Monetary Policy Transmission, Bank Market Power, and Income Source*

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Preliminary

Abstract

We provide empirical evidence on banks' market power in financial services and its implications for monetary policy transmission through deposit rates. Banks with market power in financial services not only charge higher fees for their service but also offer lower deposit rates with less pass-through from monetary policy shocks. We rationalize these findings with an illustrative model where banks use product tying for deposits and financial services: banks leverage market power in financial services to exert pricing power in deposit rates. Last, we develop a quantitative model to (i) quantify the role of non-interest income in monetary policy transmission and (ii) examine the implications of a changing natural interest rate.

JEL Classification: D43, E44, E52, G21, G51

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1 Introduction

This paper examines the role of bank fee income in determining the pass-through of monetary policy to deposit rates. We provide novel empirical evidence that banks with higher fee income have lower rate pass-through from monetary policy. Specifically, as monetary policy tightens, high-fee banks increase their deposit rates by less than their low-fee counterparts. We argue that this is the result of market power in *financial services* — such as checking, mobile banking, or branch access — which can only be accessed if consumers have a deposit account with the bank. Through tying services to deposit accounts, banks use market power financial services to exert market power in deposit pricing.

Over the past few decades, fee income has become an increasingly important source of revenue for banks. For example, 20% of bank operating income is generated through non-interest income sources, with the majority coming from deposit account service fees (DeYoung and Rice, 2004). For deposit accounts, in particular, banks charge fees for financial services related to the management and transfer of funds. Cross-sectional variation in the quality and characteristics of these services (see, e.g., Kiser 2002) suggests that this is an important margin along which banks can exert pricing power. We find empirical support for this theory, documenting that low deposit rates are correlated with high deposit account fees at the bank and branch levels.

While the literature has primarily focused on the pass-through of monetary policy to loan and deposit rates, little focus has been devoted to the role of non-interest income, an important pricing factor and source of bank income. To address this gap, we use branch-level data and local projection methods à la Jordà (2005) to examine how loan and deposit rates respond to monetary policy, and if the relationship depends on bank non-interest income. To do this, we interact conventional monetary policy shocks from Jarociński (2024) with a proxy for deposit account fees. While loan rates are unaffected, we find significant results for deposit rates. Specifically, deposit rates at high-fee banks increase by 15 basis points less compared to low-fee banks, given a 100 basis point monetary shock. These results do not hold for time deposits, such as certificates of deposits (CDs), which do not provide similar financial services.

We argue that bank financial services are the ultimate source of market power, and banks use product tying to keep deposit rates low in the spirit of Tirole (1988). Generally, with product tying, a firm uses market power in one product to achieve pricing power in another product by requiring consumers to purchase both. In the context of banking, banks require consumers to open a deposit account in order to access financial services; thus, even though deposits may be a competitively provided product within the banking system, some banks are able to offer lower deposit rates.

To illustrate this mechanism, we develop a simple model of bank market power where banks jointly set deposit rates and fees for their deposit accounts and services. Both products are characterized by separate demand elasticities which are primitives of the model. We show that when deposits and services are tied together, this generates *effective* demand elasticities in which banks create inelastic deposit demand through their existing inelastic demand for services. Consistent with our empirical findings, this implies high fee banks also have a lower deposit rate and lower pass-through of monetary policy to deposit rates. Importantly, this mechanism is consistent with the findings in the IO literature (e.g. see Egan et al. (2017)) whereby consumer demand depends on bank-level characteristics which include services. While this is true, we are more explicit about the ways in which non-interest income affects bank profitability and the joint determination of fees and deposit rates.

Building on insights from the illustrative model, we develop and calibrate a larger quantitative model of the U.S. banking sector that can be used to quantify the transmission effects of monetary policy in the presence of market power in deposits and financial services. The quantitative model features heterogeneous banks that differ in terms of their technology and depositor demand. In our first experiment, we compare our baseline model to a counterfactual in which banks do not generate any non-interest income from fees. In this setting, we find that banks become less dependent on deposit funding (and instead favor retained earnings/equity) which results in an even lower pass-through of monetary policy to deposit rates and, hence, larger outflows of deposits during a tightening episode. In our second experiment, we consider the effect of changes in the level of the natural interest rate. We find that in a low interest rate environment, banks become more dependent on fee income and increase their leverage, and this increases the volatility of their earnings. This suggests bank risks increase in a low interest rate environment which is consistent with other findings in the literature (see Whited et al. (2021)).

Related Literature. We relate to three strands of the literature: empirical deposit pricing and pass-through, market power and deposits, and the theory of product tying. First, we expand on the vast literature on empirical deposit pricing and pass-through. On the deposit side, stickiness in rates and a sluggish pass-through have been documented, particularly upwards (e.g., Berger and Hannan 1989, Diebold and Sharpe 1990, Neumark and Sharpe 1992, Driscoll and Judson 2013, Yankov 2023). We add to that literature by considering two-part pricing, the interplay of rates and fees, and studying the role of non-interest income in the transmission of monetary policy.

Second, in recent years, much interest has been devoted to the role of market power and market concentration for the pass-through of monetary policy. For example, Drechsler et al. (2017) show that, in response to an increase in the policy rate, bank branches operating in highly concentrated areas change their deposit rates by less, allowing them to increase their deposit spread. A similar mechanism has been shown by Gödl-Hanisch (2023) on the loan side but operating in the opposite direction with branches in highly concentrated areas responding by more. Other works on the link between market power and transmission include Wang et al. (2022), and Scharfstein and Sunderam (2016), emphasizing the importance of market structures for monetary policy transmission. We add to that by looking at a novel margin: fees and non-interest income and how these affect monetary policy transmission.

Last, our paper is also connected to the theory of product tying (e.g., Tirole 1988, Adams and Yellen 1976, Burstein 1960, Weinberg 1996, Loranth and Morrison 2012). We contribute to that strand of the literature by applying product tying to banking, specifically considering deposits and services. Related to the product-tying theory on the banking side, Kiser (2002) uses survey data to show significant variation in payment and product services, which leads to sticky deposits and depositor retention. Using survey data, he finds that multi-market banks are more likely to charge higher fees than single-market banks. This, in turn, places increased competitive pressure on single-market banks to charge higher fees. Our research also ties it in with spatial competition literature, specifically Barros (1999) and Park and Pennacchi (2008). Under that theory, multi-market banks can charge lower deposit rates because they have a wholesale funding cost advantage.

The remainder of this paper is structured as follows. Section 2 reviews our primary data sources. Section 3 covers our main empirical exercise and findings. Section 4 depicts our simple theoretical model. Section 5 describes the larger quantitative banking model and policy experiments. Section 6 concludes the paper.

2 Data Description

We combine several public and private banking data sources. The primary source for rates and fees at the branch and product level is RateWatch, which has been part of S&P Global Market

Intelligence since 2018. RateWatch regularly surveys 76,000 financial institution locations and collects quotes of deposits, mortgages, consumer loan rates, and fees. The set of rates contains several deposit products: savings rates, money market rates, CDs of various maturities and amounts, etc., and has been used in various previous papers (e.g., Drechsler et al. 2017; Gödl-Hanisch 2023; Wang 2018). On the fee side, we are the first to explore RateWatch's collected information on monthly service charges, transaction fees, cash checks, and many more. We merge the data using the bank identifier with the Statistics on Depository Institutions from the Federal Deposit Insurance Corporation (FDIC) to obtain information on bank (non-)interest income and other bank characteristics (such as bank capitalization ratios and funding structure). For most of the empirical section, the focus lies on the period from 2000 to 2022, the beginning of the loan rate dataset.

Table 1 provides summary statistics from bank balance sheets and income statements with a particular focus on non-interest income, a key variable of interest. Across time and banks, non-interest income accounts for 12% of banks' total income, but that share varies strongly across both dimensions. Bank non-interest income can be revenue directly related to traditional lending/borrowing practices or can be generated from non-traditional activities, such as brokerage, insurance, proprietary trading, underwriting, and other investment banking activities. With a share of almost 50%, service charges on deposit accounts contribute largely to non-interest income.[1] The other important component is additional non-interest income that splits into several sub-components, including net servicing fees, net gains on sales of real estate owned and loans, and an *other* category.

