet access, and the incidence of dividend and interest income) and mortgage-refinance data are merged via county identifiers to construct the depositor-sophistication index.

The sample is restricted to FDIC-insured commercial banks that are active over the estimation window and report the variables needed to construct deposit rates, exposure indices, and balance-sheet controls. Observations with missing or clearly erroneous values for key variables (for example, non-positive domestic deposit balances or interest expenses that imply implausible rates) are dropped. The panel is organized at the bank–quarter level. Bank identifiers are used to merge Call Reports with bank-level aggregates of SOD and county-level data. Single-bank quarters that contribute no within-bank variation after applying fixed effects are dropped by the high-dimensional fixed-effects estimator and excluded from the estimation sample.

3.2 Cross-sectional exposure indices

The first-stage specification relies on three bank-level, time-invariant exposure indices, all constructed using only pre-period data so that they are predetermined with respect to the post-period policy shocks and outcomes.

Depositor sophistication index (DSI)

The depositor sophistication index is designed as a data-driven proxy for the financial literacy and financial sophistication of the bank's retail depositor base. It is built at the county level from seven underlying variables that are standard in the empirical literature on financial literacy and participation: log median household income, the share of adults with a college degree, the share of older residents, the share of households with broadband or fixed internet access, the shares of tax filers reporting dividend and interest income, and the refinance share in new mortgage originations. Each variable is first standardized to mean zero and unit variance across counties so that all components are on a comparable scale.

Let X_c denote the 7×1 vector of standardized county characteristics. Principal component analysis (PCA) is applied to the covariance matrix of X_c to extract orthogonal linear combinations of these variables. The county-level sophistication index is defined as the first principal component

$$\mathrm{DSI}_c = w' X_c,$$

where w is the eigenvector associated with the largest eigenvalue of the covariance matrix of X_c. This component is normalized to have mean zero and unit variance across counties. Its loadings are oriented so that it places positive weight on higher income, higher education, greater internet access, and greater incidence of dividend and interest income and refinancing activity. Higher values of DSI_c therefore correspond to counties with households that are richer, more educated, more digitally connected, and more engaged with financial markets and refinancing, which are precisely the dimensions typically associated with higher financial literacy and financial sophistication.

A key advantage of using PCA rather than ad hoc weights is that the index is constructed in a transparent and replicable way: the data themselves determine how the different proxies for sophistication are combined, subject to the normalization and orientation described above. Because all inputs are standardized and the first principal component captures the direction of maximum common variation, the resulting DSI can be interpreted as a one-dimensional summary of financial-literacy-related characteristics. In robustness analysis (not reported here), alternative constructions that simply average the standardized inputs or that drop one input at a time yield indices that are highly correlated with DSI, reinforcing the interpretation of DSI as a stable proxy for financial literacy.

Bank-level DSI is obtained as a deposit-weighted average of county DSI across the bank's branch network:

$$S_i = \frac{\sum_{b \in i} \mathrm{DSI}_{c(b)} \times \mathrm{Dep}_b}{\sum_{b \in i} \mathrm{Dep}_b},$$

where Dep_b denotes domestic deposits at branch b and $c(b)$ is the county of branch b. This aggregation assigns more weight to counties where the bank actually raises more deposits. The resulting S_i is then standardized across banks to have mean zero and unit variance. In the interpretation below, S_i is referred to as the bank's depositor-sophistication index.

Relationship-banking index (branch intensity)

The relationship-banking index is intended to capture how branch-intensive a bank's retail funding model is. For each bank–year observation in SOD, the total number of branches is counted and divided by the bank's total **domestic** deposits in that year, expressed in billions of dollars:

$$R_i^{\mathrm{year}} = \frac{\mathrm{branches}_{i,\mathrm{year}}}{\mathrm{DomDep}_{i,\mathrm{year}}/10^9},$$

where $\mathrm{DomDep}_{i,\mathrm{year}}$ is the bank's total domestic deposits reported in SOD for that year. Banks with more branches per dollar of domestic deposits have higher R_i^{year}, consistent with a more branch-intensive, relationship-oriented business model. To obtain a single, time-invariant measure for each bank, R_i^{year} is averaged over the pre-period years, and the cross-sectional distribution of the resulting R_i is standardized to mean zero and unit variance.

Local concentration index (HHI exposure)

The local concentration index measures the degree of deposit-market concentration faced by a bank's branch network. For each county market, a Herfindahl–Hirschman index (HHI) of deposit shares across banks is computed using SOD branch deposits. A bank's HHI exposure is then defined as the deposit-weighted average of county HHIs across its branches:

$$H_i = \frac{\sum_{b \in i} \mathrm{HHI}_{c(b)} \times \mathrm{Dep}_b}{\sum_{b \in i} \mathrm{Dep}_b}.$$

Higher H_i indicates that the bank tends to operate in more concentrated local deposit markets. As before, H_i is fixed using pre-period data and standardized across banks.

