Why Is Monetary Policy Less Effective at Low Interest Rates: The Role of the Banking Sector

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September 2026

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Abstract

This paper investigates the effectiveness of monetary policy in a low-interest-rate environment, focusing on how loan and deposit rates respond to changes in nominal interest rates. Using U.S. bank data, I show that deposit rates reach zero when the policy rate falls to about 2 percent, with both deposit and loan rates becoming unresponsive to further cuts below the threshold. Net interest margins do not shrink, meaning that banks' equity and lending capacity do not respond to cuts in the policy rate. For these reasons, monetary policy loses its effectiveness well before the policy rate reaches zero. Stabilizing demand-driven recessions near this threshold requires earlier fiscal coordination.

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I am deeply grateful to my advisors, James Hamilton, Juan Herreño, Munseob Lee, Fabian Trottner, Michael Reher, and Johannes Wieland, for their invaluable guidance and support throughout this work. I also thank Nir Jaimovich, Arvind Krishnamurthy, Lan Nguyen, Thomas Mertens, and Allan Timmermann for their insightful feedback and helpful comments.

1. Introduction

The interest rates on bank deposits and loans are important channels through which monetary policy is transmitted to the economy. Bank deposits are the primary savings vehicle for many households, so deposit rates directly affect returns on savings, while loan rates shape households' intertemporal borrowing decisions and firms' investment spending. For banks, these two rates determine profitability, as the spread between them is a main source of earnings and, consequently, accumulated equity, which determines their lending capacity. The effectiveness of monetary policy therefore depends on how deposit and loan rates adjust to changes in the policy rate, since these adjustments affect not only the decisions of households and firms but also banks' capacity to create credit.

The literature on monetary policy transmission through the banking sector predicts that low or negative policy rates can undermine the effectiveness of monetary policy, as the pass-through from the policy rate to deposit rates breaks down and lending capacity is ultimately eroded.[1] Because cash offers a zero nominal return, negative deposit rates would prompt households to withdraw their deposits and hold cash instead, which places a lower bound of zero on deposit rates. Because banks set deposit rates below the policy rate by exercising market power as highlighted in Drechsler et al. (2017), this bound binds while the policy rate is still positive, making it distinct from the lower bound on the policy rate. Given this constraint, the conventional view holds that, as the policy rate declines, deposit rates remain stuck at zero while banks continue to lower lending rates. This compresses loan-deposit margins and erodes bank equity through reduced profits. Ulate (2021), Abadi et al. (2023), and Balloch and Koby (2023) formalize this channel, showing that the resulting compression of net interest margins slows the accumulation of bank equity and ultimately reduces lending capacity.[2] Abadi et al. (2023) extend this logic and show that, once interest rates fall below a certain threshold, known as the reversal interest rate, expansionary monetary policy becomes contractionary.

In this paper, I propose an alternative mechanism through which monetary policy loses effectiveness in low-interest-rate environments: the breakdown of loan-rate pass-through. I provide evidence for this novel mechanism using U.S. bank-level data and exogenous monetary policy shocks. The U.S. banking sector provides a useful setting because the effective lower bound on

[1] Wang (2025) examines how the pass-through from the *real* rate to loan and deposit rates varies with the level of the real rate and analyze its short-run and long-run effect while do not model the deposit-rate lower bound.

[2] Although these papers study negative nominal interest rate policy, the mechanism begins to operate as soon as the deposit-rate lower bound binds, even while the policy rate is still positive. Beyond this net interest margin channel, the literature identifies several others, including a balance-sheet channel in which falling returns on liquid assets such as reserves and government bonds reduce bank profitability (Eggertsson et al. 2023), household portfolio diversification and bank funding substitution (Onofri et al. 2023), and signaling effects (de Groot and Haas 2023).

deposit rates, a key condition underlying the conventional mechanism, can bind even while the policy rate remains positive. Therefore, the adoption of a negative nominal interest rate policy is not necessary to examine this mechanism. Moreover, U.S. banks experienced a prolonged period of low interest rates and accommodative monetary policy, allowing me to examine how banks' deposit and loan rates respond once this bound becomes binding. This mechanism differs from explanations based on weakened bank balance sheets because monetary policy loses effectiveness when further rate cuts no longer reduce borrowing costs, rather than when banks' lending capacity contracts.

To examine how banks respond to expansionary monetary policy shocks when the deposit rate bound is binding, I first estimate a threshold regression to identify the level of the policy rate below which deposit rates cease to respond even as the policy rate continues to decline. Ulate (2021) uses cross-country bank-level data and actual changes in policy rates to estimate the threshold to be approximately 0.5%. In contrast, I estimate the threshold directly using a threshold regression following Hansen (2000) and exogenous monetary policy shocks constructed by Bauer and Swanson (2023), Nakamura and Steinsson (2018), and Acosta et al. (2025). My estimates show that deposit rates stop responding once the federal funds rate falls below about 2%.

I then examine the responses of loan rates using panel local projections (Jordà 2005; Jordà et al. 2022), which allow these responses to vary across regimes. Specifically, I interact monetary policy shocks with indicator variables for whether the federal funds rate is above or below 2% to estimate their effects in each regime. Using the same exogenous monetary policy shocks as in the threshold estimation, I find that both deposit and loan rates cease to respond to monetary policy shocks once the policy rate falls below 2%, even though the policy rate itself continues to decline. These findings are robust to the possibility that low interest rates coincide with other macroeconomic conditions or bank characteristics, such as uncertainty, lending standards, or bank balance-sheet conditions, that may independently affect banks' pricing decisions. The results remain unchanged when these factors and their interactions with monetary policy shocks are included jointly alongside the interactions between the regime indicators and monetary policy shocks. The results are also robust to an alternative state-dependent local projection specification based on Ramey and Zubairy (2018).

Consistent with the muted responses of loan and deposit rates in the low-interest-rate regime, I find that the loan-deposit spread does not shrink following further expansionary monetary policy shocks and instead remains stable.[3] The baseline estimates provide limited evidence of compression in the loan-deposit rate spread following monetary easing in the low-rate regime. This result is consistent with Drechsler et al. (2021), who show that U.S. banks' net interest margins remain

[3] A recent paper by Eichenbaum et al. (2025) reports results that might seem to be inconsistent with the above claims. Section 4.2.2 reconciles the results reported by Eichenbaum et al. (2025) with those in this paper.

stable across interest rate cycles, and with Genay et al. (2014), who find that low interest rates have only negligible effects on U.S. bank profitability. The same result holds for other measures of profitability, including return on assets (ROA) and return on equity (ROE).

Next, I find limited evidence that expansionary monetary policy shocks in the low-rate regime weaken bank equity or increase leverage, contrary to the conventional view that low interest rates impair bank balance sheets. The baseline responses of book equity, market valuations, and leverage provide limited evidence of a deterioration in bank capitalization following monetary easing in the low-rate regime. This is consistent with U.S. evidence in English et al. (2018), who show that bank stock prices decline following unanticipated increases in the level or slope of the yield curve, implying that monetary easing tends to support bank valuations.[4]

Finally, I test whether the response of lending exhibits policy rate level dependence. Because loan rates do not fall, one would expect lending to fail to expand even though lending capacity remains intact. Consistent with this prediction, the stock of loans on banks' balance sheets ceases to accumulate, and loan applications no longer respond to expansionary monetary policy in the low-rate regime.[5]

To evaluate how much monetary policy's ability to stimulate output and stabilize the economy during a recession is reduced when loan-rate pass-through breaks down but other transmission channels remain active, and whether fiscal policy can offset the resulting loss of monetary policy effectiveness, I develop a general equilibrium model in which banks intermediate between households that supply deposits and firms that demand loans. Following the money-in-the-utility-function approach of Feenstra (1986) and Krishnamurthy and Vissing-Jorgensen (2012), households derive utility from consumption and from the liquidity services provided by their combined holdings of deposits and money. This feature allows households to hold deposits alongside risk-free assets that earn the policy rate, generating an endogenous spread between the policy rate and the deposit rate as in Wang (2025) and Jamilov and Monacelli (2025). Firms produce using labor and capital and finance their capital through bank loans. Banks fund loans by issuing deposits and are constrained by the equity they carry into each period. When setting loan rates, banks take into account both their deposit funding costs and the cost of leverage.

When calibrated to the U.S. economy, the model reproduces the qualitative state dependence of retail-rate pass-through and bank lending documented in the empirical analysis, retail rates,

[4]Evidence from Europe is more mixed. While Altavilla et al. (2018) show, using monetary policy surprises, that easing shocks improve euro-area bank stock prices, Basten and Mariathasan (2023) and Ampudia and Van den Heuvel (2022) find that low or negative rates in the euro area are associated with weaker bank equity outcomes and reduced lending. See also Claessens et al. (2018), Eisenshmidt and Smets (2019), Lopez et al. (2020), and Eggertsson et al. (2023).

[5]While theoretical papers share a core mechanism in which compressed net interest margins and eroded equity dampen monetary policy effectiveness, the empirical evidence is mixed; see Balloch et al. (2022) and Brandao-Marques et al. (2024) for comprehensive reviews.

loan, and equity, to monetary policy shocks. The model implies that monetary policy becomes less effective in low-rate environments because pass-through from the policy rate to loan rates collapses even without an erosion of bank equity. The model predicts that the output response to an exogenous monetary policy shock depends on the level of the policy rate, with the response nearly halved in the low-rate regime.

This attenuation is less severe when firms rely on bonds as well as bank loans because pass-through from the policy rate to corporate bond rates remains intact, allowing monetary easing to continue reducing firms' borrowing costs. In the extended model, where bond financing accounts for 40% of firms' funding, consistent with the aggregate funding structure of U.S. nonfinancial firms, monetary policy retains about two-thirds of its high-rate effectiveness, implying that the loss is reduced from one-half to one-third but remains economically sizable.

This weakening of monetary policy effectiveness in low-interest-rate environments is particularly pronounced during recessions. Following a recessionary shock modeled as a household preference shock, the Taylor rule calls for a reduction in the policy rate, but the effectiveness of this response depends on the *level* of the policy rate. If the recession occurs in the high-rate regime, deposit rates remain responsive, and policy rate cuts reduce banks' funding costs and loan rates, cushioning the declines in lending and output. However, if the recession occurs in the low-rate regime, the monetary policy response is not transmitted to either the deposit rate or the loan rate, resulting in a more severe recession and larger output losses than in the high-rate regime. Consequently, over the range of Taylor-rule coefficients considered, a stronger monetary response reduces the recession but leaves a persistent stabilization gap between the two regimes.

When the model incorporates a government spending rule that responds to output shortfalls, fiscal stabilization partly offsets the weakened transmission of monetary policy and supports the recovery from recession. The gains from fiscal intervention are modest when monetary policy remains sufficiently effective to counteract recessionary forces, but become substantially larger in the low-rate regime.

These results identify a role for fiscal stabilization at positive policy rates. When the deposit-rate floor weakens the transmission of monetary easing to bank borrowing costs, government spending can support demand directly. The model experiments show that this additional stabilization can be valuable before the policy rate reaches its own lower bound. Much of the existing literature argues that fiscal policy becomes necessary when monetary policy loses effectiveness at the zero lower bound for the policy rate. For example, Eggertsson and Woodford (2003) argue that stabilization at the lower bound requires a more active role for fiscal instruments, while Christiano et al. (2011) show that the government spending multiplier is substantially larger when the zero lower bound binds. This paper suggests, however, that the need for fiscal support may arise well before the policy rate reaches zero. Because monetary transmission through the banking sector can weaken once deposit rates reach their own lower bound, monetary policy may become constrained at a positive policy rate once the banking sector is taken into account. Therefore, fiscal and monetary policy coordination may be particularly valuable not only at the zero lower bound, but also when the policy rate itself remains unconstrained while its transmission through the banking sector is dampened.

Roadmap. The rest of this paper is organized as follows. Section 2 describes the data and monetary policy shock measures. Section 3 presents the threshold regression and state-dependent panel local projection methodology. Section 4 reports the empirical results for bank interest rates, profitability, equity, leverage, and lending activity, together with robustness checks. Section 5 develops the general equilibrium model. Section 6 presents the calibration and evaluates the model's quantitative performance, the loss of monetary policy effectiveness during recessions, the stabilizing role of fiscal policy, and the extension incorporating bond financing. Section 7 concludes.

2. Data

In this paper, I use data from several datasets to analyze the response of bank variables to monetary policy shocks and test their dependence on the policy rate level.

2.1. Bank-level Data

Bank-level data is from Consolidated Reports of Condition and Income (Call Reports) of U.S. banks provided by Wharton Research Data Services (WRDS).[6] The data span from 1986:Q1 to 2019:Q4 and include quarterly observations of U.S. commercial banks' balance sheets and income statements.[7] For publicly traded banks, Call Report data are matched to equity prices from the Center for Research in Security Prices (CRSP) using code provided by the Federal Reserve Bank of New York.[8] Bank default probabilities are estimated using the indices constructed by Nagel and Purnanandam (2020) and also merged to Call Report data.

[6] I follow the data cleaning process code from Drechsler et al. (2017, 2021)

[7] The sample is restricted to banks reporting at least 20 quarterly observations between 1986 and 2019. Drechsler et al. (2021) require at least 60 quarterly observations when estimating bank-level interest income and interest expense betas. The local projection horizon considered here is 16 quarters, and I use a minimum of 20 quarters. The results are robust to using 40 or 60 quarters.