TABLE 1

Bank-Level Summary Statistics

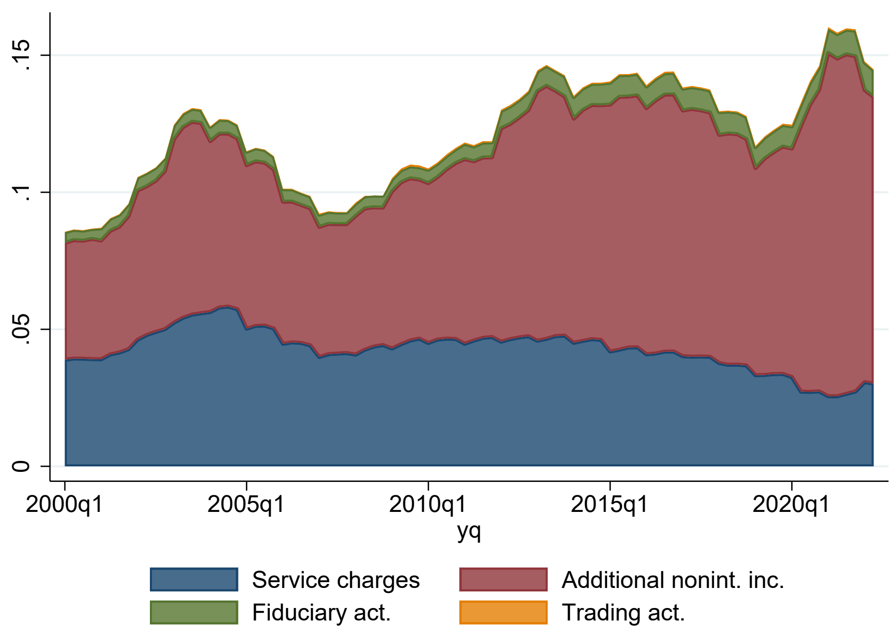
Variable	Mean	p10	p25	p50	p75	p90	N
Assets ($ million)	1,890	34	66	143	347	929	670,927
Deposits as % of Assets	82	73	79	85	88	90	657,599
Insured Deposits as % of Assets	71	55	65	74	81	85	670,477
Equity as % of Assets	11.2	7.7	8.7	10.2	12.4	15.6	656,434
Total Risk-Based Capital Ratio	17.7	11.2	12.8	15.4	20.0	27.1	632,622
Tier 1 Risk-Based Capital Ratio	16.6	10.1	11.6	14.3	18.9	26.1	632,661
Non-Int Income as % Total Income	12	4	6	10	15	22	656,786
Deposit Service Charge as % of Non-Int Income	47	13	27	46	66	80	595,826
Fiduciary Activities as % of Non-Int Income	18	1	3	11	24	44	118,584
Additional Non-Int Income as % of Non-Int Income	56	21	34	54	76	97	645,978
RE Sales as % of Non-Int Income	-1	-3	0	0	0	1	654,136
Loan Sales as % of Non-Int Income	6	0	0	0	3	22	654,473
Servicing Fees as % of Non-Int Income	9	0	2	5	13	24	177,203

Notes: Descriptive statistics of bank-level data for 2000-2022. Source: FDIC.

[1] Service charges on deposit accounts include maintenance fees, minimum balance fees, withdrawals from non-transaction accounts, premature closing of savings accounts, non-sufficient funds check fees, stop payment orders, certifying checks, wire transfers, etc.

Figure 1 decomposes the share of non-interest income in total income over time. The largest contribution comes from additional non-interest income (such as income and fees from check services, money orders, or use of the bank's ATMs). Together with service charges on deposit accounts, these account for the majority of non-interest income, while fiduciary and trading activities do not play a significant role on average and are not the focus of our analysis in this paper.

Figure 1: Decomposition of non-interest income share over time



Notes: Decomposition of non-interest income share over time for 2000-2022. The non-interest income share is composed of: share of service charges on deposit accounts, additional non-interest income, gross fiduciary activities income, and trading account gains and fees relative to total income (calculated as non-interest income plus interest income). Source: FDIC.

3 Empirical Evidence

This section uses bank and branch-level data to present novel empirical evidence on the relationship between non-interest income, fees, and deposit rates over time. We provide evidence that banks with market power in deposits, as measured by lower deposit rates and lower pass-through from monetary policy, tend to have a higher reliance on non-interest income and more market power in their financial services, as measured by higher fees. As discussed in Section 2, we focus on financial services and non-interest income which are directly related to depositors and their accounts.

3.1 Empirical Strategy

We use state-dependent local projections to assess the pass-through of monetary policy to deposit rates across banks with different shares of non-interest income taken as a proxy for financial services market power. At each horizon h, we estimate the following regression equation for bank i's branch c at time t:

$$r_{t+h,i,c} - r_{t-1,i,c} = \alpha^h_{i,c} + \beta^h s_t + \gamma^h s_t \times X_{t,i} + \theta^h X_{t,i} + \eta^h Z_t + \epsilon_{t+h,i,c}, \tag{1}$$

where $\alpha^h_{i,c}$ represents a bank-branch fixed effect, s_t stands for a standard monetary policy surprise taken from Jarociński (2024),[2] $X_{t,i}$ reflects the five-year average non-interest income share,[3] and $Z_{t,i}$ is a vector of macroeconomic and financial controls. The vector of macroeconomic and financial controls contains the unemployment rate, industrial production growth rate, CPI inflation, VIX, excess bond premium, and a dummy for the zero lower bound period. As a robustness check, we additionally control for the relevance of other bank-level characteristics. Specifically, we control for the size (log assets) and capitalization (equity ratio) in those specifications with bank-level controls and additionally interact these with the policy surprise.[4]

Hence, the pass-through of a monetary policy surprise to deposit rates defined as the derivative of the change in the deposit rate to the monetary policy surprise corresponds to the sum of $\beta^h + \gamma^h X_{t,i,c}$. For the visualization of the results, we focus on two states: low and high non-interest income shares defined as the 10th and 90th percentile of the non-interest income share distribution.

3.2 Empirical Results

Figure 2 shows that the estimated pass-through of monetary policy shocks to deposit rates is dependent upon a bank's non-interest income share. The figure plots pass-through for three different types of accounts: savings accounts, money market accounts, and certificates of deposit. The key finding is that deposit rate pass-through is lower for banks with more dependence on non-interest income. The effect is most pronounced for savings accounts which are the most associated with ad-

[2]The standard monetary policy captures unexpected movements in the short-end of the yield curve and isolates any information effect. The monetary policy shock is scaled to increase the federal funds rate by one percentage point after 12 months.

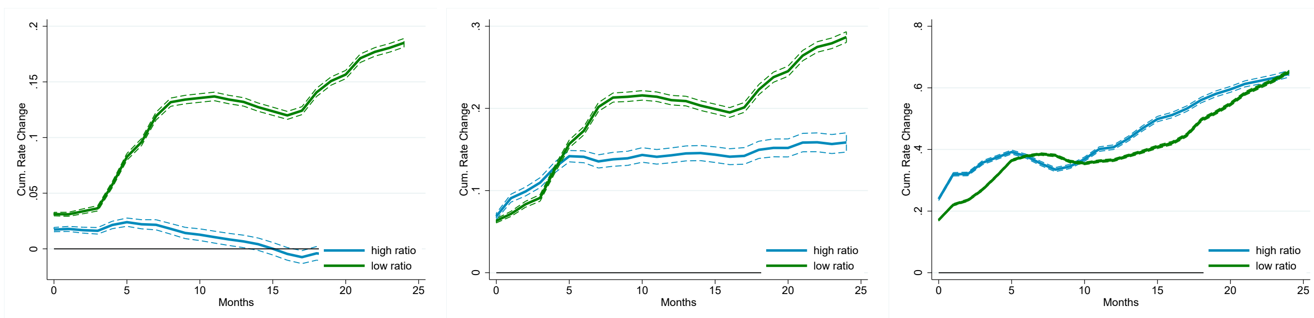
[3]Using the five-year lagged average instead of the contemporaneous share addresses the potential endogeneity concern that banks actively adjust their non-interest income shares to monetary policy.

[4]We take use the deviation from the period average to account for secular trends in the size and capitalization.

ditional bank services, particularly financial services.[5] Again, using non-interest income shares as a proxy for pricing power in financial services, these results suggest that banks with pricing power in services also have pricing power in deposits as measured by lower pass-through. As an important proof of concept, note that for CDs, which offer a very limited set of services to depositors, there is little difference in pass-through.

Figure 2: Local projections of deposit rates to monetary policy shock

(a) Savings (2.5K) (b) Money Market (10K) (c) Certificate of deposit (10K)



Notes: Impulse responses of deposit rates (savings accounts, money market accounts, and certificates of deposit) to a monetary policy shock at both high (blue) and low (green) shares of non-interest income to interest rate income. Horizon is in months. 90% confidence intervals.

We also find differences in the level of pass-through across different deposit accounts: The pass-through of monetary policy is the strongest for time deposits, followed by money market accounts and savings accounts, also in line with Drechsler et al. (2017). While there is almost a complete pass-through to time deposits, particularly of larger denominations, savings account rates barely respond. The limited pass-through to savings accounts is due to banks exploiting the non-elastic demand of savings account holders. Moreover, we find that our main empirical finding holds whether we consider only the (i) deposit component or the (ii) non-traditional component of bank non-interest income.[6] That is, we find that banks that use more deposit fees or banks that use more non-traditional products have less elastic deposit pricing in response to a monetary policy shock.

3.3 Facts about the relationship of deposit rates and fees over time

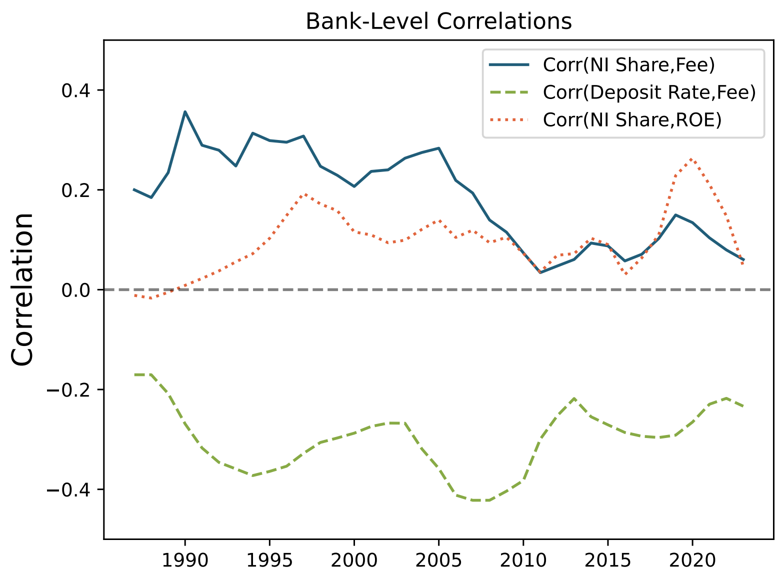
In the previous subsection, we documented that banks with high non-interest income shares have lower deposit rate pass-through. In this subsection, we provide evidence on the bank characteristics

[5]Refer to Appendix Figure A.4 for estimated pass-through across a wider range of deposit accounts.
[6]See Appendix Figure A.7

that are correlated with high non-interest income, particularly as it relates to the level of prices.