3.3 Policy shocks and instrument construction

Monetary policy shocks are measured by the quarterly change in the effective federal funds rate, denoted Δr_t^{FF}. The exposure indices S_i, R_i, and H_i are constructed using only data prior to the policy-tightening period and treated as fixed characteristics of each bank. To generate bank-specific policy shocks to deposit funding conditions, each exposure is interacted with the contemporaneous policy shock:

$$zS_{i,t} = S_i \times \Delta r_t^{FF}, \quad zR_{i,t} = R_i \times \Delta r_t^{FF}, \quad zH_{i,t} = H_i \times \Delta r_t^{FF}.$$

These interactions vary over time only through Δr_t^{FF} and differ across banks through the cross-sectional exposure indices. They are therefore predetermined with respect to post-period lending and deposit outcomes. In the empirical implementation, the three instruments are denoted zS_dffr, zR_dffr, and zH_dffr.

3.4 First-stage regressions for deposit rates and quantities

The primary endogenous variable in the deposit channel is the bank's effective domestic deposit rate. For each bank–quarter, an effective rate on domestic deposits is constructed as interest expense on domestic deposits over the quarter divided by the average stock of domestic deposits, and the first-stage left-hand side is the quarter-on-quarter **level change** in this effective rate, denoted

$$\Delta r_{i,t}^{dep} = r_{i,t}^{dep} - r_{i,t-1}^{dep}.$$

The baseline first-stage regression in the panel of commercial banks is

$$\Delta r_{i,t}^{dep} = \alpha_i + \lambda_t + \beta_S zS_{i,t} + \beta_R zR_{i,t} + \beta_H zH_{i,t} + \sum_r \sum_q \gamma_{r,q}\, s_{i,r} \mathbf{1}\{t = q\} + \varepsilon_{i,t},$$

where α_i are bank fixed effects, λ_t are quarter fixed effects, and $s_{i,r}$ denotes the share of bank i's domestic deposits located in Census region r (for example, New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain). The interactions $s_{i,r}\mathbf{1}\{t = q\}$ form a rich set of deposit-weighted region-by-quarter effects that absorb region-specific funding and demand shocks. Standard errors are clustered at the bank level to account for serial correlation and heteroskedasticity within banks.

The same structure is used to study domestic deposit quantities, but the left-hand-side variables are defined as **percentage changes** in domestic deposit balances rather than level differences. Let $g_{i,t}^{IB}$ denote the quarter-on-quarter percentage change in domestic interest-bearing deposits for bank i in quarter t, and let $g_{i,t}^{Tot}$ denote the quarter-on-quarter percentage change in total domestic deposits (interest-bearing plus non-interest-bearing). First-stage regressions of the form

$$g_{i,t}^{IB} = \alpha_i + \lambda_t + \beta_S^{IB} zS_{i,t} + \beta_R^{IB} zR_{i,t} + \beta_H^{IB} zH_{i,t} + \sum_r \sum_q \gamma_{r,q}^{IB}\, s_{i,r} \mathbf{1}\{t = q\} + \varepsilon_{i,t}^{IB},$$

and an analogous specification for $g_{i,t}^{Tot}$, are estimated to assess whether the instruments also predict funding quantity adjustments. These deposit-quantity first stages are primarily used as diagnostics for the role of interest-bearing deposits in the deposit channel, while the main IV specifications in the subsequent analysis focus on level changes in the domestic deposit rate as the endogenous variable.

3.5 Second-stage regressions for lending

The second-stage regression links changes in banks' domestic lending to changes in their domestic deposit rates that are instrumented by the policy–exposure interactions described above. For each bank–quarter and each lending outcome k (such as total domestic loans, domestic business loans, or domestic real estate loans), let $g_{i,t}^k$ denote the quarter-on-quarter percentage change in the corresponding domestic loan balance. The baseline second-stage specification relates $g_{i,t}^k$ to the instrumented change in the effective domestic deposit rate:

$$g_{i,t}^k = \alpha_i^k + \lambda_t^k + \theta^k\, \widehat{\Delta r_{i,t}^{dep}} + X_{i,t-1}' \delta^k + u_{i,t}^k,$$

where α_i^k and λ_t^k are bank and quarter fixed effects, respectively, $\widehat{\Delta r_{i,t}^{dep}}$ is the fitted value of the change in the effective domestic deposit rate from the first-stage regression, and $X_{i,t-1}$ is a vector of lagged bank characteristics (such as size, capitalization, liquidity, and funding structure) included as controls. Under the usual IV assumptions, the coefficient θ^k can be interpreted as a local semi-elasticity of domestic lending growth with respect to shifts in the domestic deposit rate that are driven by the interaction of pre-period exposure indices with subsequent federal funds rate changes, holding fixed unobserved bank heterogeneity and common time shocks. Standard errors are clustered at the bank level.

In addition to estimating this specification in the full commercial-bank sample, the analysis considers heterogeneity by bank size by re-estimating the same second-stage equation separately for large and small banks, using the size-appropriate first-stage instruments described above. An analogous IV specification can be written with instrumented percentage changes in domestic deposit quantities in place of $\Delta r_{i,t}^{dep}$, but first-stage diagnostics show that the policy–exposure interactions are weak predictors of deposit quantity growth. Because the instruments fail conventional first-stage strength tests for deposit quantities, the paper does not develop a separate quantity-based second-stage equation; instead, deposit flows are analyzed as descriptive or reduced-form outcomes rather than as endogenous variables in an additional IV design.

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