[8] https://www.newyorkfed.org/research/banking_research/datasets

2.2. Aggregate-level Data

Aggregate time series data are obtained from the Federal Reserve Economic Data (FRED) database and include the effective federal funds rate, market yields on U.S. Treasury securities with various maturities (2, 5, and 10 years), real GDP, CPI, the unemployment rate, and the NBER Recession Indicator. For financial market data, I use the excess bond premium constructed by Gilchrist and Zakrajšek (2012). The Macroeconomic/Financial Market Uncertainty index developed by Ludvigson et al. (2021) are drawn from WRDS. Monetary policy uncertainty, as developed by Baker et al. (2016), is obtained from their website. Finally, quarterly aggregate-level bank profile data are from the FDIC Historical Bank Data.[9]

2.3. Monetary Policy Shock Series

Throughout the analysis, I use monetary policy shocks constructed using high-frequency identification strategies. The baseline monetary policy shock is constructed by Bauer and Swanson (2023), who address both the exogeneity and relevance of monetary policy surprises as instruments.[10] For robustness, I use the shock series constructed by Nakamura and Steinsson (2018) and extended by Acosta (2023). I also use the shocks constructed by Acosta et al. (2025).

3. Empirical Methodology

To examine whether banks respond differently to monetary policy across interest rate environments, I proceed in two steps. First, I use Hansen's (2000) methodology to estimate a threshold in the policy rate below which further rate cuts no longer pass through to deposit rates. I then use panel local projections to compare the responses of bank interest rates and balance-sheet variables to monetary policy shocks above and below this threshold.

3.1. Threshold Regression Model

I estimate a threshold regression to examine how the relationship between deposit rates and monetary policy shocks varies with the level of the policy rate. The specification allows the intercept, the monetary-shock coefficient, and the coefficients on the controls to differ across regimes. I utilized the exogenous monetary policy shock series and find the threshold where the

[9] https://www.fdic.gov/quarterly-banking-profile

[10] Bauer and Swanson (2023) include speeches by the Fed Chair, thereby doubling the number and importance of announcements (Swanson and Jayawickrema 2023). They also account for the "Fed response to news" channel by orthogonalizing the surprises with respect to macroeconomic and financial data that predate each announcement.

pass-through of monetary policy shock to deposit rate changes based on the algorithm suggested by Hansen (2000).[11] Hansen (2000) provides an asymptotic distribution theory for the threshold estimate and constructs asymptotic confidence intervals by inverting the likelihood ratio statistic. The regression specification estimated is

$$i^D_{t+h} = \begin{cases} \alpha_L + \beta_L \varepsilon_t + \mathbf{X}'_{t-1}\Gamma_L + \zeta_{t+h}, & \text{if} \quad i_{t-1} < \gamma \\ \alpha_H + \beta_H \varepsilon_t + \mathbf{X}'_{t-1}\Gamma_H + \zeta_{t+h} & \text{if} \quad i_{t-1} \geq \gamma. \end{cases} \tag{1}$$

The left-hand side variable, i^D_{t+h}, denotes the deposit rate at time $t+h$, and ε_t on the right-hand side represents the monetary policy shock. X_{t-1} captures other macroeconomic variables, including the lagged inflation rate, unemployment rate, excess bond premium, and the lagged value of the deposit rate. Given a wide and fine grid support, $\Gamma \in [0, 10]$, the regression tests $\beta_L = \beta_H$ by estimating the likelihood ratio statistic, $LR(\gamma)$, at a given $\gamma \in \Gamma$, and checking whether it is less than or equal to the critical value c.

Table 1. Threshold (γ) Estimation Results for the Deposit Rate

	Shock		
Horizon	Bauer and Swanson (2023)	Nakamura and Steinsson (2018)	Acosta et al. (2025)
$h = 0$	**2.40** [1.75, 3.05]	**2.40** [2.40, 2.40]	**2.40** [1.75, 2.40]
$h = 1$	**2.40** [2.22, 2.47]	**2.40** [2.19, 2.40]	**2.13** [1.94, 2.47]
$h = 4$	**1.92** [1.30, 3.06]	**1.25** [1.01, 1.25]	**1.25** [1.02, 1.43]

Note. This table reports threshold estimates for the deposit rate using equation (1) and the Hansen's (2000) algorithm. Bold values denote point estimates, with 95% confidence intervals reported in brackets. The rows correspond to horizons $h = 0$, $h = 1$, and $h = 4$.

Table 1 reports the threshold estimates and their 95% confidence intervals across different monetary policy shock measures and horizons. The horizons correspond to the impact period, one quarter ahead, and one year ahead, allowing sufficient time for the deposit rate to adjust. The threshold estimates vary across shock measures and horizons. I use 2% as the benchmark cutoff, informed by the baseline one-year estimate of 1.92%. The local-projection estimates are conditional on this cutoff. I assess sensitivity to nearby alternatives using cutoffs of 1.8% and 2.4%.

[11] Ulate (2021) conducted threshold estimation based on Hansen (1999) under the panel data setting and used policy rate level directly because of the absence of monetary policy shock for each country in data sample.

3.2. State-dependent Panel Local Projection

To examine how U.S. banking-sector dynamics respond to exogenous monetary policy shocks and whether these responses differ above and below the estimated policy rate threshold, I employ panel local projections à la Jordà (2005) using a rich panel dataset.

The main specification is as follows.

$$y_{t+h,b} = \beta_h^H \cdot \mathbb{I}\left[i_{t-1} > \gamma\right] \cdot \varepsilon_t + \beta_h^L \cdot \mathbb{I}\left[i_{t-1} \leq \gamma\right] \cdot \varepsilon_t + \mathbf{X}'_{b,t-1}\Gamma_h + \alpha_{b,h} + e_{b,t+h} \tag{2}$$

The left-hand side variable of equation (2), $y_{t+h,b}$, captures the variable of interest at $t + h$, where b denotes the bank index. The indicator functions $\mathbb{I}[i_{t-1} > \gamma]$ and $\mathbb{I}[i_{t-1} \leq \gamma]$ tells whether the policy rate level is higher or lower than the threshold γ or not. The indicator $\mathbb{I}[i_{t-1} \leq \gamma]$ selects the low-rate regime. The coefficients β_h^L and β_h^H describe monetary-shock responses conditional on the initial interest-rate regime. The coefficients β_h^H and β_h^L estimate how the monetary policy shock, ε_t, affects the behavior of the outcome in different regime after h quarters the shock. $\mathbf{X}_{b,t-1}$ includes constant, the indicator $\mathbb{I}[i_{t-1} > \gamma]$, the lagged value of the outcome ($y_{t-1,b}$) and both aggregate level economy environment and bank level characteristics that the literature has shown which can simultaneously affect banks' decision. In case of aggregate-level economy environment, I includes lagged value of inflation rate, unemployment rate, the slope of the yield curve, and quarter dummies. In addition, I include recession indicator to control the recessionary effect during the low interest rate environment. The bank-characteristics I control are logarithm level of total assets (size of the bank), security ratio that measures the liquidity of the bank (which is security/asset), and deposit share (which is deposit/liability) emphasized in Eggertsson et al. (2023). $\alpha_{b,h}$ denotes horizon h specific bank fixed effects. The monetary policy shock, ε_t, is normalized so that a positive value corresponds to an expansionary shock. The shock's size is also normalized to induce a decrease in the federal funds rate of 100 basis points on impact.

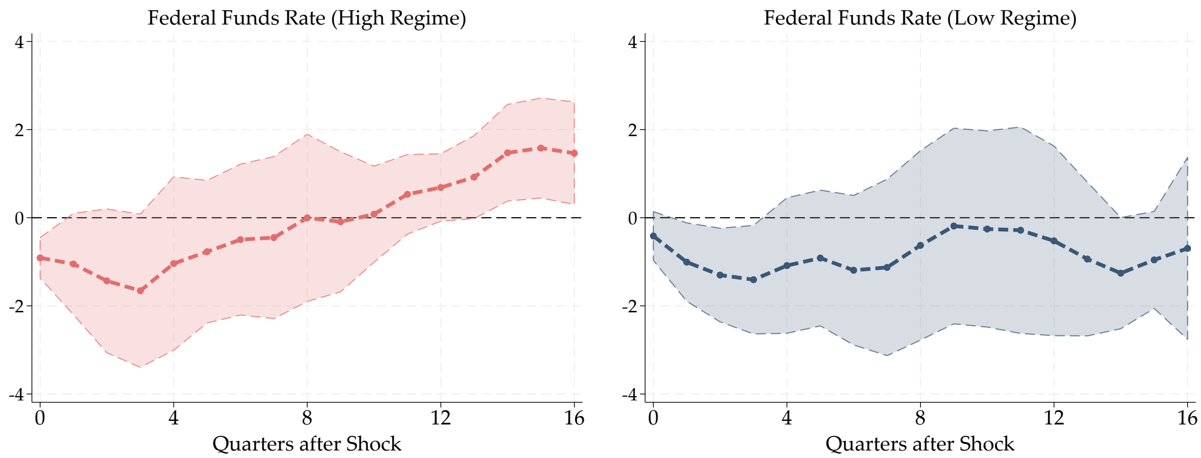
4. Estimation Results

This section reports the estimated coefficients, β_h^H and β_h^L, for the policy rate, banking variables, and real economy outcomes at horizons $h = 0, \ldots, 16$ of equation (2).

4.1. Policy Rate Response

I first estimate the response of the policy rate to test whether the policy rate itself exhibits dependence on its own level. The left panel of Figure 1 describes the estimate of $\{\beta_h^H\}_{h=0}^{16}$ and the right panel illustrates the estimate of $\{\beta_h^L\}_{h=0}^{16}$ of equation (2) for the federal funds rate.[12]

FIGURE 1. Impulse Responses of Federal Funds Rate to Monetary Policy Shock



Note. The estimated regression equation is $FedFundsRate_{t+h} = \beta_h^H \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta_h^L \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma_h' \mathbf{X}_{t-1} + e_{t+h}$ for each horizon $h \in \{0, 1, \ldots, 16\}$ where γ set to be 2%. The upper panels illustrate the sequences of $\{\beta^h\}_{h=0}^H$ and lower panels show sequences of $\{\beta^h\}_{h=0}^H$ with 90% confidence bands. The shaded areas represent pointwise 90% confidence intervals based on heteroskedasticity-robust standard errors.

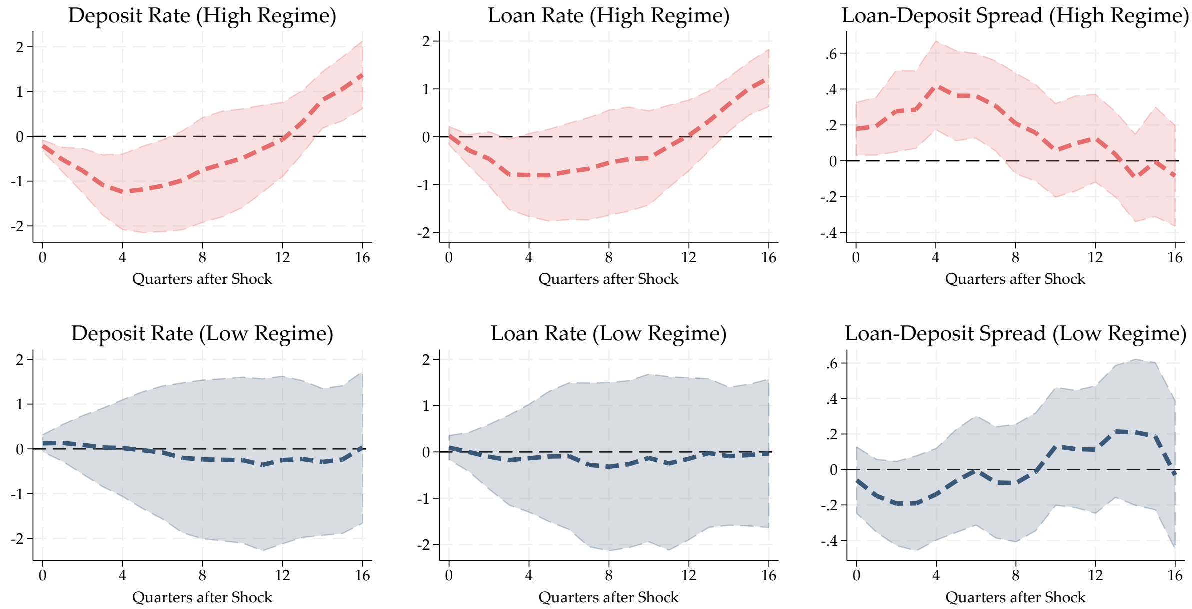
In both regime, the policy rate declines by 100 basis points within one quarter: in the high-interest-rate regime, the policy rate falls by 100 basis points on impact, and in the low-interest-rate regime, the same decline occurs with a one-quarter later and continues to fall for an additional two to three quarters. When the policy rate normalizes after the shocks, it converges more quickly when the initial rate is above the threshold, but remains persistently lower for a longer period when the policy rate environment is below the threshold. In other words, the policy rate exerts stronger and more prolonged downward pressure on the interest rates faced by banks in a low-rate environment, reflecting the Zero Lower Bound (ZLB) periods that the U.S. economy experienced for an extended duration.

4.2. Loan Rate, Deposit Rate, and Loan-Deposit Spread

After confirming that the policy rate declines in both regimes, I examine the responses of bank variables, beginning with loan rates, deposit rates, and the loan-deposit spread. The upper panels of Figure 2 present the estimates of β_h^H for each variable, while the lower panels show the corresponding estimates of β_h^L at each horizon h. The left panels of Figure 2 report results for the loan rate, the middle panels for the deposit rate, and the right panels for the loan–deposit spread.