High non-interest income is associated with high fees and low deposit rates. Banks offering lower deposit rates tend to charge higher fees. We illustrate this finding with the time-varying pairwise correlation at the bank level using Call Report data in Figure 3 and at the branch level using Ratewatch data in Appendix Figure A.2.[7] This indicates that banks with market power in setting deposit rates, also charge higher fees. We also find that banks with higher fees have higher non-interest income shares (solid blue line) which provides further support for interpreting non-interest income shares as a proxy for market power in financial services.

Figure 3: Correlation of Deposit rates, Fees and Non-Interest Income at the Bank Level



Notes: Deposit rate computed as the ratio of total deposit interest expense to total deposits. Fee rate is computed as the ratio of service charge income on deposit accounts to total deposits. Numbers are annualized by using comprehensive Q4 expenses and income for each fiscal year. For each quarter, compute the cross-sectional correlation and apply a rolling three-year average to smooth out the time series. Source: FDIC.

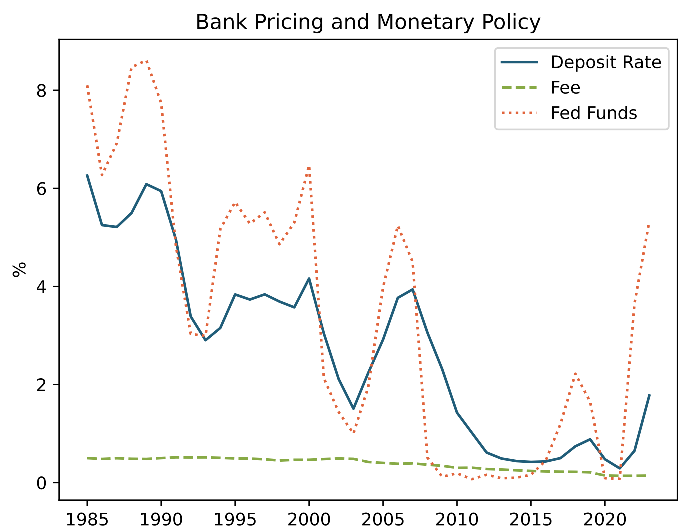
Taking stock, we have demonstrated that banks with high non-interest income shares have lower deposit rate pass-through, and this is correlated with setting a higher level of fees and lower level of deposit rates in the cross-section. We take this as suggestive evidence that banks with high non-interest income exert considerable market power in the pricing of their deposits and financial services. While we do not observe costs and, hence, cannot compute markups for these bank products, we also document a positive correlation between non-interest income shares and return

[7]This result also holds across the size distribution of banks, with larger banks exhibiting a stronger negative relation between deposits and fees, as shown in Appendix Figure A.3.

on equity (dotted red line in Figure 3) which does suggest higher margins for these same banks.

Fee prices are sticky and invariant to monetary policy. Figure 4 plots the average deposit rate and average fee prices for the U.S. banking sector over time.[8] While deposit rates fluctuate considerably over time and move in close proximity with the monetary policy rate (see also Drechsler et al. 2017, Yankov 2023), fee prices are fairly stable over time and invariant to changes in monetary policy. Leveraging the granular branch-level fee dataset, this result holds even at the branch level when focusing on a particular product, such as monthly charges for savings or money market accounts as shown in Appendix Figure A.2.

Figure 4: Deposit rates and fees over time



Notes: Deposit rate computed as the ratio of total deposit interest expense to total deposits. Fee rate computed as the ratio of service charge income on deposit accounts to total deposits. Numbers are annualized by using comprehensive Q4 expense and income for each fiscal year. Source: FDIC.

In addition, we find that total revenue from financial services is constant over time. This implies that the quantities or underlying demand behavior that generate fee income is stable over time, as well. This is consistent with previous findings of a stable customer base and stickiness due to high switching costs (e.g., Kim et al. 2003). A simple implication of the stability and acyclicality of non-interest income is that fee income can be an important source of revenue, particularly in a low interest rate environment.

[8]This result is robust to using the weighted average and across the bank size distribution (Figure A.1).

4 Illustrative Model

In this section, we develop a simple banking model to demonstrate the type of demand behavior that rationalizes the empirical results presented in Section 3. Specifically, we consider a monopolistically competitive banking sector, in which banks provide deposit accounts as well as financial services. We show that when the two products are *tied* (i.e. a consumer must open a deposit account in order to access a bank's services) the bank can exert its services market power in the deposit market and thereby generate lower deposit rates and lower deposit rate pass-through.

Consumer preferences are linear in consumption $\{c, c'\}$ and bank services q^n:

$$c + \beta c' + q^n, \tag{1}$$

where c' is next-period consumption. The consumer chooses these three objects to maximize welfare and satisfy a budget constraint:

$$c + \sum_i \frac{q_i^d}{1 + r_i^d} + \sum_i f_i q_i^n = \omega, \tag{2}$$

where q^n is a CES aggregator over different banks with elasticity ϵ^n, next-period consumption is a CES aggregation of deposit savings with elasticity ϵ^d, and ω is an endowment. We now impost a *tying* constraint

$$q_i^n \leqslant \phi q_i^d \tag{3}$$

for each bank which requires consumers to hold some quantity of deposits in order to access bank services.[9] In the case of a binding constraint, the consumer's first order condition with respect to deposits can be stated as:

$$\beta \left(\frac{q_i^d}{q^d} \right)^{-\frac{1}{\epsilon^d}} + \phi \left(\frac{q_i^d}{\tilde{q}^d} \right)^{-\frac{1}{\epsilon^n}} = \frac{1}{1 + r_i^d} + \phi f_i, \tag{4}$$

where $\tilde{q}^d = \left(\sum_i (q_i^d)^{\frac{\epsilon^n - 1}{\epsilon^n}} \right)^{\frac{\epsilon^n}{\epsilon^n - 1}}$ and this implicitly defines deposit demand as a function of both

[9]Unlike the tying literature reviewed in Section 1, we are not explicit about the strategic decision of banks to tie products in order to generate increased market power but, instead, impose this constraint ad hoc.

elasticities $q_i^d(r_i^d, f_i; \epsilon^d, \epsilon^n)$. Given a bank which chooses prices $\{r_i^d, f_i\}$ to maximize profits:

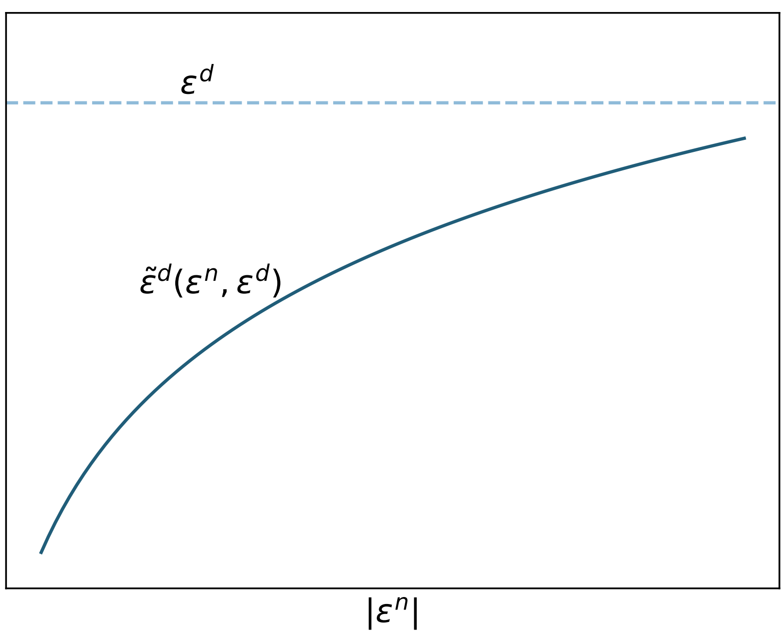
$$\Pi_i = q^d(r - r_i^d) + q^n(f_i - mc), \tag{5}$$

where r is the monetary policy rate, and considering the case in which the tying constraint combines, the bank first order condition on deposit pricing can be stated as:

$$\underbrace{\frac{\partial q_i^d}{\partial r_i^d}\frac{r_i^d}{q_i^d}}_{\tilde{\epsilon}_d(r_i^d, f_i; \epsilon_d, \epsilon_n)} \left[r - r_i^d + \phi(f_i - mc)\right] - r_i^d = 0, \tag{6}$$

where $\tilde{\epsilon}^d$ is an *effective* demand elasticity. Intuitively, in a bank with inelastic demand for services (i.e. low ϵ^n) for which the tying constraint binds, the bank is able to utilize its service market power by setting lower deposit rates. This creates an effective deposit elasticity $\tilde{\epsilon}^d$ which is lower than the primitive elasticity parameter ϵ^d. Thus, as illustrated in Figure 5, a positive correlation exists between primitive services demand elasticity ϵ^n and the effective deposit demand elasticity $\tilde{\epsilon}^d$.

Figure 5: Deposit Demand Elasticity with Product Tying



Notes: Effective deposit demand elasticity in a model without product tying ϵ^d and with product tying $\tilde{\epsilon}^d$ as a function of services demand elasticity ϵ^n.

This allows the bank to maintain relatively high fees f_i, low deposit rates r_i^d, and operate with a higher non-interest income share. Further, the lower deposit rate generates a higher spread $r - r_i^d$ and, hence, less pass-through from changes in the monetary policy rate r.

5 Quantitative Model

In this section, we solve a quantitative model of the U.S. banking sector and use it to perform counterfactual analysis, testing the monetary policy implications that bank fee dependence has for profitability and transmission, specifically the pass-through of monetary policy to deposit rates.

Section 4 provided a micro-founded approach for how banks with market power in one product (such as financial services) can exert additional market power in another product (such as deposits) through product tying. The observed effect reveals itself as a correlation in bank-level demand elasticities: banks with less elastic demand for services also have less elastic depositors.

5.1 Bank Problem

Decisions, Constraints and Technology. There exists I bank types with corresponding probability masses $(p_1, p_2, ..., p_I)$ who monopolistically compete for consumer deposits and financial services. Each bank i has a fixed set of technology and demand parameters. In practice, these differences could emerge from bank characteristics relating to the quality of financial services such as the branch network, ATM network, mobile banking technology, or customer service.

Banks earn profits along two margins: financial services and a more standard deposit-loan balance sheet model. Each period, banks provide a quantity of financial services q_i^n at a fee price f_i. In addition, banks borrow deposits d_i at a rate r_i^d and originate one-period loans ℓ_i which offer an exogenous, risky return r^ℓ. Loan returns can be decomposed into two components

$$r^\ell = r(z_-, z) + \Delta \tag{7}$$

where $r(z_-, z)$ is the monetary policy rate, determined by a simple Taylor rule, and Δ is a constant spread earned on bank loans above the policy rate. The monetary policy rate is determined by the realization of the aggregate shock z in the current period and its value z_- in the previous period. We assume the aggregate shock follows an AR(1) process; specifically, $z' = \rho_z z + \epsilon_z$ where ϵ_z is an iid, mean zero random variable with standard error σ_z.

Each period, banks must satisfy a budget constraint:

$$\pi_i + \ell_i + C_i(\pi_i, q_i^n, \ell_i) = n + d_i + q_i^n f_i. \tag{8}$$

The right-hand side of equation (8) represents bank funding which consists of networth n, deposits d_i, and income from financial services $q_i^n f_i$. Beginning-of-period networth n can be thought of as retained earnings or beginning-of-period equity for the bank. Total deposits are determined by the demand function of the bank $d_i = q^d(r_i^d; r, \epsilon_i^d)$, where ϵ_i^d is a bank-specific demand sensitivity parameter and, similar to Drechsler et al. (2021), demand is sensitive to the level of the monetary policy rate. Last, total service demand is determined via $q_i^n = q^n(f_i; \epsilon_i^n)$ where ϵ_i^n is an elasticity parameter.[10]

The left-hand side includes expenses for dividends π_i, loan origination ℓ_i, and operational costs $C_i(\pi_i, q_i^n, \ell_i)$ composed of a dividend adjustment cost as well as separate costs for financial services and loan origination.[11] We provide explicit functional forms in Section 5.2.

Last, the dynamics of the bank problem are captured through the law of motion on bank networth defining future networth n':

$$\begin{aligned} n' =& (1 + r^\ell)\ell_i - (1 + r_i^d)d_i \\ =& \big(1 + r(z, z') + \Delta\big)\ell_i - (1 + r_i^d) q^d\big(r_i^d; r(z_-, z), \epsilon_i^d\big). \end{aligned} \tag{9}$$

Note that bank loan returns in the next period $(1+r^\ell)\ell_i$ are stochastic and vary with the realized value of the monetary policy rate in the next period such that bank loan rates are adjustable but with a constant spread. Further, deposit demand d_i varies with the monetary policy rate in the previous period in which they were contracted.

Optimization. The bank's objective is to maximize the expected, discounted dividend stream to equity owners subject to the budget constraint, law of motion of networth, and law of motion for

[10] We do not impose a timing restriction on the use of service income in the current period. While this simplifies the analysis, it also generates consistent pricing behavior of financial services, which we discuss in more detail later.

[11] Dividend adjustment costs introduce an important financial friction that helps capture the leverage dynamics faced by banks.

the aggregate shock. Thus, we can express the bank value function as:

$$
\begin{aligned}
v(n, z_-, z; i) = \max_{\pi_i, r_i^d, f_i, \ell_i} \quad & \pi_i + \beta E[v(n', z, z'; i)] \\
s.t. \quad & \pi_i + \ell_i + C_i(\pi_i, q_i^n, \ell_i) = n + q^d(r_i^d; r, \epsilon_i^d) + f_i q^n(f_i; \epsilon_i^n) \\
s.t. \quad & n' = [1 + r(z, z') + \Delta]\ell_i - (1 + r_i^d) q^d(r_i^d; r, \epsilon_i^d) \\
s.t. \quad & z' = \rho_z z + \epsilon_z
\end{aligned}
\tag{10}
$$

Define a bank's state as $\mathbf{s}_i = (n, z_-, z; i)$ such that a policy function $y(\mathbf{s}_i)$ represents a current-period decision and $y(\mathbf{s}'_i)$ represents a policy function based upon the bank's state in the future period. Let $\lambda(\mathbf{s}_i)$ be the shadow multiplier on the bank's current period budget constraint. The bank's first order conditions with respect to pricing and loan origination can be stated as:

$$
[r_i^d]: \quad \frac{\partial d_i}{\partial r_i^d}(\mathbf{s}_i) - E[m(\mathbf{s}'_i)]\left[r_i^d(\mathbf{s}_i) \frac{\partial d_i}{\partial r_i^d}(\mathbf{s}_i) + d_i(\mathbf{s}_i) \right] = 0 \tag{11}
$$

$$
[f_i]: \quad f_i(\mathbf{s}_i) \frac{\partial q_i^n}{\partial f_i}(\mathbf{s}_i) + q_i^n(\mathbf{s}_i) - \frac{\partial C_i}{\partial q_i^n} \frac{\partial q_i^n}{\partial f_i}(\mathbf{s}_i) = 0 \tag{12}
$$

$$
[\ell_i]: \quad -\left(1 + \frac{\partial C_i}{\partial \ell_i}(\mathbf{s}_i)\right) + E\left[m(\mathbf{s}'_i) \left(1 + r(z, z') + \Delta\right) \right] = 0, \tag{13}
$$

where $m(\mathbf{s}'_i)$ is the bank stochastic discount factor, defined as $m(\mathbf{s}'_i) = \beta \frac{E[\lambda(\mathbf{s}'_i)]}{\lambda(\mathbf{s}_i)}$ and $\lambda(\mathbf{s}_i)$ is defined by the dividend equilibrium condition $1 - \lambda(\mathbf{s}_i)\big(1 + \frac{\partial C_i}{\partial \pi_i}(\mathbf{s}_i)\big) = 0$.

For some context in how banks set prices, consider the case in which deposit and service demand are characterized by constant price elasticities of (e^d, e^n) where $e^d > 1$ and $e^n > 1$. Further, consider a non-stochastic equilibrium in which $\lambda(\mathbf{s}_i) = \lambda(\mathbf{s}'_i)$ in all states. Then deposit rates and fees are respectively set as constant markdowns and markups:

$$
[r_i^d]: \quad 1 + r_i^d = \frac{1}{\beta} \frac{e^d}{1 + e^d} \tag{11a}
$$

$$
[f_i]: \quad f_i = \frac{e^n}{e^n - 1} \frac{\partial C_i}{\partial f_i} \tag{12a}
$$

For deposits, the markdown is with respect to the inverse of the discount factor β^{-1} and in the case in which the monetary policy rate is defined as $1 + r = \beta^{-1}$, banks have a positive deposit spread $s^d = r - r^d = (1 + r)\frac{1}{1+e^d}$ which has imperfect pass-through of monetary policy given

$\frac{\partial s^d}{\partial r} = \frac{1}{1+e^d} < 1$.

5.2 Calibration

Functional Forms. For bank demand, we specify payment services demand as a CES demand function with constant elasticity ϵ_i^n such that $q_i^n = q^n(f_i; \epsilon_i^n) = q^n(f_i^n)^{-\epsilon_i^n}$ which provides a constant price elasticity of $-\epsilon_i^n$. Further, for deposit demand, we specify a logistic functional form

$$q^d(r_i^d; r, \epsilon_i^d) = \frac{exp(\epsilon_i^d r_i^d)}{exp(\epsilon_i^d r) + exp(\epsilon_i^d r_i^d)} \tag{13}$$

which is decreasing in the monetary policy rate r. We choose this functional form as it provides a tractable way to account for the monetary policy rate as an outside option for depositors, and it helps generate the pricing dynamics observed in the data.[12] Further, the demand function can be restated in terms of the deposit spread $s_i^d = r - r_i^d$ such that $q^d(r_i^d; r, \epsilon_i^d) = \frac{exp(-\epsilon_i^d s_i^d)}{1+exp(-\epsilon_i^d s_i^d)}$. In terms of operational costs, we specify the following functional forms:

$$C_i(\pi_i, q_i^n, \ell_i) = \phi_i^\pi(\pi_i - \bar{\pi}_i)^2 + q^n(f_i; \epsilon_i^n) mc^f + mc_i^\ell \ell_i^2, \tag{14}$$

where banks have a convex cost in adjusting dividends away from their long run target, a convex cost in loan origination, and linear costs in services.

As noted earlier, the aggregate shock process for loan returns is AR(1) and of form $z' = \rho_z z + \epsilon_z$ where ϵ_z is an iid, mean zero random variable with standard deviation σ^z. Further, let monetary policy follow a Taylor rule:

$$1 + r' = (1 + r^*) \left(\frac{z'}{z}\right)^{\phi_z} \epsilon^r, \tag{15}$$

where the log of ϵ^r is an iid monetary policy shock with zero mean and standard deviation σ^r and r^* represents the neutral or natural rate of interest in the economy.