[12]While equation (2) is specified for bank-level data, I estimate the same regression using aggregate data, omitting bank fixed effects and bank-level balance-sheet information from $\mathbf{X}_{t-1}$.

FIGURE 2. Impulse Responses of Deposit Rate, Loan Rate, and Loan-Deposit Spread to Monetary Policy Shock



Note. The estimated regression equation is $y_{t+h,b} = \beta_h^H \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta_h^L \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma_h' \mathbf{X}_{t-1} + \alpha_{b,h} + e_{b,t+h}$ for each horizon $h \in \{0, 1, \ldots, 16\}$ where γ set to be 2%. The upper panels illustrate the sequences of $\{\beta^h\}_{h=0}^H$ and lower panels show sequences of $\{\beta^h\}_{h=0}^H$ with 90% confidence bands. Standard errors are two-way clustered by bank and quarter.

As shown in the upper panels of Figure 2, when the policy rate is above 2%, an expansionary monetary policy shock that lowers the policy rate by 100 basis points on impact leads to gradual declines in both lending and deposit rates. Both rates decline gradually, with the deposit rate initially falling more than the loan rate. The loan-deposit spread consequently widens temporarily before moving back toward its pre-shock level, consistent with Drechsler et al. (2021).[13]

The results for the low-interest-rate regime are displayed in the lower panels of Figure 2. As shown in the lower-left panel, deposit rates remain unresponsive to an expansionary monetary policy shock. This confirms that the estimated threshold properly identifies the policy rate level at which the pass-through from the policy rate to deposit rates collapses and aligns with the literature estimation (Greenwald et al. 2023; Emin et al. 2025).

The main results of interest are the estimated coefficients for the loan rate response, displayed

[13]Empirical analysis on the effect of policy rate changes to loan-deposit spread is mixed. Literature, including Drechsler et al. (2021) and Ennis et al. (2016), shows there exists weak correlation between net interest margin, measured by the gap between the asset income rate and liability cost rate, and the policy rate dynamics. Taking into account the fact banks usually hold long-term fixed-rate assets (including loans) and floating rate liabilities, a decline of policy rate could lead to an rise of the net interest margin (Paul 2022).

in the lower-middle panel. Contrary to the assumption in the literature, loan rates, like deposit rates, exhibit a muted response to expansionary monetary policy even as the policy rate continues to decline, as shown in Figure 1. From 6 to 8 quarters after the shock, the point estimates show a decline of about 30 basis points, while they revert to zero again around 9 quarters after the shock.

This lack of adjustment in both loan and deposit rates results in a stable loan–deposit spread, as shown in the lower-right panel in Figure 1. The estimated coefficients for loan-deposit rate margin indicate that the null hypothesis that the spread responses are equal to zero cannot be rejected. This finding implies that the primary source of profits on which banks rely to build lending capacity is preserved, despite the downward pressure from the policy rate and the prolonged period during which banks could have lowered loan rates while deposit rates remained at zero.

4.2.1. Evidence from Loan Rates on Newly Originated Loans.

The primary data consist of balance sheet and income statement information, from which loan and deposit rates are measured as average rates on outstanding balances. Drechsler et al. (2021) documents that while deposits have relatively short maturities, loans have an average maturity of four years. A potential concern is that the estimated responses, particularly those of loan rates, may reflect changes in the composition of outstanding and newly originated loans on banks' balance sheets. To address this concern, I estimate the responses of interest rates on newly originated mortgage, auto, and commercial and industrial (C&I) loans.[14]

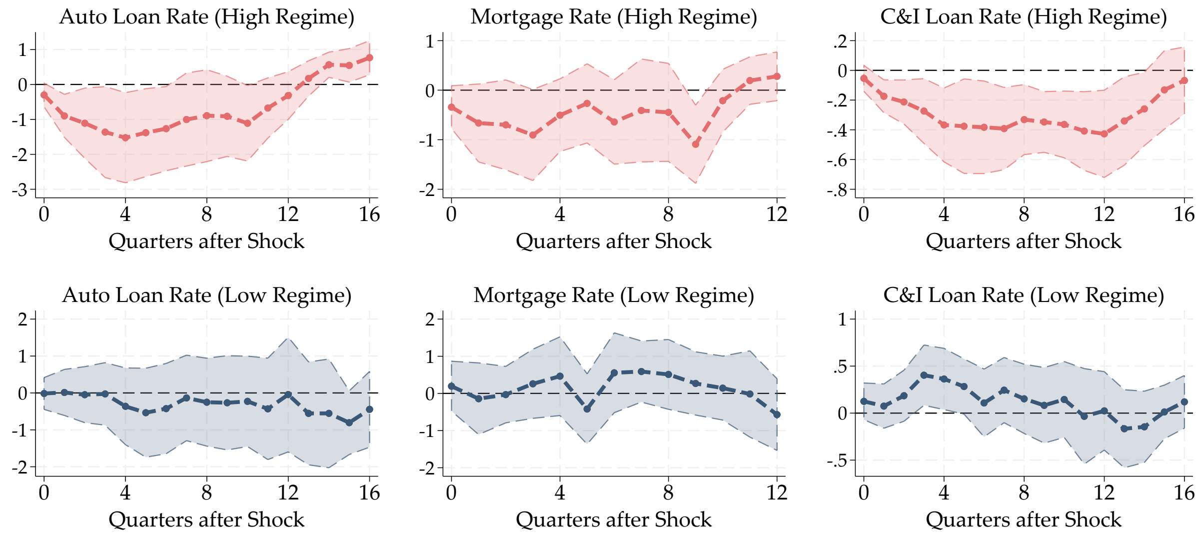
Figure 3 presents the responses of the three loan-rate series in the high- and low-interest-rate regimes. As shown in the upper panels, all rates on newly originated loans decline significantly following an expansionary monetary policy shock when deposit rates adjust accordingly. The low-rate responses differ across loan categories and do not display the broad downward adjustment observed in the high-rate regime. In particular, the C&I rate shows a temporary increase. The evidence therefore points to impaired downward pass-through across lending markets.

4.2.2. Relationship with Eichenbaum et al. (2025).

In a contemporaneous and independent study, Eichenbaum et al. (2025) also employ policy-rate-level-dependent local projections and find that the loan-deposit spread, referred to as core NIM in their paper, declines following monetary easing in a low-policy-rate environment. Specifically,

[14]For mortgage rates, I use the 30-Year Fixed Rate Mortgage Average in the United States (MORTGAGE30US). For auto loan rates, I use the Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 48-Month Loan (TERMCBAUTO48NS). For C&I loan rates, I use historical data from Table E.2 of the Survey of Terms of Business Lending, which reports the spread between C&I loan rates and the intended federal funds rate from 1986:Q1 to 2017:Q2 (https://www.federalreserve.gov/releases/e2/e2chart.htm). I recover the C&I loan rate by adding the federal funds rate to this spread.

FIGURE 3. Impulse Responses of Loan Rate for Newly Originated Loans to Monetary Policy Shock



Note. The estimated regression equation is $LonaRate^j_{t+h} = \beta^H_h \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta^L_h \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma'_h \mathbf{X}_{t-1} + e_{t+h}$ for each horizon $h \in \{0, 1, \dots, 16\}$ where γ set to be 2%. Here, $iLonaRate^j_t$ denotes the interest rate on newly originated loans in category j, covering mortgages, auto loans, and C&I loans. The high- and low-rate responses correspond to $\{\beta^H_h\}^{16}_{h=0}$ and $\{\beta^L_h\}^{16}_{h=0}$, respectively. The shaded areas represent pointwise 90% confidence intervals based on heteroskedasticity-robust standard errors.

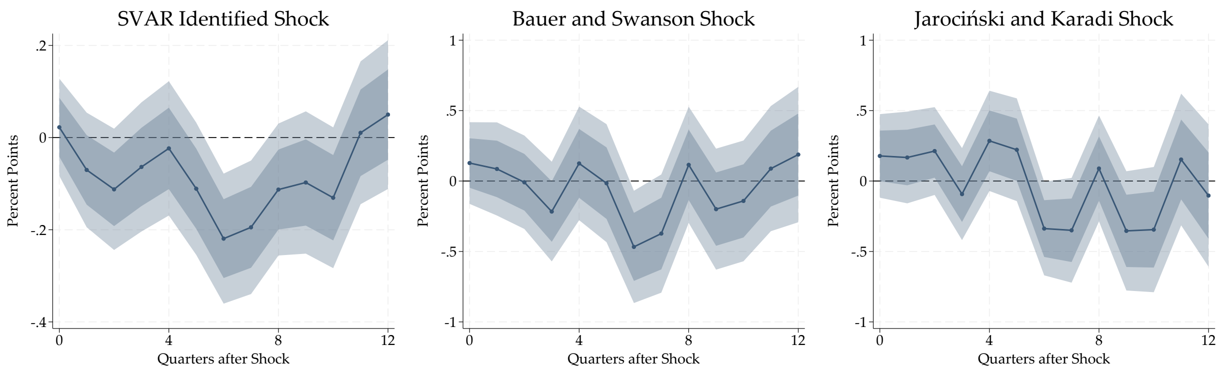
they find that a 100-basis-point cut in the federal funds rate leads to a statistically significant decline of roughly 30 basis points in the spread two quarters after the cut. By contrast, in this paper, I find no sustained decline in the spread once deposit rates cease to respond to monetary policy.

The main differences stem from the definition of the low-interest-rate regime. Eichenbaum et al. (2025) use a 4% cutoff for the six-quarter moving average of the federal funds rate. They motivate this threshold by mapping the approximately 3.2% attention threshold for annualized quarterly inflation documented in Pfäuti (2025) into a nominal interest rate, assuming a 1% real interest rate. In this paper, I use a 2% cutoff for the one-quarter-lagged federal funds rate, motivated by the estimated change in deposit-rate pass-through described in Section 3.1. Their definition captures a broader low-rate environment, whereas my benchmark is intended to identify the regime in which deposit rates cease to respond to monetary policy shocks.

To examine the role of the regime definition, I first replicate the results of Eichenbaum et al. (2025) using their original specification. I then reestimate the responses using the 2% cutoff for the one-quarter-lagged federal funds rate.

Benchmark Replication. I begin with their original low-rate regime, defined by a six-quarter moving average of the federal funds rate below 4%. Figure 4 reports the replication results. Under their baseline specification, a 100-basis-point cut in the federal funds rate is followed six quarters later by a statistically significant 21-basis-point decline in the loan-deposit spread. This reproduces the direction and significance of their baseline result, although the magnitude and timing differ.[15] These estimates provide the benchmark for examining the response once deposit rates cease to adjust.

Figure 4. IRFs of NIM to Monetary Policy Shock in the Low-Interest-Rate Regime Replicating Eichenbaum et al. (2025) Results



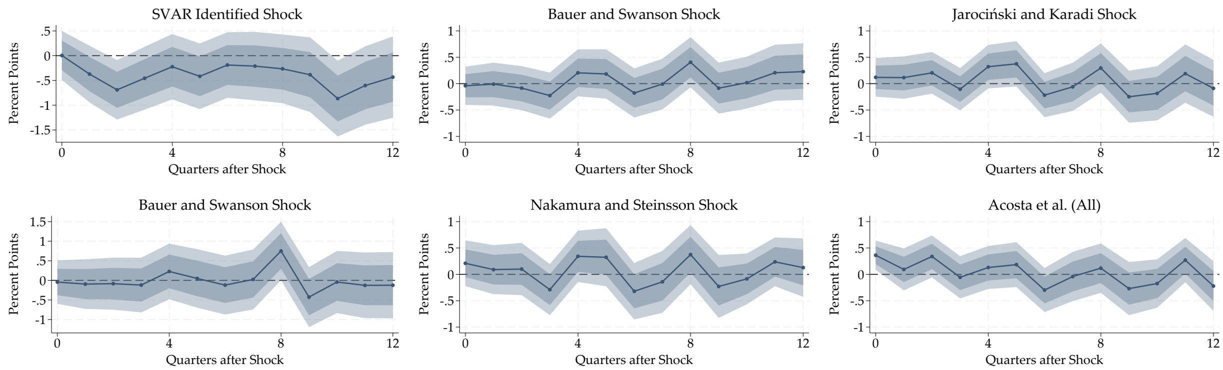
Changing the Threshold. I reestimate their aggregate specification using a low-rate regime defined by the one-quarter-lagged federal funds rate below 2%. For this exercise, I use both the monetary policy shocks employed by Eichenbaum et al. (2025) and those used in my baseline analysis. Figure 5 reports the results. Under this definition, the estimates do not show sustained compression of the loan-deposit spread across the specifications considered.[16] Thus, using the regime definition motivated by deposit-rate pass-through yields results consistent with the main finding of this paper, even when their aggregate specification is retained.

Key Takeaway. The comparison helps reconcile the two sets of results by emphasizing that the low-rate regime is defined with respect to different research questions. A decline in the loan-deposit spread in a broader low-rate environment can coexist with limited evidence of sustained spread compression once deposit rates cease to respond. In Eichenbaum et al. (2025), both deposit and loan rates respond to monetary policy, but the stronger pass-through to loan rates allows monetary easing to compress the loan-deposit spread as loan rates decline more than deposit rates, whereas our results show that once deposit rates cease to respond, loan rates also exhibit little

[15]Under the 4% definition, the unorthogonalized Bauer and Swanson (2023) series also produces a statistically significant decline, whereas its orthogonalized version and the other high-frequency shocks considered do not. I use the same six shock measures under both regime definitions.

[16]The recursively identified shock produces temporary declines, while the high-frequency shocks do not produce a decline.

Figure 5. IRFs of NIM to Monetary Policy Shock in the Low-Interest-Rate Regime
2% Threshold



additional adjustment, leaving the spread between the two largely unchanged. The 2% benchmark is therefore intended to isolate this latter condition, rather than to serve as an alternative general classification of low interest rates. Viewed in this way, the results suggest that further monetary easing below this threshold need not generate sustained compression of the loan-deposit spread.

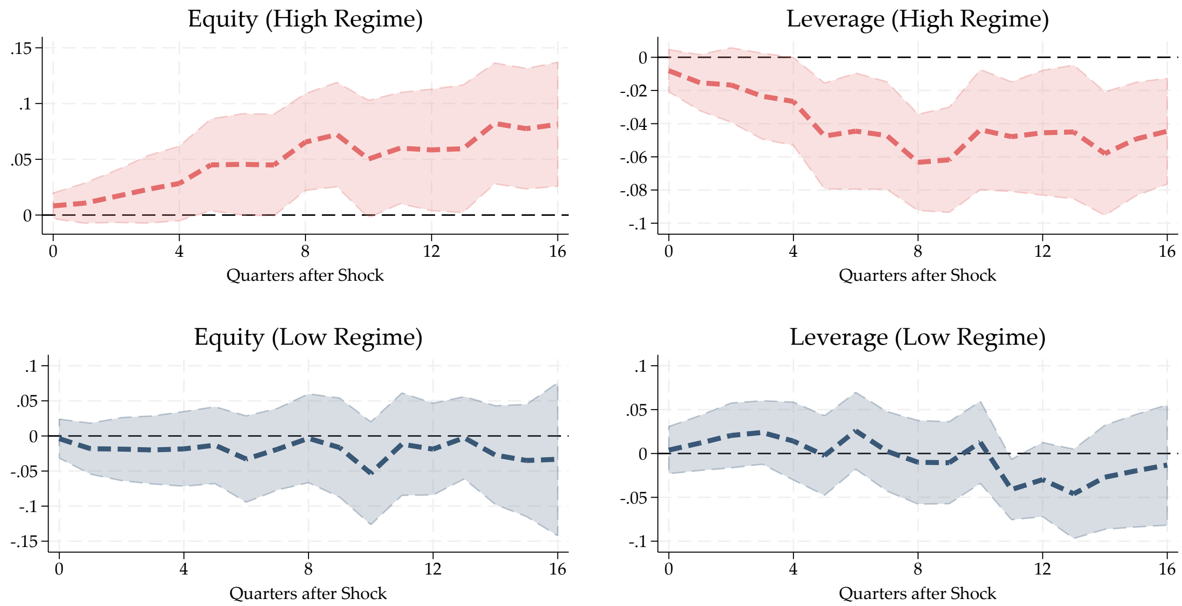
4.3. Equity and Leverage

Next, I estimate the responses of bank equity and leverage, both of which the literature identifies as important determinants of lending volumes.[17] According to the mechanism emphasized in this literature, a compression of the loan-deposit spread in a low-interest-rate environment reduces bank profits and erodes equity. The resulting increase in leverage raises the likelihood that regulatory capital constraints become binding. Once these constraints bind, Abadi et al. (2023) shows banks' capacity to extend credit is limited and may even contract. Although the U.S. economy did not adopt negative policy rates, this mechanism should still be observable if it is driven by the effective lower bound on deposit rates, since U.S. deposit rates became unresponsive while the policy rate remained positive and banks experienced a prolonged period of low interest rates and accommodative monetary policy.

The upper panels of Figure 6 show the responses of book equity and leverage when the policy rate is above the threshold, whereas the lower panels report the corresponding estimates when the policy rate is below the threshold. The left panels present the results for book equity, and

[17]Heider et al. (2019), for instance, show that when policy rates entered negative territory, banks that relied more heavily on deposits and consequently experienced larger declines in profitability reduced lending relative to other banks, while increasing their risk taking. Bittner et al. (2022) similarly find that bank net worth was an important determinant of lending by Germany and Portugal banks during the negative-rate period.

Figure 6. Impulse Responses of Equity and Leverage (Book Value) to Monetary Policy Shock



Note. The estimated regression equation is $y_{t+h,b} = \beta_h^H \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta_h^L \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma_h' \mathbf{X}_{t-1} + \alpha_{b,h} + e_{b,t+h}$ for each horizon $h \in \{0, 1, \ldots, 16\}$ where γ set to be 2%. The upper panels illustrate the sequences of $\{\beta^h\}_{h=0}^H$ and lower panels show sequences of $\{\beta^h\}_{h=0}^H$ with 90% confidence bands. Standard errors are two-way clustered by bank and quarter.

the right panels present those for leverage. Book equity increases following an expansionary monetary policy shock when the policy rate is above the threshold. This finding is consistent with the expansion of loans and deposits, documented in the following section, combined with the preservation or slight increase of the loan–deposit spread. Together, these responses allow banks to accumulate equity and reduce leverage.[18] Consistent with this mechanism, leverage declines following an expansionary monetary policy shock, which is consistent with Uppal (2025).

When the policy rate is below the threshold, as shown in the lower panels, there is no statistically significant evidence that expansionary monetary policy erodes book equity or increases leverage. The baseline low-rate estimates provide limited evidence that monetary easing erodes book equity or increases leverage. The leverage point estimates become negative at longer horizons, although their timing and precision vary across specifications. These results motivate examining a transmission mechanism that operates without a deterioration in bank capitalization.[19] These

[18] Another channel through which an expansionary monetary policy shock may contribute to equity accumulation is a reduction in loan losses (Uppal 2025).

[19] One might suggest that banks could maintain their book equity by realizing capital gains from securities sales or adjusting noninterest income and fees. Nevertheless, the majority of banks' profits are generated through net interest

results are robust to the alternative controls, shocks, and local projection specifications discussed in Section 4.5.

Other Profit Measures. Ulate (2021) has examined bank profitability using various measures such as Return on Equity (ROE) and Return on Assets (ROA). In addition, net interest income, the dollar amount accrued for equity accumulation and dividend distribution, is another important indicator. The analysis of ROE, net interest income, and loan loss provision reveals a pattern similar to that observed for equity. Both ROE and net interest income improve when the policy rate is above the threshold. However, when the policy rate is below the threshold, these measures remain relatively stable in response to an expansionary monetary policy shock. The findings are shown in Appendix A.3.

Market Value. As Nuno and Thomas (2017) and Li (2022) point out, book-value equity and leverage are appropriate measures for analyzing banks' decisions, and their use is consistent with real-world policy frameworks, including those governing lending. However, English et al. (2018) and Ampudia and Van den Heuvel (2022) examine the responses of equity and leverage using market values. For a robustness check, I also examine market-value equity and leverage and obtain similar results. Market-value equity does not decline, nor does market-value leverage increase, when the policy rate is below the threshold. Appendix A.4 presents the results.

4.4. Loan Volume and Loan Application

Now, I estimate the final interest outcome, the loan volume reported in the banks' balance sheet. Figure 7 displayed the estimated coefficients $\{\beta_h^H\}_{h=0}^{16}$ and $\{\beta_h^L\}_{h=0}^{16}$.

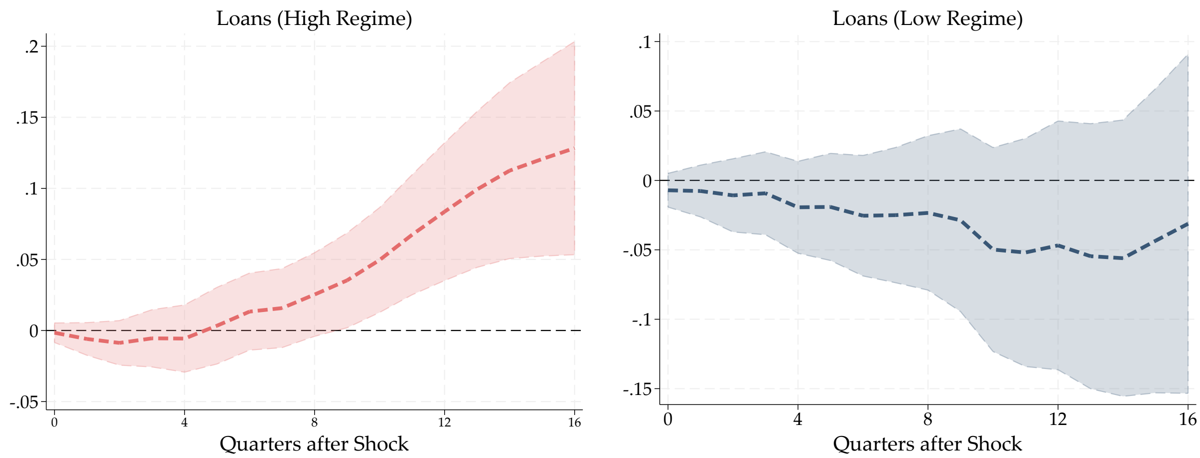
As shown in the left panel, bank lending increases by 15% over the 16 quarters following the shock. In the low-interest-rate regime, however, the right panel shows that an expansionary monetary policy shock that lowers the policy rate by 1 percentage point does not induce a statistically significant increase in bank lending, as it does in the high-interest-rate regime. Instead, the stock of loans on banks' balance sheets declines mildly.

Because balance sheets report the *stock* of loans, they do not distinguish among previously originated loans, newly originated loans, and repayments. To address this concern, I use monthly Home Mortgage Disclosure Act data on mortgage applications and originations from 1994 to 2021.[20] These data provide complementary evidence on mortgage applications, originations, and approval rates. Applications capture borrowers' participation in the mortgage market, while approval rates describe lenders' decisions conditional on the applicant pool. Together, these outcomes help assess

income.

[20] The data are available at https://sites.google.com/site/neilbhutta/data.

Figure 7. Impulse Responses of Outstanding Loan to Monetary Shocks



Note. The estimated regression equation is $y_{t+h,b} = \beta_h^H \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta_h^L \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma_h' \mathbf{X}_{t-1} + \alpha_{b,h} + e_{b,t+h}$ for each horizon $h \in \{0, 1, \ldots, 16\}$ where γ set to be 2%. The upper panels illustrate the sequences of $\{\beta^h\}_{h=0}^H$ and lower panels show sequences of $\{\beta^h\}_{h=0}^H$ with 90% confidence bands. Standard errors are two-way clustered by bank and quarter.

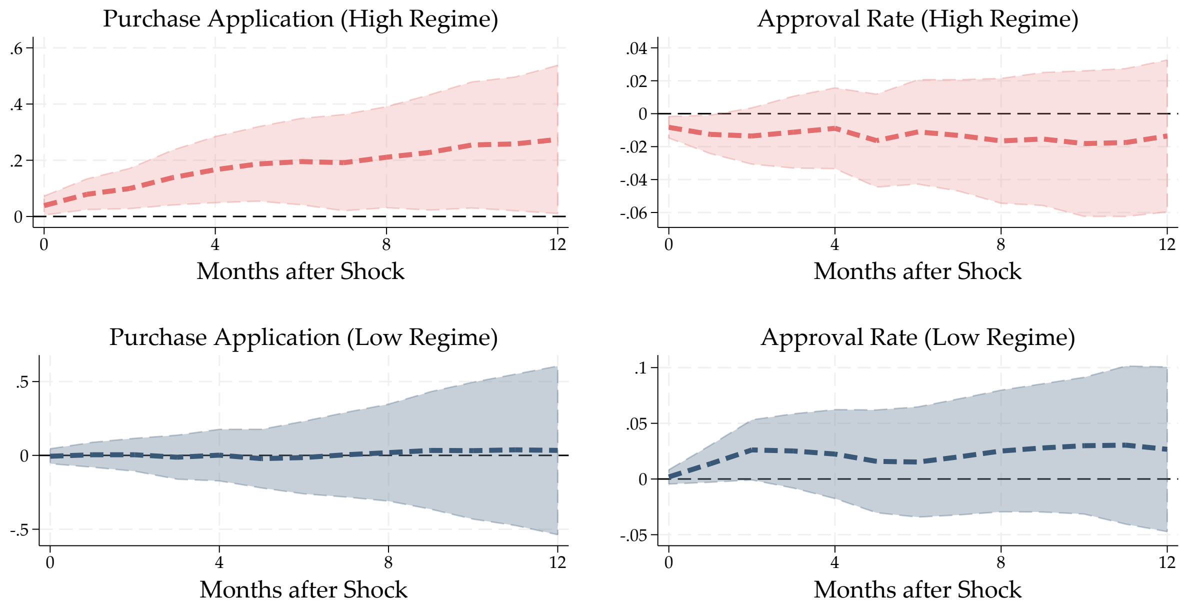
whether the lending responses are consistent with weaker borrowing demand. If applications and originations exhibit similar state dependence while the approval rate remains unchanged, the results are likely driven by the state-dependent response of loan rates. Conversely, if originations and approval rates exhibit similar state dependence while applications do not, the results are likely driven by banks' lending stance.

Figure 8 shows that mortgage applications exhibit a pattern similar to that of loan volumes in Figure 7. The approval rate declines by 1 percentage point on impact in the high-interest-rate regime but increases by approximately 2 percentage points in the low-interest-rate regime. Thus, the lack of loan growth in the low-interest-rate regime cannot be attributed to a tightening of banks' lending stance. Instead, the results are consistent with the hypothesis that the unresponsiveness of loan rates suppresses loan demand while protecting banks from the profit contraction that lower policy rates might otherwise induce.