External Calibration. Model parameters can be summarized by the bank i-specific set

$$\Theta_i = \{ \underbrace{r^*, \phi_z, \sigma^r}_{\text{monetary policy}}, \underbrace{\rho_z, \sigma^z, \Delta}_{\text{loan returns}}, \underbrace{mc^\ell, \phi_i^\pi, \bar{\pi}_i}_{\text{bank costs}}, \underbrace{\epsilon_i^d, \epsilon_i^n}_{\text{demand}}, \underbrace{\beta}_{\text{Discount}} \} \tag{16}$$

[12] Specifically, that deposit rates increase in the monetary policy rate, deposit spreads increase in the monetary policy rate (i.e. imperfect pass-through) and that deposit demand decreases in the monetary policy rate.

where some parameters (such as the cost and demand parameters) are unique to a bank's specific type $i \in I$. Specifically, there are five bank-i parameters $\{\phi_i^f, mc_i^f, \bar{\pi}_i, \epsilon_i^d, \epsilon_i^n\}$ such that the total set of parameters $\Theta = \cup_{i=1}^I \Theta_i$ is a set of $8 + 4^* I$ parameters. For the current calibration, we set $I = 2$ and partition banks according to their size (i.e. between small and large banks according to the median). As is illustrated in Table 2 and in Appendix Table A.1, there exists a strong correlation between bank size and non-interest income shares. Thus, small banks are defined as $i \in I = \{low, high\}$ where *low* corresponds to low non-interest income share banks and *high* corresponds to high non-interest income share banks.

TABLE 2
EMPIRICAL MOMENTS: 2000 Q1-2024 Q1

Moment	Units	Big/Small Bank	Large/Small Markdown	All
Fee Rate	%	0.40/0.33	0.47/0.22	0.39
Deposit Markdown	–	1.08/1.56	0.71/1.96	1.06
Deposit-to-Asset	–	0.65/0.78	0.64/0.70	0.65
Dividend Yield	%	0.67/0.44	0.69/0.59	0.66
ROE	%	10.6/6.4	11.0/9.3	10.5
ROA	%	1.02/0.63	1.03/0.98	1.02
Non-Int Share	%	28.7/11.4	28.6/27.6	28.3
Non-Int Share Dep	%	5.9/4.8	7.1/3.2	5.9
Equity Issuance Rate	%	13.2/4.5	6.1/10.8	9.0
Fee Adjust Rate	%	4.4/4.4	3.6/4.9	4.4

Notes: Unless otherwise specified, all objects are annualized and computed as asset-weighted averages. Fee adjustment rates are aggregated up from the bank level: for each bank, de-trend its series of fee prices, compute the standard error of the cyclical component, and then record observations where the absolute value of the deviation from trend exceeds that of the standard error. *Non-Int Share Dep* measures non-interest income using only the deposit service charge line item.

We can further partition the set of parameters into those which will be externally calibrated versus those which will be internally calibrated; i.e. values determined by matching model moments with empirical counterparts. Parameters related to monetary policy implementation $\{r^*, \phi_z, \sigma^r\}$ can be externally calibrated based upon common values within the literature. Further, we externally estimate the values of $\{\rho_z, \sigma^z\}$ by filtering real GDP and then setting the loan return spread Δ to achieve an average spread observed in the data. We further set the natural rate of interest in the monetary policy rule to the inverse of the discount factor such that $r^* = \beta^{-1} - 1$. The remaining external parameters are listed in Table 3.

TABLE 3
External Calibration Parameters

Parameter	Label	Value	Source/Target
β	Discount Factor	0.998	1% annual rate
ρ_z	Agg Shock Persistence	0.89	Fernald (2014)
σ_z	Agg Shock Volatility	0.0138	Real GDP Growth (1980s-Present)
ϕ_z	MP Exponential Term	0.9	Literature
Δ	Loan Spread	0.016	Corporate Loan Spread BofA

Note: Model parameters are set for a model in quarterly frequency.

Internal Calibration. The remaining set of parameters for the internal calibration are $\{\{\epsilon_i^d, \epsilon_i^n, \phi_i^\pi\}_i, mc^\ell\}$. Given the functional form assumption for services demand, the equilibrium condition simplifies to

$$f_i = \frac{\epsilon_i^n}{\epsilon_i^n - 1} mc_i^f \tag{17}$$

such that total services profit enters the period budget constraint as $\pi_i^n = q_i^n(f_i; \epsilon_i^n)(f_i - mc_i^f)$ which is a constant and invariant to the bank's state $\mathbf{s}_i$. In this way, services net income π_i acts simply as a period endowment. While this pricing condition may seem unrealistic, it is entirely consistent with the observed invariance of bank fees, as shown in Figure 4 of Section 3. In the model, this generates an indeterminacy in the level of $\{mc_i^f, \epsilon_i^n\}$ which generates π_i^n. To manage this, we set $mc_1^f = mc_2^f$ at an arbitrary number and vary ϵ_i^n in the model to match the moment related to bank non-interest income shares, defined as $\frac{q^n f_i}{q^n f_i + r^\ell \ell}$. While this renders the level of ϵ_i^n uninformative, the observed differences across bank types still inform on the relative market power each bank has in services. As shown in Table 4, we recover $\epsilon_{high}^n = 1.3 < 2 = \epsilon_{low}^n$ such that the high non-interest income banks do, in fact, have less elastic demand.

TABLE 4
Internal Calibration Parameters

Parameter	Label	Value	Target	Data	Model
ϵ_{high}^d	Deposit Sensitivity	1.5	Deposit Spread	3.5	3.4
ϵ_{high}^n	Services Elasticity	1.3	Non-Int Share	28.7	26.7

Continued on next page

Table 4 – continued from previous page

Parameter	Label	Value	Target	Data	Model
ϕ^{π}_{high}	Dividend Adjustment	0.04	Equity Issue Rate	13.2	16.1
ϵ^{d}_{low}	Deposit Sensitivity	1.7	Deposit Spread	2.8	2.5
ϵ^{n}_{low}	Services Elasticity	2	Non-Int Share	11.4	12.5
ϕ^{π}_{low}	Dividend Adjustment	0.25	Equity Issue Rate	4.5	4.8
mc^{ℓ}	Loan Cost	0.02	Deposit-Asset Ratio	78	74

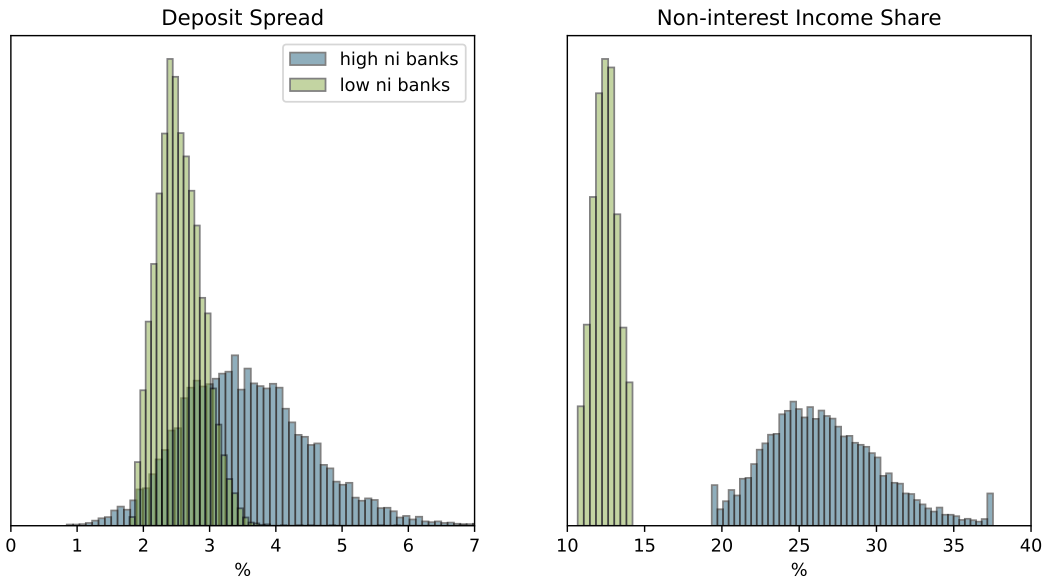
Note: Model parameters are set for a model in quarterly frequency. Data and Model moments are quoted in annualized terms.

We further set the marginal cost parameter on lending to match moments on the average percentage of deposits relative to total assets, which is 78% in the data. We allow the dividend adjustment cost parameter ϕ^{π}_{i} to vary by bank type as we observe significant differences in the use of equity issuance. In particular, for $i = low$ banks, the average annualized rate of equity issuance is 4.5% while it is 13.2% for $i = high$ banks, suggesting that large banks (which also have large non-interest income shares) have a lower cost of external financing. This is reflected by a dividend adjustment parameter which is six times smaller than their small bank, low non-interest income share counterparts.

Last, we set the sensitivity parameter ϵ^{d}_{i} to target the average deposit spread observed in the data, using the federal funds rate as the corresponding monetary policy rate. For the high non-interest income share banks, the annualized spread is 3.5% while for low non-interest income share banks it is 1.8%, reflecting the relative funding advantage of the high non-interest income share banks. The corresponding sensitivity parameters are $\epsilon^{d}_{high} = 1.5 < 1.7 = \epsilon^{d}_{low}$ such that high non-interest income share banks have less elastic deposit demand, as well. Further, note that the model is consistent with the implications of the illustrative model in Section 4 whereby there exists a positive correlation in bank-level demand elasticities. Thus, in the calibrated quantitative model, banks that yield relatively higher market power in services also have higher market power in the deposit funding market.

Baseline Model Output and Validation. Figure 6 plots some simulated cross-sectional moments from the calibrated quantitative model. Specifically, we see that low non-interest income banks operate with, on average, lower deposit rates and spreads (left panel) as well as a smaller non-interest income share, relative to their high non-interest counterparts. High non-interest income banks also have more dispersion in their deposit spreads, which also reflects their lower dividend adjustment cost ϕ_i^π which allows them to more flexibly alter their funding mix between debt and equity.

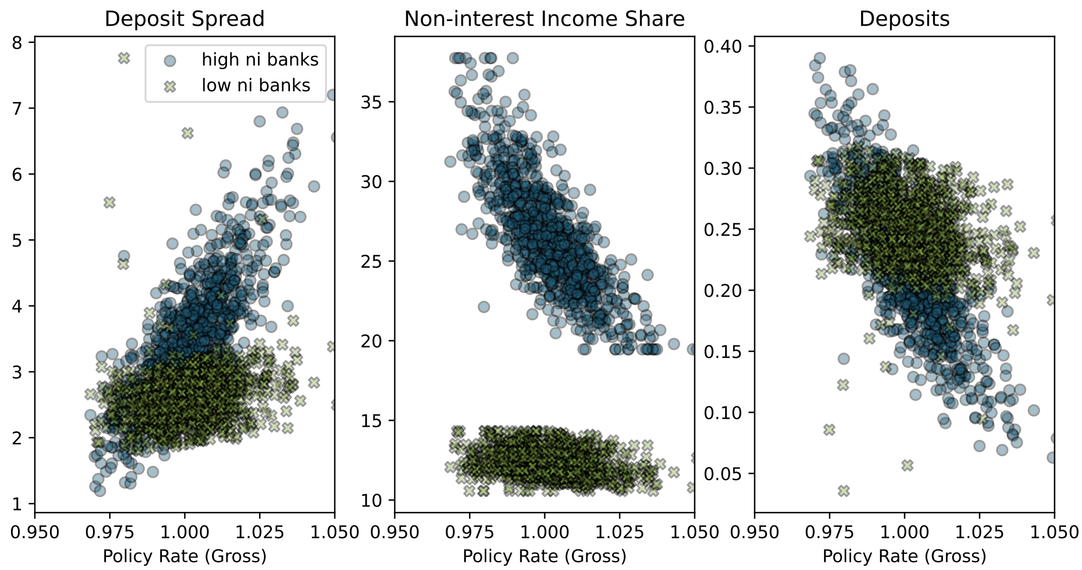
Figure 6: Simulated Cross-Sectional Moments



Notes: The left panel shows the distribution of deposit spreads for high and low non-interest income banks. The right panel shows the distribution of non-interest income shares for high and low non-interest income banks.

Figure 7 plots the simulated relationship of key bank variables/moments with changes in the monetary policy rate. For both types of banks, there is a positive relationship between the monetary policy rate and the deposit spread (left panel): as monetary policy rates increase, banks increase deposit rates to remain competitive with the outside option in $q^d(r_i^d; r, \epsilon_i^d)$ but the spread widens. The net effect is that deposits flow out of the banking sector (right panel) as the policy rate increases. Conversely, when the policy rate is lower, banks operate with a smaller deposit spread and, thus, a lower total net interest margin. This increases the relative importance of fee income and hence banks operate with higher non-interest income shares (center panel) in a lower interest rate period.

Figure 7: Simulated Monetary Policy Trends

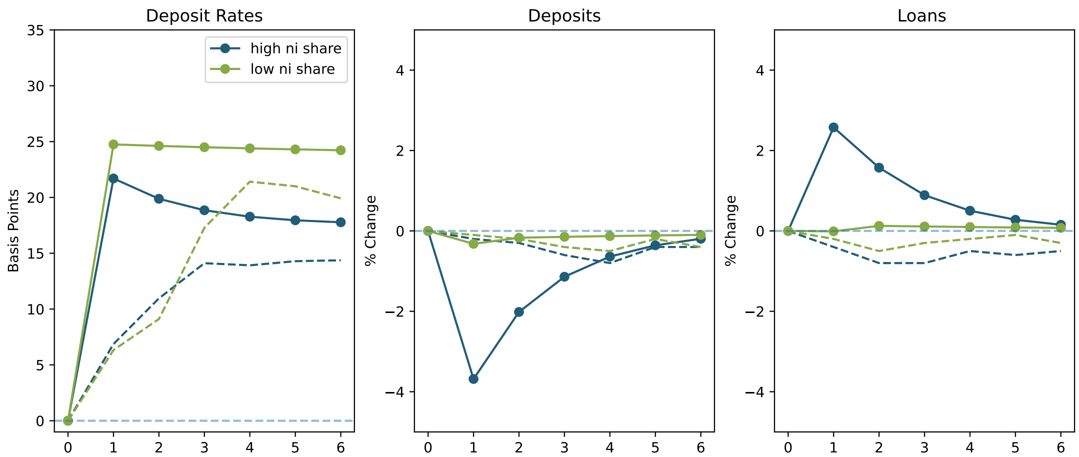


Notes: The left panel shows the deposit spread for high and low non-interest income banks at different levels of the policy rate. The center panel shows the non-interest income share for high and low non-interest income banks at different levels of the policy rate. The right panel shows bank deposits for high and low non-interest income banks at different levels of the policy rate.

We also simulate the impact of a one-time unanticipated 100 basis point monetary policy shock to see how equilibrium objects in the model respond. As shown in Figure 8, deposit rates for high non-interest income share banks respond by the least and this is, in fact, consistent with the empirical trends observed in the data. We do observe a relatively larger response in quantities from high non-interest income share banks, relative to their data counterparts. This is likely due to them substituting more easily into equity financing and/or the model overstating the possible loan returns after a tightening in the monetary policy rate.[13]

[13]Recall, that loan returns are a constant spread above the monetary policy rate; thus, loan rates adjust one-for-one with monetary policy. In practice, banks do not experience a perfect pass-through and, in fact, loan rates and loan demand are dampened considerably.

Figure 8: 100 Basis Point MP Shock (Model and Data)



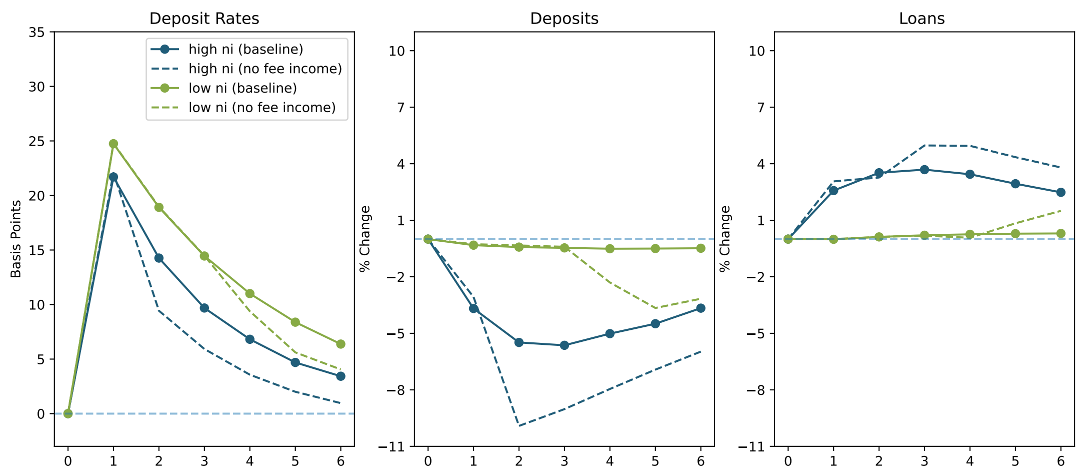
Notes: Solid lines reflect model-implied responses of deposit rates, deposits, and loans to a 100 basis point increase in the policy rate. Dotted lines correspond to the estimated pass-through for low and high non-interest income share banks, as plotted in Figure 2.

5.3 Counterfactual Analysis

In this section, we perform our two main policy experiments on the quantitative model to observe the effect on both the transmission of monetary policy as well as cross-sectional moments. In the first experiment, we measure the effect that eliminating fee income would have on monetary policy transmission. In the second experiment, we consider the effect that changing the natural, or neutral, interest rate would have on monetary policy transmission as well as bank profitability and risk.

Monetary Policy Transmission without Non-Interest Income To simulate the effect of no fee income for banks, we set the services elasticity parameters sufficiently high such that $f_i \to mc_i^f$ and banks earn zero profit from services. We then observe the impact of a 100 basis point monetary policy shock with a decay rate of 0.77. Figure 9 depicts the transmission response for the baseline model and the counterfactual. For deposit rates, the lack of fee income generates relatively less pass-through. Given that depositor demand is unchanged, this creates a larger outflow in deposits for both types of banks.

Figure 9: 100 Basis Point MP Shock (Baseline and *No Fee* Counterfactual)



Notes: Model-implied responses with non-interest income (solid lines) and without non-interest income (dashed lines), where the services elasticity parameters are set sufficiently high so that banks earn zero profit from services.

These results can be explained by examining how banks respond to the loss of their fee profits $\pi_i^n = q_i^n(f_i - mc_i^f)$ which effectively acts as risk-free endowment, boosting bank period networth to be $\tilde{n} = n + \pi_i^n$ where n is an equilibrium object based upon retained earnings from balance sheet decisions in the previous period. When banks lose their fee income (i.e. $\pi_i^n = 0$) they respond by increasing their retained earnings through cutting dividends which increases expected next-period networth $E[n'|\mathbf{s}_i]$. Thus, for any given period, the funding mix $n - \pi_i + d_i$ is more tilted towards retained earnings and equity issuance. The net effect is that banks are less dependent on deposits and, thus, less responsive to monetary policy events, choosing lower pass-through.