4.5. Robustness Checks

This section describes a battery of robustness checks performed on the baseline results. The results for each exercise are presented in Appendix A.

FIGURE 8. Impulse Responses of Loan Application and Approavl Rate to Monetary Monetary Shocks



Note. The estimated regression equation is $y_{t+h} = \beta_h^H \times \mathbb{I}[i_{t-1} > \gamma] \times \varepsilon_t + \beta_h^L \times \mathbb{I}[i_{t-1} \leq \gamma] \times \varepsilon_t + \Gamma_h' \mathbf{X}_{t-1} + \alpha + e_{t+h}$ for each horizon $h \in \{0, 1, \ldots, 16\}$ where γ set to be 2%. The upper panels illustrate the sequences of $\{\beta^h\}_{h=0}^H$ and lower panels show sequences of $\{\beta^h\}_{h=0}^H$ with 90% confidence bands. Standard errors are corrected by the Newey-West correction.

4.5.1. Alternative Shocks

I repeat the estimation from the previous section using alternative monetary policy shock series: those constructed by Nakamura and Steinsson (2018) and extended by Acosta (2023) (spans from 1995:Q1 to 2019:Q4), as well as those from Acosta et al. (2025) which employ a different identification strategy and cover a different time horizon. Both alternative shock measures preserve the muted responses of loan and deposit rates in the low-rate regime and the absence of systematic compression in the loan-deposit spread. Detailed results are reported in Appendices A.1 and A.2.

4.5.2. Alternative Specifications

(a) Different Threshold. I reestimate equation (2) using cutoffs of 1.8% and 2.4% to assess sensitivity to nearby alternatives to the 2% benchmark. These exercises examine local sensitivity around the benchmark rather than the full range of threshold estimates in Table 1. When the threshold is set to 1.8%, the loan rate response remains muted. When the threshold is set to 2.4%, both deposit and loan rates respond to the monetary policy shock by about 20 basis points after seven to eight quarters, but the net interest margin remains largely unchanged. As a result, the responses of the net interest margin and the other bank balance sheet variables, including equity and leverage, are similar to the baseline results. The results for $\gamma = 1.8\%$ and 2.4% are displayed in Appendix A.5 and Appendix A.6, respectively.

(b) Indirect Term. To assess whether the state dependence also appears without imposing a discrete threshold, I interact the monetary policy shock with the lagged level of the policy rate rather than a regime indicator. This specification allows the shock response to vary continuously with the policy-rate level.

$$y_{t+h,b} = \beta_h^{Direct} \times \varepsilon_t + \beta_h^{Indirect} \times i_{t-1} \times \varepsilon_t + \mathbf{X}'_{b,t-1}\Gamma_h + \alpha_{b,h} + e_{b,t+h} \tag{3}$$

In this exercise, $\beta_h^{Indirect}$ is the primary focus. Under an expansionary monetary policy shock, $\beta_h^{Indirect} < 0$ implies that the outcome decreases more in response to the expansionary monetary policy change when interest rates are higher. Conversely, $\beta_h^{Indirect} > 0$ implies that the outcome increases more in response to the expansionary monetary policy change when interest rates are higher.

The outcome is displayed in Appendix A.7. The results show that both loan and deposit rates exhibit negative values for $\beta_h^{Indirect}$, which implies that both rates fall more when the policy rate environment is set to a higher level. Equity and loan display positive $\beta_h^{Indirect}$ values, which denotes that they increase more in response to an expansionary monetary policy when the policy rate is set to a higher level. Leverage takes a negative value. The spread takes a statistically insignificant value, which is well aligned with the results when using the dummy variable specification.

(c) Confounding Effect. Because the policy rate level can be highly correlated with other economic conditions or bank characteristics that might affect banks' decisions, it's crucial to control for these potentially confounding factors. To do so, I include covariates $(C_{b,t-1})$ and interaction terms between these covariates and the monetary policy variable, $(C_{b,t-1}) \times \varepsilon_t$. This specification assesses the sensitivity of the state-dependent responses to additional covariates and to interactions that allow monetary transmission to vary with those covariates, while accounting for other potentially confounding factors and specifically testing whether that effect changes depending on whether the policy rate is below the threshold or not.

$$\begin{aligned} y_{t+h,b} = {} & \beta_h^H \cdot \mathbb{I}\left[i_{t-1} > \gamma\right] \cdot \varepsilon_t + \beta_h^L \cdot \mathbb{I}\left[i_{t-1} \leq \gamma\right] \cdot \varepsilon_t \\ & \underbrace{+\gamma_h \cdot C_{b,t-1}}_{\text{Confounding Factor } \varepsilon_t} + \underbrace{\gamma_h^C \cdot C_{b,t-1} \cdot \varepsilon_t}_{\text{Interaction Term with } \varepsilon_t} + \mathbf{X}'_{b,t-1}\Gamma_h + \alpha_{b,h} + e_{b,t+h} \end{aligned} \tag{4}$$

Under the specification of equation (4), I reestimate β_h^H and β_h^L for each variable's response. Because low-interest-rate states can be associated with other economic conditions that may also affect banks' decisions, I consider the excess bond premium (Gilchrist and Zakrajšek 2012), recession periods, the Great Financial Crisis period, macro and financial uncertainty (Ludvigson et al. 2021), monetary policy uncertainty (Baker et al. 2016), and bank-level loan loss provision[21] as possible economic conditions ($C_{b,t-1}$). The corresponding results are reported in Appendix A.8. The estimated responses of deposit rates, loan rates, the loan-deposit spread, equity, leverage, and loans remain quantitatively close to the baseline results after adding these controls and their interactions with monetary policy shocks. In particular, loan and deposit rates remain weakly responsive in the low-rate regime, without systematic compression of the loan-deposit spread or deterioration in bank capitalization.

(d) Ramey and Zubairy (2018)-Type Local Projection. To allow the other covariates, including both aggregate-level economic environments and bank characteristics, to affect the bank's decisions differently based on the policy rate environment, I utilize state-dependent local projection à la Ramey and Zubairy (2018).

$$y_{t+h,b} = \mathbb{I}[i_{t-1} > \gamma] \cdot \left[\beta_h^H \varepsilon_t + \mathbf{X}'_{b,t-1}\Gamma_h^H\right] + \mathbb{I}[i_{t-1} \leq \gamma] \cdot \left[\beta_h^L \varepsilon_t + \mathbf{X}'_{b,t-1}\Gamma_h^L\right] + \alpha_{b,h} + e_{b,t+h}$$

Allowing the coefficients on the controls to differ across regimes preserves the main low-rate findings. When the deposit-rate lower bound binds, the loan-deposit spread and loan growth remain broadly unchanged, with little evidence of declining book equity or rising leverage. Appendix A.9 reports the detailed impulse responses.

5. Model

The central question of this paper is the extent to which the banking sector dampens the effectiveness of monetary policy and whether this attenuation becomes stronger when the policy rate is already low. This issue is particularly important when a recession begins in a low-rate environment. During a recession, the central bank typically lowers the policy rate to reduce borrowing costs, stimulate consumption and investment, and support the recovery of output. The preceding results, however, show that when the policy rate is already low, further rate cuts pass through only weakly to bank loan rates and do little to encourage banks to expand lending. As deposit rates approach their effective lower bound, bank funding costs become less responsive to

[21] In case of Bank-level Loan loss provision, I standardize the loss provision within bank, which captures the given bank's loan loss status is higher or lower than average following Ottonello and Winberry (2020).

additional policy rate cuts, leading banks to preserve their net interest margins rather than reduce loan rates one for one. A recession that occurs when rates are already low may therefore leave the central bank with a weaker transmission mechanism precisely when monetary stimulus is needed most.

To assess how much impaired bank-rate pass-through weakens monetary policy during recessions and whether fiscal policy can offset the resulting stabilization loss, I develop a New Keynesian model with financial intermediation and an effective lower bound on deposit rates. Time is discrete and infinite. The economy is populated by a representative household, a continuum of intermediate-good firms, competitive capital producers, capital suppliers, a representative bank, and the government. The model distinguishes among the policy rate, the deposit rate, and the loan rate. Their differential responses determine how the level of the policy rate affects bank lending conditions and, ultimately, the effectiveness of monetary policy in mitigating a recession.

5.1. Banking Sector

The banking sector mainly follows Cúrdia and Woodford (2011). I assume a financial intermediary sector consisting of identical and perfectly competitive banks. Banks issue one-period deposits, D_t, promising a gross nominal deposit return R_t^D, and extend one-period loans, L_t, at the gross nominal loan rate R_t^L in nominal terms. Each bank enters period t with a predetermined stock of nominal equity, E_t, and takes both contractual rates as given. Its balance sheet satisfies

$$L_t = D_t + E_t. \tag{5}$$

Dynamic Bank Problem The loan and deposit contracts chosen in period t are settled in period $t+1$. After receiving loan repayments, repaying depositors, and paying intermediation costs, the bank distributes a fixed fraction $\gamma \in (0,1)$ of the remaining resources as dividends and retains the fraction $1-\gamma$ as next period's equity. Banks cannot issue external equity. Bank equity therefore evolves according to

$$E_{t+1} = (1-\gamma)(R_t^L L_t - R_t^D D_t - \Xi(L_t, E_t)). \tag{6}$$

The representative household is the residual owner of the bank and receives its dividends. Let $\Lambda_{t,t+1} \equiv \beta(\xi_{t+1}/\xi_t)(\Lambda_{t+1}/\Lambda_t)$ denote the household's real stochastic discount factor. Nominal bank dividends and continuation values are discounted using $\Lambda_{t,t+1}/\Pi_{t+1}$.

After rescaling the bank's ex-dividend value by the constant retention rate $1-\gamma$, let $V_t(E_t)$ denote $(1-\gamma)$ times the nominal ex-dividend value of a bank entering period t with nominal equity E_t. Subject to (5) and (6), the representative bank solves

$$V_t(E_t) = \max_{\{L_t, D_t\} \geq 0} \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t+1}} \left(\gamma E_{t+1} + V_{t+1}(E_{t+1}) \right) \right]. \tag{7}$$

The first term inside the expectation is the dividend expressed in normalized value units. The corresponding unscaled dividend is then $\gamma E_{t+1}/(1-\gamma)$. Intermediation costs are paid before the bank divides its end-of-period resources between dividends and retained equity.

Intermediation Costs and Loan Pricing The function $\Xi(L_t, E_t)$ captures monitoring expenses as in Cúrdia and Woodford (2011) and Eggertsson et al. (2023).[22] Its total value reduces the resources available for dividends and retained equity, while its marginal value determines the cost of supplying an additional loan. I assume that marginal intermediation costs are nonnegative and weakly increasing in bank leverage, and that greater bank equity weakly lowers the marginal cost of lending. The functional form used in the quantitative analysis is specified in the calibration section.

Using the balance-sheet identity, an additional unit of lending is financed by an additional unit of deposits. The bank's lending condition is therefore

$$R_t^L = R_t^D + \Xi_L(L_t, E_t). \tag{8}$$

Thus, the loan rate equals the sum of the marginal deposit-funding cost and the marginal cost of intermediation captured by Ξ. The capital-supplier block determines loan demand. Together, the bank's lending condition and the capital supplier's optimality condition determine the equilibrium loan rate.

5.2. Households

The representative household derives utility from consumption, disutility from labor, and utility from the liquidity services provided by deposits and money. The household allocates its savings across bank deposits, D_t, money, M_t, and government bonds, B_t. Deposits earn the gross nominal return R_t^D, money yields a gross nominal return of one, and government bonds earn the policy

[22] The introduction of intermediation can also be microfounded, such as the presence of a leverage constraint (Eggertsson et al. 2023). The dependence of costs on a bank's equity, or net worth, is microfounded in Gertler and Kiyotaki (2010).

rate, R_t, but provide no liquidity services. The household maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_t \left[u\big(C_t - h\bar{C}_{t-1}\big) - \chi_N \frac{N_t^{1+\varphi}}{1+\varphi} + \chi_D v\left(\frac{D_t + M_t}{P_t}\right) \right], \tag{9}$$

where $\beta \in (0,1)$ is the discount factor and ξ_t denotes a time-preference shock. Preferences feature external habit formation: $\bar{C}_{t-1}$ is lagged aggregate consumption, which the household takes as given. The parameter h governs habit persistence, φ is the inverse Frisch elasticity of labor supply, and χ_N and χ_D determine the weights on labor disutility and liquidity services, respectively.

Deposits and money are perfect substitutes in providing liquidity services as in Abadi et al. (2023). Their combined real balances enter utility directly, following the money-in-utility approach of Feenstra (1986) and Krishnamurthy and Vissing-Jorgensen (2012). The quantitative implementation uses

$$u(x) = \frac{x^{1-\sigma}}{1-\sigma}, \qquad v(x) = \frac{x^{1-\nu}}{1-\nu}, \tag{10}$$

with the logarithmic specifications when $\sigma = 1$ or $\nu = 1$.[23]

The household chooses consumption, labor supply, and asset holdings subject to

$$P_t C_t + D_t + M_t + B_t = W_t N_t + R^D_{t-1} D_{t-1} + M_{t-1} + R_{t-1} B_{t-1} + T_t, \tag{11}$$

with $D_t, M_t \geq 0$, where W_t is the nominal wage and T_t collects net lump-sum transfers and distributed profits, including bank dividends.

Let

$$\Lambda_t = u'\big(C_t - h\bar{C}_{t-1}\big) = \big(C_t - h\bar{C}_{t-1}\big)^{-\sigma}$$

denote the marginal utility of consumption. The labor-supply condition is

$$\frac{W_t}{P_t} = \frac{\chi_N N_t^{\varphi}}{\Lambda_t}. \tag{12}$$

The first-order condition for government bonds gives

$$R_t = \left[\mathbb{E}_t \left(\frac{\Lambda_{t,t+1}}{\Pi_{t+1}} \right) \right]^{-1}, \tag{13}$$

where $\Lambda_{t,t+1} \equiv \beta \xi_{t+1} \Lambda_{t+1} / (\xi_t \Lambda_t)$ is the stochastic discount factor and $\Pi_{t+1} \equiv P_{t+1}/P_t$ is gross inflation.

[23]Following Abadi et al. (2023), liquidity utility has a finite satiation point. The CRRA specification applies below that point, and utility remains constant thereafter.

For positive deposit holdings, the household's deposit condition is

$$\frac{\chi_D v'((D_t + M_t)/P_t)}{\Lambda_t} = 1 - \frac{R_t^D}{R_t}. \tag{14}$$

The optimality condition for nonnegative money holdings is

$$\frac{\chi_D v'((D_t + M_t)/P_t)}{\Lambda_t} \leq 1 - \frac{1}{R_t}, \tag{15}$$

with equality when $M_t > 0$. Because deposits and money provide the same liquidity services, households would prefer money to deposits if the deposit rate fell below the gross return on money. Positive deposit holdings therefore require $R_t^D \geq 1$. When the deposit rate exceeds unity, households prefer deposits and hold no money. These portfolio choices are summarized by

$$R_t^D \geq 1, \qquad M_t(R_t^D - 1) = 0. \tag{16}$$

Combining the deposit condition evaluated at $M_t = 0$ with the lower bound, the equilibrium deposit rate can be expressed as

$$R_t^D = \max\left\{1,\ R_t\left[1 - \frac{\chi_D v'(D_t/P_t)}{\Lambda_t}\right]\right\}. \tag{17}$$

When the deposit floor binds while the policy rate remains positive, households are indifferent between deposits and money. Their portfolio condition determines desired total liquidity balances, while the bank's choices and deposit-market clearing determine deposit holdings through $D_t = L_t - E_t$. Households hold money to satisfy the remaining demand for liquidity. The allocation between deposits and money is therefore determined jointly by household portfolio choice and equilibrium in the banking sector.

5.3. Non-Financial Firms

The production side consists of intermediate-good producers, a representative final-good producer, and competitive capital-producing firms.

Intermediate-Good and Final-Good Producers Intermediate-good firm i produces using capital and labor according to

$$Y_t(i) = K_t(i)^\alpha N_t(i)^{1-\alpha}, \qquad 0 < \alpha < 1. \tag{18}$$

Let r_t^k denote the real return on capital and w_t the real wage. Cost minimization yields

$$r_t^k = \alpha mc_t \frac{Y_t(i)}{K_t(i)}, \qquad w_t = (1-\alpha) mc_t \frac{Y_t(i)}{N_t(i)}, \tag{19}$$

where mc_t denotes real marginal cost. A representative, perfectly competitive final-good producer aggregates the differentiated intermediate goods. Price setting by intermediate-good firms is subject to Calvo rigidity (Calvo 1983) and yields a standard New Keynesian Phillips curve.

Capital-Producing Firms Competitive capital-producing firms produce new capital subject to adjustment costs. Aggregate capital evolves according to

$$K_{t+1} = (1-\delta)K_t + I_t. \tag{20}$$

The value of new capital is Q_t in nominal term. A representative capital-producing firm chooses investment to maximize

$$\frac{Q_t}{P_t} I_t - I_t - \frac{\widetilde{\phi}}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t, \tag{21}$$

where $\widetilde{\phi} > 0$ governs investment adjustment costs. The first-order condition for investment is

$$\frac{Q_t}{P_t} = 1 + \widetilde{\phi}\left(\frac{I_t}{K_t} - \delta\right). \tag{22}$$

Capital Financing and Loan Demand Intermediate-good firms borrow from banks to finance their capital purchases (Ulate 2021). The value of capital financed in period t satisfies

$$L_t = Q_t K_{t+1}. \tag{23}$$

A unit of capital purchased at price Q_t generates the return r_{t+1}^k and retains the value $(1-\delta)q_{t+1}$ in period $t+1$. Optimal capital demand therefore requires

$$R_t^L \frac{Q_t}{P_t} = \mathbb{E}_t\left[\frac{P_{t+1}}{P_t}\left(r_{t+1}^k + (1-\delta)\frac{Q_{t+1}}{P_{t+1}}\right)\right]. \tag{24}$$

Thus, the expected nominal return on capital equals the contractual cost of bank borrowing. While the baseline model restricts nonfinancial firms to bank financing, I extend the model by allowing firms to issue bonds alongside bank loans as in De Fiore and Uhlig (2011) and Crouzet (2018) in Section 6.5.

5.4. Monetary Policy

The central bank sets the policy rate according to an inertial Taylor rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \left[\left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y}\right]^{1-\rho_R} \exp\left(\varepsilon_{m,t}\right), \tag{25}$$

where ρ_R governs interest-rate smoothing, ϕ_π and ϕ_y gauge the responses to inflation and output, and $\varepsilon_{m,t}$ denotes a monetary policy shock. Given the policy rate, the central bank accommodates households' demand for money, so the quantity of money in circulation is determined endogenously by money-market clearing.

5.5. Fiscal Policy

The government purchases final goods, denoted by G_t. Consolidating the fiscal authority and the central bank, and maintaining government bonds in zero net supply, the government budget constraint is

$$P_t G_t + T_t^g = M_t - M_{t-1}, \tag{26}$$

where T_t^g denotes net lump-sum transfers to the household, with negative values representing taxes. Given the initial stock of money, these transfers adjust to balance the government budget. The household takes transfers as given, and T_t^g, together with profits distributed by firms and banks, constitutes T_t in its budget constraint.

In the baseline model, government spending follows an exogenous process given by

$$G_t = \bar{G}^{1-\rho_G} G_{t-1}^{\rho_G} \exp\left(\varepsilon_{g,t}\right), \tag{27}$$

where $\bar{G}$ denotes steady-state government spending, $\rho_G \in [0, 1)$ governs its persistence, and $\varepsilon_{g,t}$ is an exogenous government-spending shock.

In the fiscal-policy experiment, I allow government spending to respond automatically to the output gap according to

$$G_t = \bar{G}^{1-\rho_G} G_{t-1}^{\rho_G} \left[\min\left\{\frac{Y_t}{\bar{Y}}, 1\right\}\right]^{-\phi_G} \exp(\varepsilon_{g,t}). \tag{28}$$

where $\bar{Y}$ denotes steady-state output and $\phi_G \geq 0$ governs the response to an output shortfall. Output below $\bar{Y}$ raises government spending relative to its baseline path. When output reaches or exceeds $\bar{Y}$, this additional response is zero and spending follows its usual persistence. Setting

$\phi_G = 0$ recovers the baseline rule.

5.6. Market Clearing and Equilibrium

Bank intermediation and investment adjustment both use final goods. Goods-market clearing requires

$$Y_t = C_t + I_t + G_t + \frac{\Xi_t}{P_t} + \frac{\widetilde{\phi}}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t. \tag{29}$$

Investment adjustment costs and their first derivatives vanish at the steady state, where $I_t = \delta K_t$. They therefore do not enter the first-order resource constraint. Government purchases are present in the steady state of every experiment; absent fiscal shocks, their log deviation is zero, and the fiscal-policy experiment activates the automatic stabilizer.

Equilibrium in the loan market requires

$$L_t = Q_t K_{t+1}. \tag{30}$$

Government bonds are in zero net supply and are eliminated from the quantitative system after using their first-order condition to obtain the household Euler equation.

Equilibrium An equilibrium consists of an allocation $\{C_t, N_t, Y_t, I_t, K_{t+1}, G_t, D_t/P_t, M_t/P_t, B_t/P_t, L_t/P_t, E_t/P_t, T_t^g/P_t\}$ and a price system $\{w_t, r_t^k, q_t, \Pi_t, R_t, R_t^D, R_t^L\}$ such that: (i) the allocation solves the decision problems of the household, intermediate-good firms, capital producers, capital suppliers, and the bank, (ii) bank equity accumulates according to (6), (iii) the policy rate satisfies the monetary-policy rule, the deposit rate satisfies (17), government spending satisfies (27) in the baseline fiscal block, and lump-sum transfers satisfy the government budget constraint (26), and (iv) the goods, loan, deposit, money, labor, and zero-net-supply bond markets clear.

6. Calibration and Model Performance

6.1. Calibration

The model is calibrated at a quarterly frequency. I consider two regimes. In the high-rate regime, the deposit-rate lower bound is slack, and the observed deposit rate responds to monetary policy shocks through the portfolio condition (14). In the low-rate regime, the observed deposit rate is at its lower bound and remains fixed following an expansionary monetary policy shock. The household discount factor is calibrated separately in each regime so as to anchor that regime's steady-state policy rate. All remaining structural parameters remain common across the two regimes.

Externally Calibrated Parameters Preference and technology parameters take standard values from the literature. The inverse intertemporal elasticity of substitution is $\sigma = 1$, so momentary utility is logarithmic in consumption. Following Gertler and Karadi (2011), I set the external-habit parameter to $h = 0.81$. The inverse Frisch elasticity is $\varphi = 1$, consistent with Chetty et al. (2011), and the curvature of liquidity utility is normalized to $\nu = 1$. On the production side, I follow Gertler and Karadi (2011) and set the capital share to $\alpha = 0.36$ and the quarterly depreciation rate to $\delta = 0.025$. I define $\phi \equiv \delta\widetilde{\phi}$, so that the first-order investment condition is $\hat{q}_t = \phi(\hat{I}_t - \hat{K}_t)$. The quantitative implementation sets $\phi = 0.25$ as in Bernanke et al. (1999). I set the elasticity of substitution across intermediate goods to $\theta = 6$ following Galí (2008), implying a steady-state markup of 20 percent. Finally, following the estimate in Hazell et al. (2022), the slope of the New Keynesian Phillips curve is set to $\kappa = 0.0062$.

The intermediation cost $\Xi(L_t, E_t)$ is nominal and takes the constant-elasticity form

$$\frac{\Xi(L_t, E_t)}{P_t} = \zeta \left(\frac{l_t}{\bar{l}}\right)^{\eta} \left(\frac{e_t}{\bar{e}}\right)^{-\iota}$$

following Eggertsson et al. (2023), where $l_t = L_t/P_t$ and $e_t = E_t/P_t$.[24] $\bar{l}$ and $\bar{e}$ denote steady-state real loans and real equity in the high-rate regime. The scale ζ therefore equals real intermediation costs in the high-rate steady state. Under this functional form, higher leverage widens the spread while additional bank capital compresses it,[25] This specification is consistent with the regulatory, funding, and risk-bearing costs of leverage emphasized by Van den Heuvel (2008); Begenau (2020); Adrian and Shin (2014). I set the cost elasticities to $\eta = 4.5$ and $\iota = 2.28$ following Eggertsson et al. (2023). The scale ζ is calibrated internally (see below) so that the steady-state marginal cost equals the high-rate loan–deposit spread.

In the policy block, I follow Galí (2008) and set the interest-rate smoothing parameter to $\rho_R = 0.8$. The inflation response is $\phi_\pi = 2.11$ and the output response is $\phi_y = 0.26$, following Hofmann et al. (2024). On the fiscal side, the steady-state government-purchase share is $\bar{G}/\bar{Y} = 0.20$, and government spending follows an AR(1) process with persistence $\rho_G = 0.90$.

[24] Whereas Eggertsson et al. (2023) use nominal adjustment cost, here, the resource cost is specified in terms of real lending and real equity. Multiplication by P_t converts it into the nominal charge Ξ_t. A proportional change in nominal balances and the price level leaves real intermediation costs and the marginal lending spread unchanged.

[25] In log deviations the loan–deposit spread satisfies $\hat{R}^L_t - \hat{R}^D_t = (\eta - 1)\hat{L}_t - \iota\hat{E}_t$: the marginal cost of lending responds to loans with elasticity $\eta - 1$ and to equity with elasticity $-\iota$.

Table 2. Externally Calibrated Parameters

Parameter	Description	Value	Source
Household Block			
σ	Inverse intertemporal elasticity	1	Wang (2025)
ν	Curvature of liquidity utility	1	Wang (2025)
h	External consumption habit	0.81	Gertler and Karadi (2011)
φ	Inverse Frisch elasticity	1	Chetty et al. (2011)
Non-financial Intermediary Block			
α	Capital share	0.36	Gertler and Karadi (2011)
δ	Quarterly depreciation rate	0.025	Gertler and Karadi (2011)
κ	Phillips-curve slope	0.0062	Hazell et al. (2022)
ϕ	Investment-adjustment coefficient	0.25	Bernanke et al. (1999)
θ	Elasticity across intermediate goods	6	Galí (2008)
Banking Sector Block			
η	Intermediation-cost elasticity in loans	4.5	Eggertsson et al. (2023)
ι	Intermediation-cost elasticity in equity	2.28	Eggertsson et al. (2023)
Policy Block			
ρ_R	Interest-rate smoothing	0.8	Galí (2008)
ϕ_π	Inflation response	2.11	Hofmann et al. (2024)
ϕ_y	Output response	0.26	Hofmann et al. (2024)

Internally Calibrated Parameters All interest-rate targets are specified as annual net rates and converted to gross quarterly rates within the calibration. In the high-rate regime the policy, deposit, and loan rates are 4%, 1%, and 5% as I observe at the aggregate level data. In the low-rate regime the policy rate is 2% and the deposit rate sits at its zero lower bound, so it supplies no additional identifying restriction.