Implications for High Versus Low Interest Rate Environments In the second policy experiment, we consider the implications for changing the natural/neutral interest rate r^* in the monetary policy rule. For each counterfactual exercise, we not only change r^* but also change the discount factor β to be consistent with the inverse of the gross rate. We then consider a *lower* and *higher* rate environment defined by a 50 basis point change in the natural interest rate. Results for key bank variables of interest are shown in Table 5. In a low interest rate environment, banks become slightly more dependent upon fee income, choose higher leverage, and increase the volatility of their earnings. Ultimately, these results are driven by two factors: first, fee income is invariant to the monetary policy rate and, thus, remains a stable source of funding for the bank. Second, bank deposit spreads decline and this, in turn, decreases their net interest margin and balance sheet profitability. Banks respond by increasing their leverage which corresponds to lower capital ratios. Further, given the increase in leverage, bank earnings become more volatile and this increases the risk profile of banks, as measured by a lower z-score.

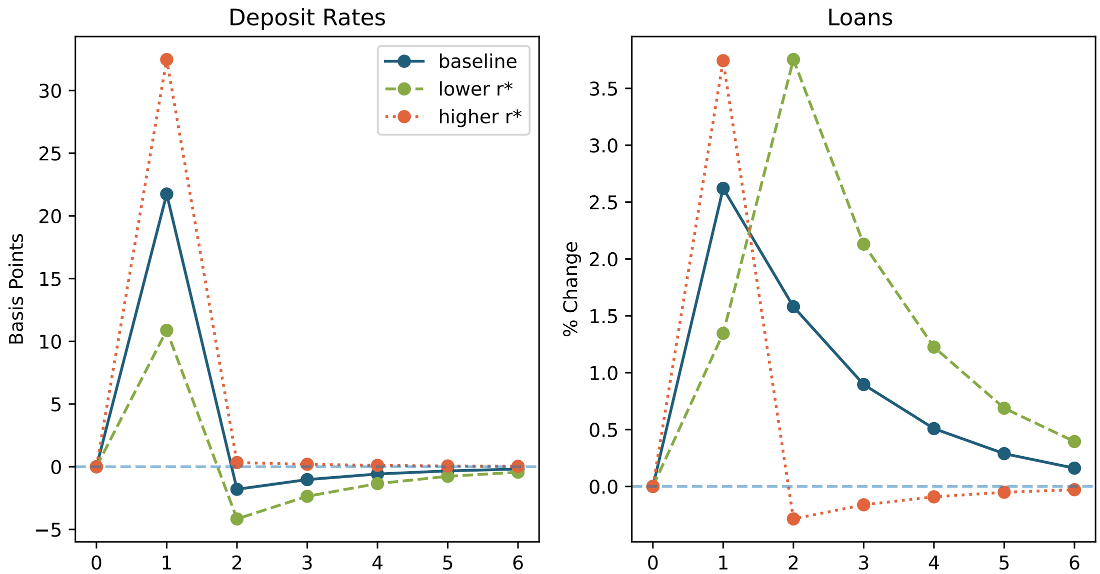
TABLE 5
LOW VERSUS HIGH INTEREST RATE ENVIRONMENT

Object	**Lower** r^*	**Baseline**	**Higher** r^*
Capital Ratio	-11%	–	+9%
Return on Assets	-9%	–	+8%
Non-Interest Income Share	+0.9%	–	-0.9%
Z-Score	-1.8	–	+2.5
Deposit-to-Asset	+10.9%	–	-9.7%
Deposit Spread	-0.42%	–	+0.46%

Note: This table reports the change in model moments in response to a 50 basis point increase and decrease in the natural interest rate.

In addition, we consider the impact of an unanticipated, one-time 100 basis point monetary policy shock in the three different interest rate environments. The results are shown in Figure 10. While bank loan responses are quite similar across the interest rate environments, we do observe differences in the deposit rate pricing behavior. Specifically, bank deposit rates are less responsive (i.e. lower pass-through) in a low-interest rate environment and more responsive in a high-interest rate environment.

Figure 10: 100 Basis Point MP Shock (*Different Natural Rate* Counterfactual)



Notes: Model-implied responses varying the natural rate: baseline (1%), lower r* (0.5%) and higher r* (1.5%).

6 Conclusion

[Work in progress]

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A Figures and Tables

TABLE A.1

Bank balance sheet characteristics by non-interest income share %

	1	2	3	4	Average
% Non-int Income Share	.05	.09	.12	.21	.12
Assets ($,mil)	464	401	603	6,398	1,966
% Deposits	.82	.83	.84	.83	.83
% Insured deposits	.84	.83	.81	.79	.81
Maturity Gap	4.40	4.34	4.41	4.40	4.39
eqv	11.86	10.87	10.53	10.38	10.91
Total Risk-Based CR	19.83	17.47	16.67	16.06	17.50
Tier 1 Risk-Based CR	18.73	16.35	15.54	14.92	16.38
Liquidity Ratio	3.46	3.01	2.68	2.38	2.88
Loan Markups	4.86	2.51	2.71	3.26	3.23
Deposit Markups	.67	.67	.68	.68	.68
Service Charge as % NII	.50	.50	.48	.40	.47
Fiduciary as % NII	.11	.11	.15	.20	.16
Other as % NII	.58	.52	.52	.56	.54
Loan Sales as % Assets	.63	.63	.63	.63	.62
RE Loan Sales % Assets	.47	.44	.45	.44	.45
Securities as % Assets	.23	.23	.22	.22	.23
Wholesale Funding % Assets	.13	.15	.16	.17	.15
Int-Bearing Deposits % Assets	.71	.74	.74	.74	.73
Deposit Rates	1.45	1.17	.93	.90	1.06
Loan Rates	5.63	5.57	5.28	5.19	5.37

Notes: Summary statistics grouped by share of non-interest income. We differ between four groups and calculate the average for the period of 2000-2022. Non-interest income share is the 20-quarter average by bank institutions.[14]

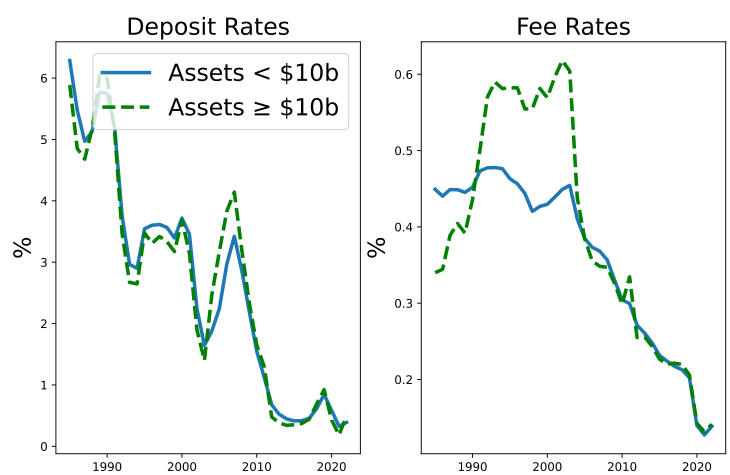
TABLE A.2

Empirical Moments: 2016 Q1-2024 Q1

Moment	Units	Big/Small Bank	Large/Small Markdown	All
Fee Rate	%	0.22/0.18	0.27/0.13	0.22
Deposit Markdown	–	0.59/0.91	0.34/1.04	0.60
Deposit-to-Asset	–	0.65/0.78	0.64/0.70	0.66
Deposit-to-Loan	–	1.35/1.35	1.34/1.34	1.35
Dividend Yield	%	0.71/0.47	0.73/0.67	0.71
Dividend Loan Yield	%	1.26/0.76	1.32/1.09	1.25
ROE	%	10.5/8.7	10.6/10.2	10.5
ROA	%	1.10/0.94	1.06/1.14	1.09
Non-Int Share	%	27.8/12.4	31.6/20.6	27.6
Non-Int Share Dep	%	5.4/3.8	7.0/2.7	5.4
Equity Issuance Rate	%	15.4/3.8	7.6/11.4	10.1
Fee Adjust Rate	%	1.5/1.5	1.3/1.6	1.5

Notes: Unless otherwise specified, all objects are annualized and computed as asset-weighted averages. The designation ^{u}w represents unweighted averages. Fee adjustment rates are aggregated up from the bank level: for each bank, de-trend its series of fee prices, compute the standard error of the cyclical component, and then record observations where the absolute value of the deviation from trend exceeds that of the standard error. *Non-Int Share Dep* measures non-interest income using only the deposit service charge line item.

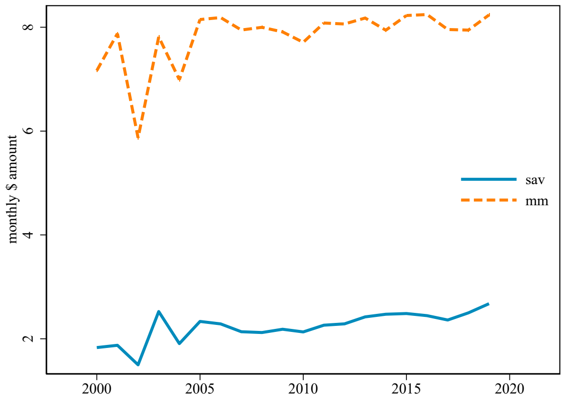
Figure A.1: Deposit rates and fees over time by size



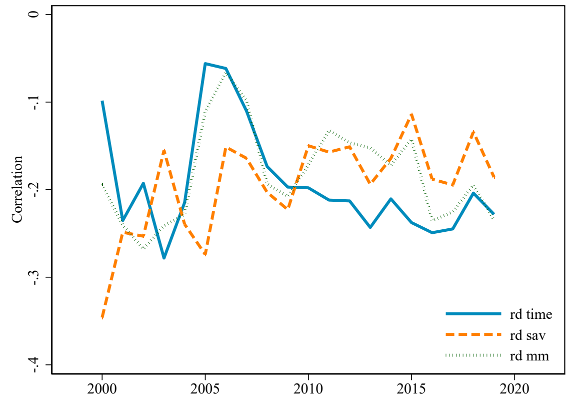
Notes: Deposit rate computed as the ratio of total deposit interest expense to total deposits. Fee rate computed as the ratio of service charge income on deposit accounts to total deposits. Numbers are annualized by using comprehensive Q4 expense and income for each fiscal year.