Conditional on the externally assigned parameters and the regime-specific discount factors, four steady-state conditions identify four structural parameters. The deposit-portfolio condition pins down the deposit-utility scale χ_D. The loan-pricing condition pins down the intermediation-cost scale ζ given the targeted high-rate leverage. The stationary bank-equity condition then pins down the dividend-payout rate γ. Finally, the labor-supply condition pins down the labor-disutility scale χ_N under the normalization $\bar{N}_H = 1$.

Table 4 reports the resulting values. Given the borrowed elasticities $\eta = 4.5$ and $\iota = 2.28$, the high-rate loan–deposit spread pins down the intermediation-cost scale through $\zeta = 0.057$. Given

Table 3. Internally Calibrated Parameters and Conditions

Parameter	Calibration target	Value	Identifying condition
χ_D	Deposit rate	1%	Deposit-portfolio condition
χ_N	High-rate labor, $\bar{N}_H$	1	Labor-supply condition
ζ	High-rate loan rate	5%	Loan-pricing condition
γ	High-rate loan-to-equity ratio	10.5	Stationary bank-equity condition

Note. The deposit rate, loan rate, and loan-to-equity ratio are steady-state calibration targets. High-rate labor is normalized to one. Interest-rate targets are annual net rates. Identification is triangular: the loan-pricing condition determines ζ given the targeted high-rate leverage, after which the bank-equity condition determines γ.

the cost function, the bank-equity stationarity condition selects the payout rate γ that sustains this leverage through retained earnings.

Table 4. Internally Calibrated Structural Parameters

Parameter	Description	Value	Identifying condition
χ_D	Liquidity-utility scale	0.481	Deposit-portfolio condition (high regime)
χ_N	Labor-disutility scale	4.829	Labor-supply condition ($\bar{N}_H = 1$)
ζ	Intermediation-cost scale	0.057	Loan-pricing condition (high regime)
γ	Dividend-payout rate	0.076	Stationary bank-equity condition

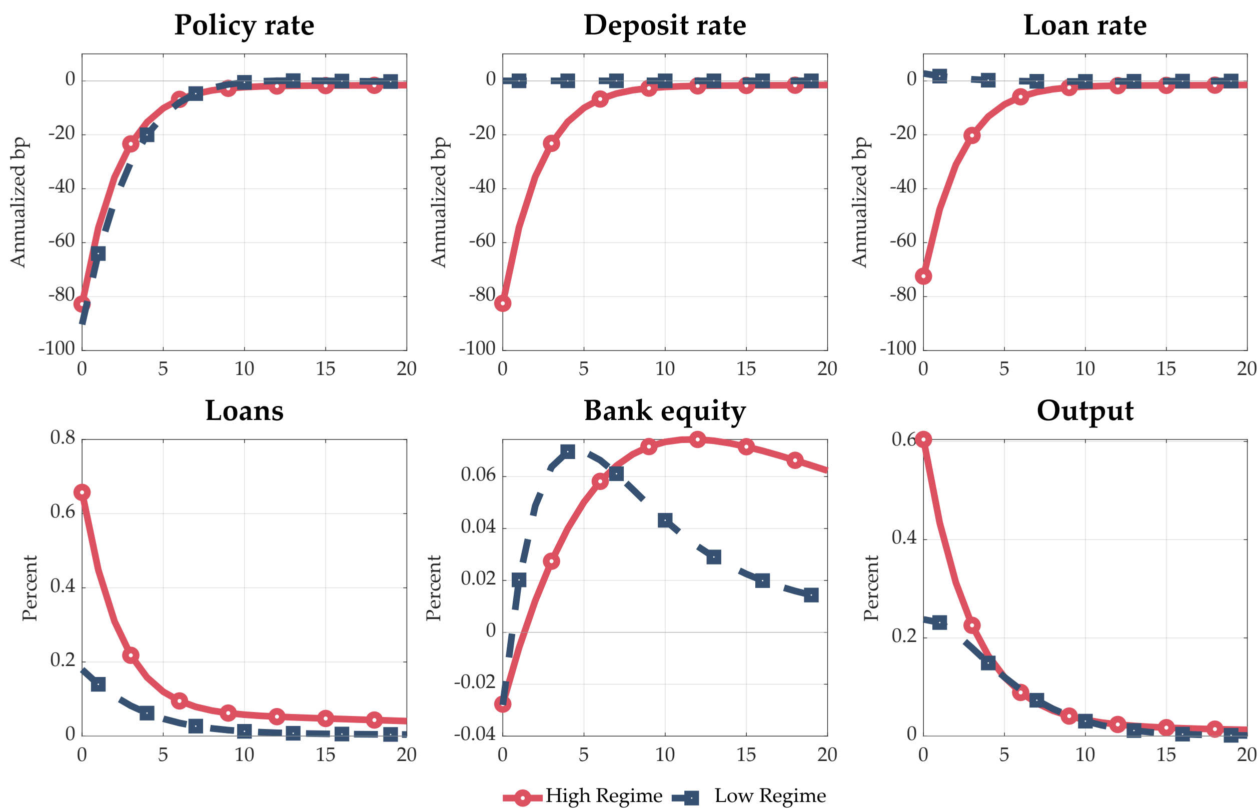
6.2. Model Performance

To evaluate the model's performance, I trace the transmission of an expansionary monetary policy innovation in the high- and low-rate regimes. Figure 9 reports the responses of six variables. The upper row traces the bank-rate transmission mechanism from the policy rate to the deposit and loan rates, while the lower row reports the resulting responses of output, loans, and bank equity. These responses are qualitatively consistent with the state-dependent patterns documented in the empirical analysis.

The monetary policy innovation is set to a quarterly decline of 25 basis points, corresponding to a 100-basis-point annualized policy innovation. The policy rate falls on impact in both high-rate regime and the low-rate regime. The similarity of the two policy-rate responses is consistent with the empirical finding that the policy-rate adjustment itself displays little state dependence.

The deposit- and loan-rate panels reveal the source of the difference in transmission. In the high-rate regime, the deposit rate falls by 82.5 annualized basis points and the loan rate falls by 72.4 basis points on impact. In the low-rate regime, the deposit rate remains fixed at its lower

Figure 9. Responses to an Expansionary Monetary Policy Shock



Note. Impulse responses to an expansionary monetary policy innovation in the high-rate regime (red) and the low-rate regime (blue). Rates are expressed in annualized basis points. Loans, bank equity, and output are percent deviations from their regime-specific steady states.

bound, and the loan rate response is also muted, which reproduces the empirical finding that retail-rate pass-through operates normally away from the deposit-rate floor but largely disappears when the floor binds.

The loan and bank-equity responses are qualitatively consistent with the state-dependent patterns documented in the empirical analysis. In the high-rate regime, loans increase by around 0.6 percent on impact and remain persistently above their steady-state level. At the deposit-rate floor, the loan response is only 0.2 percent, approximately one-third of its high-rate counterpart, and dissipates more rapidly. Bank equity exhibits the same state dependence. In the high-rate regime, the sustained expansion in lending leads bank equity to accumulate gradually and remain elevated throughout the reported horizon. At the low-rate regime, while bank equity does not accumulate as persistently as in the high-rate regime, it does not produce a lasting deterioration in bank capitalization or erode the bank's lending capacity. Monetary easing therefore continues to support the bank's balance sheet in the low interest rate regime.

The final panel shows the output response induced by this state-dependent banking channel.

Output increases by around 0.6 percent in the high-rate regime but by only 0.2 percent at the deposit-rate floor. Thus, despite similar policy-rate responses, the output effect of monetary easing is substantially weaker at the floor because the policy-rate reduction is not transmitted to deposit and loan rates, limiting the expansion of bank credit.

6.3. Loss of Monetary Policy Effectiveness during Recessions

In this section, I evaluate the effectiveness of monetary policy during recessions by introducing a contractionary household preference shock, ξ_t, in equation (9) following Eggertsson et al. (2023). The recession is initiated by an unanticipated, one-period decline in the household preference shifter:

$$\xi_1 = \exp(-\varepsilon_d), \qquad \xi_t = 1 \quad \text{for } t \geq 2,$$

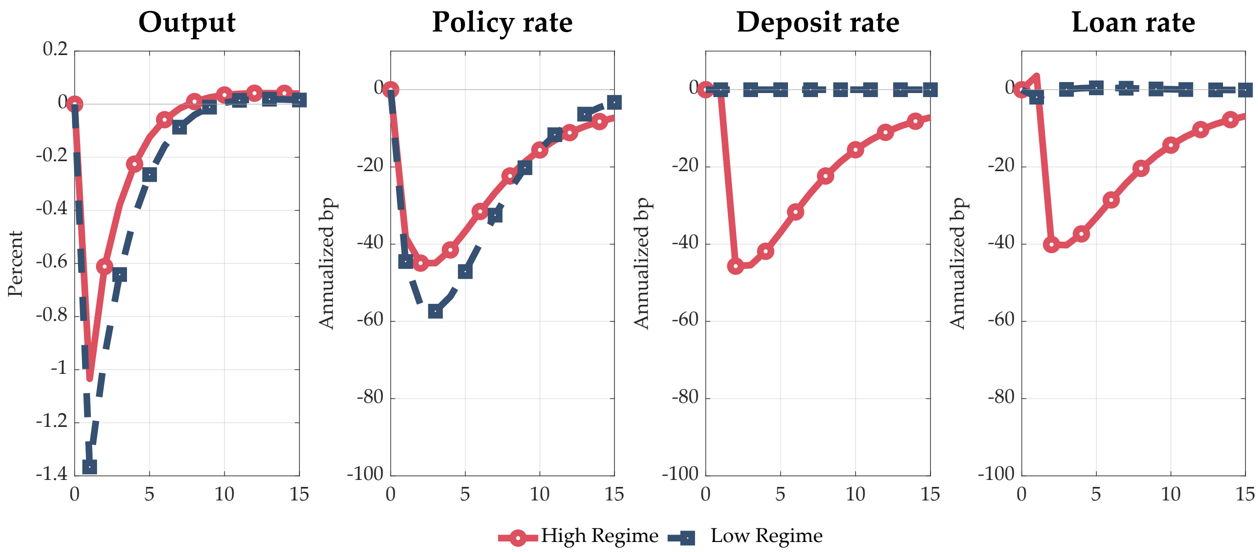
with $\xi_t = 1$ before the shock. Both regimes face the same shock, while monetary policy follows the Taylor rule. The magnitude ε_d is calibrated once to produce an output trough of approximately minus one percent in the high-rate regime under the benchmark rule. Figure 10 reports, from left to right, the responses of output, the policy rate, the deposit rate, and the loan rate.

The key finding is that the recession is deeper at the deposit-rate floor. Output falls by about 1.0 percent in the high-rate regime but by about 1.4 percent in the low-rate regime. This difference arises despite a larger reduction in the policy rate in the low-rate regime. If the recession occurs when the deposit rate lower bound is not binding, monetary easing passes through to both deposit and loan rates and cushions the contraction. However, when the deposit rate lower bound binds, the deposit rate remains fixed and the loan rate response is also muted. The larger policy-rate reduction therefore does not translate into a comparable decline in borrowing costs, causing the same demand shock to generate a deeper and more persistent recession.

One concern is whether a stronger response of the Taylor rule to the output gap can restore the effectiveness of monetary policy in the low-rate regime. To examine this, I vary the coefficient on the output gap, ϕ_Y, while holding the recession shock and all other parameters fixed. For each value of ϕ_Y, I solve the model in both regimes with the zero lower bound on the policy rate and compare two measures of the recession. Figure 11 reports the results. The left panel shows the output trough, while the right panel shows the cumulative output response over sixteen quarters. More negative values indicate a deeper or more persistent recession. The red crosses in the right panel indicate the values of ϕ_Y for which the zero lower bound binds in the low-rate regime.