Figure A.2: Branch-level evidence

(a) Average monthly charges

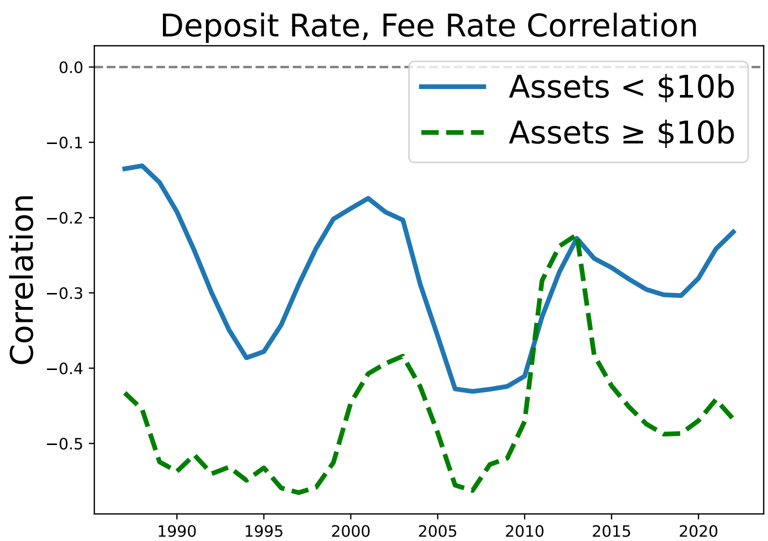


(b) Correlation monthly charges and rates



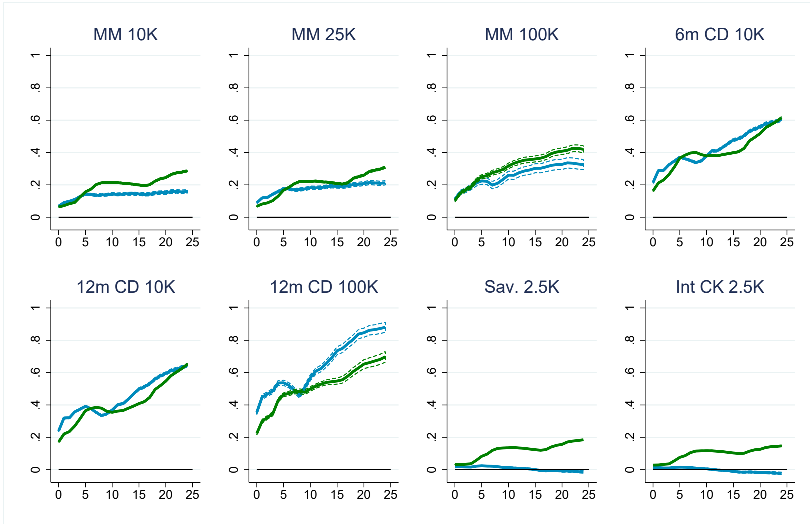
Notes: Average monthly charges for savings and money market accounts. The correlation coefficient of monthly charges and deposit rates. Converted to yearly frequency (average). Correlation for each point in time. Source: RateWatch.

Figure A.3: Correlation of deposit rates and fees at the bank level by size



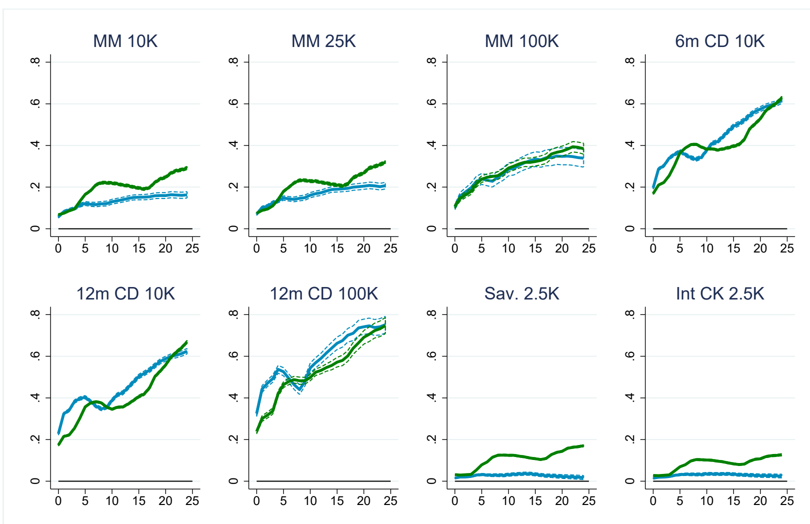
Notes: Deposit rate computed as the ratio of total deposit interest expense to total deposits by bank size (threshold of $10 billion in 2017$). Fee rate computed as the ratio of service charge income on deposit accounts to total deposits. Numbers are annualized by using comprehensive Q4 expenses and income for each fiscal year. For each quarter, compute the cross-sectional correlation.

Figure A.4: Local projections of deposit rates to monetary shock by 5-year avg. non.-int inc. share



Notes: Impulse responses of different deposit rates to a monetary policy shock at both high (green) and low (blue) shares of non-interest income to interest rate income. Horizon is in months. (90% confidence intervals).

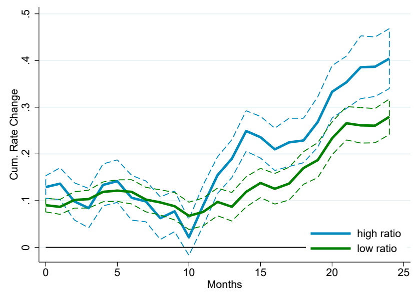
Figure A.5: Local projections of deposit rates to monetary shock by 5-year avg. non.-int inc. share (with bank-level controls)



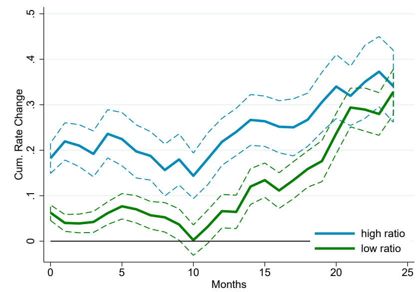
Notes: Impulse responses of different deposit rates to a monetary policy shock at both high (blue) and low (green) shares of non-interest income to interest rate income. Horizon is in months. (90% confidence intervals).

Figure A.6: Local projections of loan rates to monetary shock by 5-year avg. non.-int inc. share

(a) Baseline



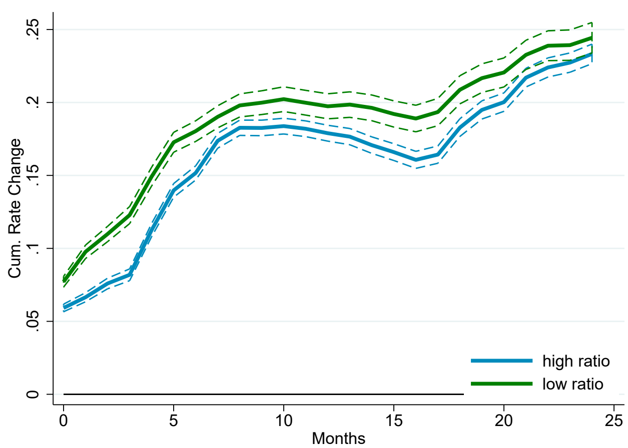
(b) With bank-level controls



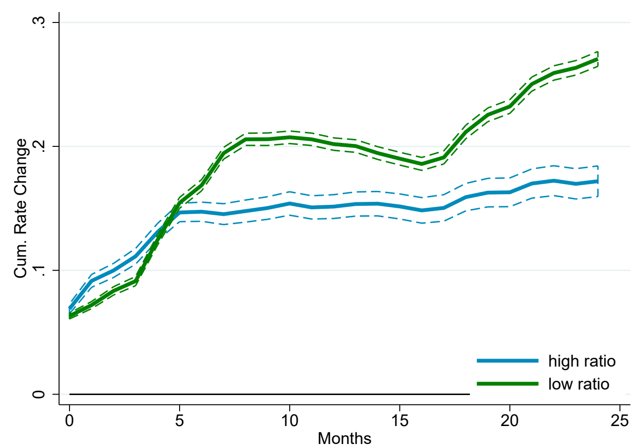
Notes: Impulse responses of the 1-year adjustable mortgage rate to a monetary policy shock at both high (blue) and low (green) shares of non-interest income to interest rate income. Horizon is in months. (90% confidence intervals).

Figure A.7: Narrower categories of non-interest income

(a) Service charges on deposit accounts over total non-interest income



(b) Additional non-interest income over total non-interest income



Notes: Impulse responses of the MM rate 10K to a monetary policy shock at both high (blue) and low (green) shares of 5-year avg. of service charges on deposit accounts over total non-interest income and 5-year avg. of additional non-interest income over total non-interest income, respectively. Horizon is in months. (90% confidence intervals).