Figure 11 shows that a stronger response to the output gap does not fully restore monetary policy effectiveness for two reasons. First, increasing ϕ_Y reduces the size of the recession in both regimes, but the difference between the two regimes remains. At the benchmark value $\phi_Y = 0.26$,

Figure 10. Recession Dynamics across Interest-Rate Regimes



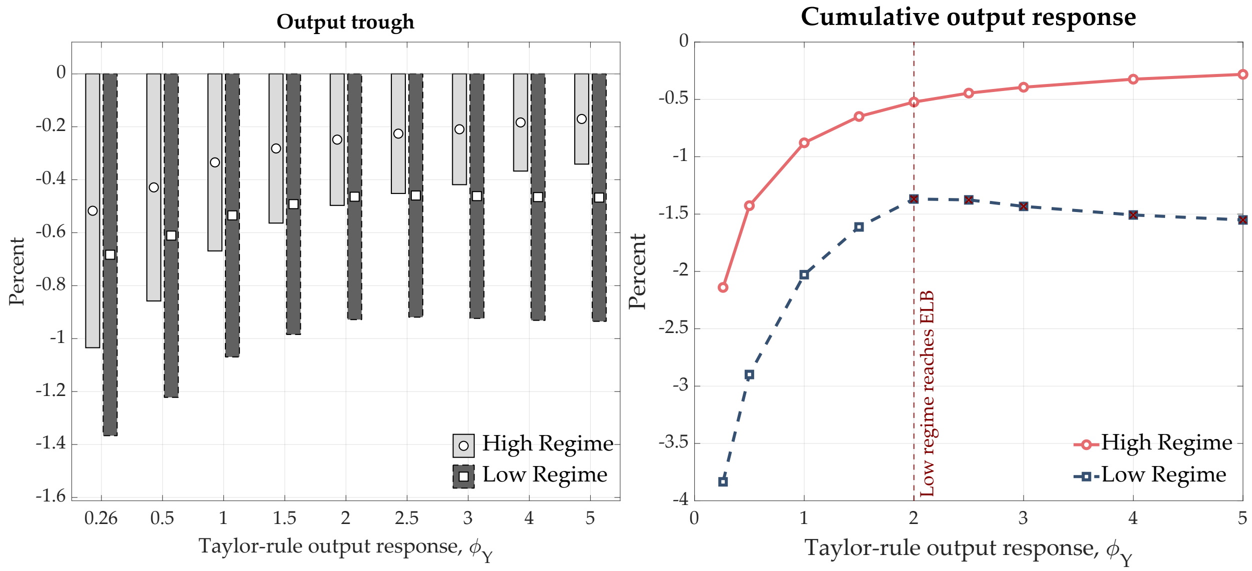
Note. Responses to the same contractionary household preference shock under the benchmark monetary policy rule. The shock occurs at $t = 1$. Output is expressed as a percent deviation from its regime-specific steady state; interest rates are expressed in annualized basis points.

the output trough is -1.03 percent in the high-rate regime and -1.37 percent in the low-rate regime. The cumulative output responses are -2.14 and -3.83 percent-quarters, respectively. As ϕ_Y increases, both output declines become smaller. However, even at $\phi_Y = 2$, the output trough in the low-rate regime is -0.93 percent, while it is only -0.5 percent in the high-rate regime. The cumulative output loss in the low-rate regime also remains more than twice as large. Therefore, a more aggressive monetary policy response can reduce the recession, but it cannot eliminate the difference created by the weak pass-through to deposit and loan rates.

Second, a more aggressive rule eventually reaches the zero lower bound on the policy rate. Since the policy rate starts from a lower level in the low-rate regime, the policy rate reaches zero at around $\phi_Y = 2$ under the current shock size and Taylor rule.[26] Once the zero lower bound binds, a further increase in ϕ_Y requires additional policy-rate cuts that cannot be implemented. As a result, the output trough in the low-rate regime no longer improves, and the cumulative output loss starts to increase. In contrast, both measures continue to improve in the high-rate regime. Therefore, monetary policy faces two limits in the low-rate regime. The deposit-rate floor weakens the transmission of policy-rate cuts to borrowing costs, while the zero lower bound eventually limits the amount of policy-rate cuts that can be implemented.

[26]This implies that, as the shock becomes larger, the threshold value of ϕ_Y at which the policy rate reaches the zero lower bound becomes lower.

Figure 11. Limits of a More Aggressive Taylor Rule



Note. The left panel reports the output trough for each value of the Taylor-rule output coefficient ϕ_Y; all troughs are plotted as negative percent deviations. The right panel reports the cumulative output response over sixteen quarters, in percent-quarters, under the same recession shock. The policy rate is subject to a zero lower bound in both regimes. Red denotes the high-rate regime and blue the low-rate regime. The marked observations indicate values of ϕ_Y at which the policy-rate lower bound binds in the low-rate regime.

6.4. The Stabilizing Effects of Monetary–Fiscal Policy Coordination

I then examine whether fiscal policy can stabilize the economy when conventional monetary policy becomes less effective at the deposit-rate floor. I repeat the same low-rate recession under three policy configurations. The first is the benchmark monetary rule, the second is an aggressive monetary rule with $\phi_Y = 0.50$, and the third is a fiscal stabilizer with $\phi_G = 3$ combined with the benchmark monetary rule. Table 5 reports the results.

Table 5. Stabilization at the Deposit-Rate Floor

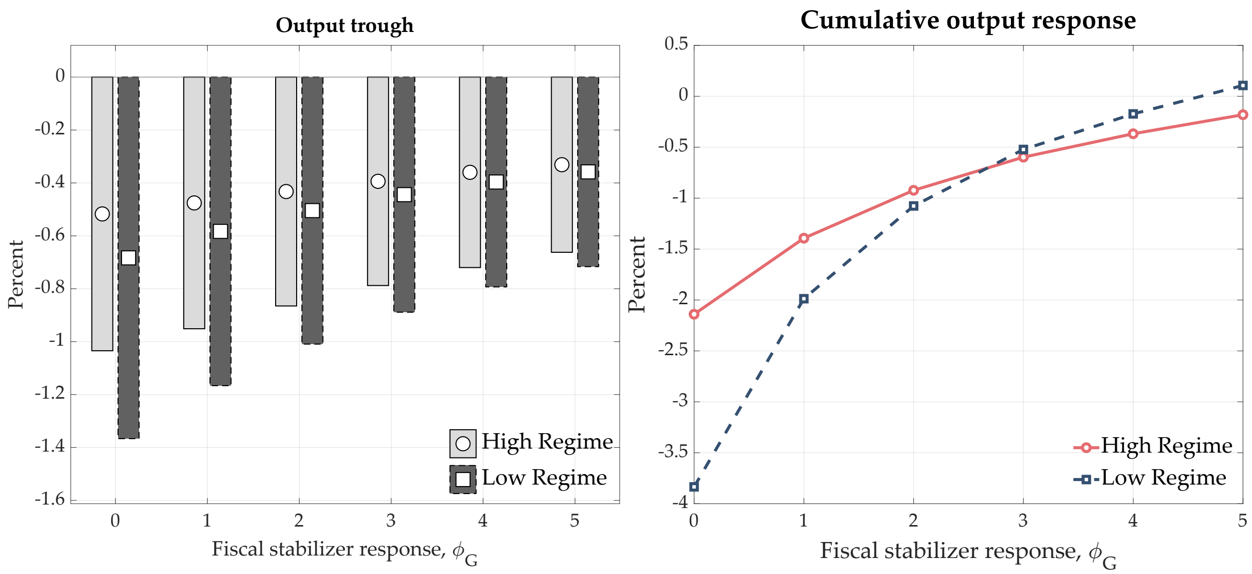
Policy mix	Monetary rule (ϕ_Y)	Fiscal rule (ϕ_G)	Output trough	Cumulative output
Benchmark	0.26	0	−1.367%	−3.835
Aggressive MP	0.50	0	−1.222%	−2.899
Fiscal stabilizer	0.26	3	−0.889%	−0.522

Note. All configurations are evaluated in the low-rate regime using the same recession shock. Cumulative output is the signed sum of the output deviation over sixteen quarters, measured in percent-quarters. Less negative values indicate smaller cumulative output losses.

Increasing the monetary policy response from $\phi_Y = 0.26$ to $\phi_Y = 0.50$ reduces the output trough by approximately 11 percent and the cumulative loss by approximately 24 percent. However, the fiscal stabilizer reduces the output trough by approximately 35 percent and the cumulative loss by approximately 86 percent. The effect on the output trough is about 3.3 times larger than that of the aggressive monetary rule. This is because fiscal policy directly supports aggregate demand, while additional monetary easing still relies on the impaired pass-through from the policy rate to bank retail rates.

I then vary ϕ_G from zero to five while holding the monetary rule at its benchmark to examine whether this result holds for different degrees of fiscal intervention. Figure 12 reports the results. The left panel shows the output trough, while the right panel shows the cumulative output response over sixteen quarters. As ϕ_G increases, both measures improve in the low-rate regime. At $\phi_G = 3$, the output trough improves from -1.37 percent to -0.89 percent, while the cumulative output loss falls from -3.83 to -0.52 percent-quarters. The cumulative gap between the two regimes is almost closed, while the trough gap also continues to decline. This differs from Figure 11, where increasing the Taylor rule response does not eliminate the gap between the two regimes. Therefore, fiscal policy can stabilize the low-rate recession even when additional conventional monetary easing becomes less effective.

Figure 12. Fiscal Stabilization beyond Monetary Policy Constraints



Note. The left panel reports the output trough for fiscal-stabilizer coefficients between zero and five; all troughs are plotted as negative percent deviations. The right panel reports the cumulative output response over sixteen quarters, in percent-quarters, under the same recession shock as Figure 11. The monetary-policy rule is held at its benchmark, $\phi_Y = 0.26$, and the policy-rate lower bound is imposed in both regimes. A less negative value indicates a milder recession.

The broader implication is about the timing of fiscal–monetary coordination. Fiscal support does not become important only after the policy rate reaches zero, as emphasized by Eggertsson and Woodford (2003) and Christiano et al. (2011). The experiments show that government spending can strengthen output stabilization when the deposit-rate floor weakens transmission to bank borrowing costs. This role for fiscal policy can arise while the policy rate remains positive.

6.5. Model Extension: Bond Financing Channel

In the baseline model, firms rely only on bank loans. However, market-based debt is also quantitatively important in the United States, as documented by Crouzet (2018). Based on the Federal Reserve's Financial Accounts, debt securities account for approximately 40 percent of total nonfinancial business debt when I aggregate the nonfinancial corporate and noncorporate business sectors. These sectors together include publicly traded firms, privately held corporations, and unincorporated businesses, including many small and medium-sized businesses.

I therefore extend the baseline model by allowing firms to issue bonds in addition to borrowing from banks, following De Fiore and Uhlig (2011). Firms aggregate bank loans and bonds using a CES formulation to finance capital purchases. This allows firms to substitute toward bond financing when bank credit becomes more costly or less available.[27] The firm problem is presented in Appendix B.

Table 6 compares the baseline model and the extended model that allows firms to finance with bonds. Panel A reports the monetary policy shock experiment. In the high-rate regime, the output response changes only slightly, from 0.60 percent to 0.58 percent once bond financing is allowed. However, the difference is larger in the low-rate regime. The impact output response increases from 0.24 percent to 0.38 percent, by 14 basis points. Bond finance therefore recovers about 42 percent of the transmission loss in the baseline model. This is because firms substitute toward bonds when monetary easing no longer lowers bank loan rates in the low-rate regime. This provides an additional financing channel through which monetary policy affects output.

Panel B reports the recession experiment. The extended model does not show much difference in the high-rate regime. In the low-rate regime, however, bond finance reduces the decline in output. Under the benchmark monetary rule, the output trough improves from -1.37 percent to -1.19 percent. Under the aggressive monetary rule, the low-rate trough improves from -1.22 percent to -1.02 percent, while the regime gap falls from 0.36 to 0.16 percentage point. Therefore, bond finance reduces the stabilization gap between the two regimes by more than one-half under both monetary policy rules.

The fiscal stabilizer experiment shows a similar pattern. In the high-rate regime, the output

[27] The two sources of financing are not assumed to be perfect substitutes. Bond financing is concentrated among large firms, while small and medium-sized firms remain substantially dependent on bank lending. Because the model represents the aggregate corporate sector rather than individual firms, I set the benchmark elasticity of substitution to 0.5 and consider 0.25, 1, and 2 in the sensitivity analysis.

Table 6. Baseline Model and Bond-Finance Extension

Experiment and policy	Regime	Baseline	Bond finance
Panel A. Output response to an expansionary monetary-policy shock			
Impact response	High-rate	0.604	0.580
Impact response	Low-rate	0.238	0.378
Low/high response ratio	–	39.4	65.1
Panel B. Output trough under the common recession shock			
	High-rate	−1.031	−1.039
Benchmark MP	Low-rate	−1.367	−1.186
	Low–high gap	**-0.332**	**-0.147**
	High-rate	−0.858	−0.862
Aggressive MP	Low-rate	−1.222	−1.018
	Low–high gap	**-0.364**	**-0.156**
	High-rate	−0.788	−0.785
Fiscal stabilizer	Low-rate	−0.889	−0.822
	Low–high gap	**-0.101**	**-0.037**

Note. Panel A reports the impact output response, in percent, to the same expansionary monetary-policy shock. The low/high response ratio is expressed in percent. Panel B reports the output trough, in percent, under the same recession shock. The low–high gap is the low-rate trough minus the high-rate trough. The aggressive monetary rule sets $\phi_Y = 0.50$, the fiscal stabilizer sets $\phi_G = 3$, and the bond-finance extension sets the elasticity of substitution between bank loans and bonds to 0.5.

trough remains around −0.79 percent in both models. In the low-rate regime, bond finance improves the output trough from −0.89 percent to −0.82 percent. The gap between the low- and high-rate regimes therefore falls from 0.10 percentage point in the baseline model to 0.04 percentage point with bond finance. Fiscal policy remains effective even after bond finance is introduced, while bond finance further reduces the difference between the two regimes.

Overall, bond finance matters mainly in the low-rate regime. When the deposit-rate floor prevents bank loan rates from declining further, firms substitute part of their bank borrowing with bonds. This reduces the loss of monetary policy transmission and makes the recession less severe. However, bank loans and bonds are imperfect substitutes, so bond finance cannot fully replace bank lending. Therefore, the extension weakens but does not eliminate the main result.

7. Conclusion

This paper shows that monetary policy can lose its effectiveness in a low but positive policy rate regime through the banking sector. I show that once the policy rate gets low enough to induce banks to set the deposit rate to 0% and further policy rate cuts are no longer translated into declines in the deposit rate, the loan rate also stops responding to further policy rate cuts. Then, the net interest margin remains stable in response to an additional monetary policy shock, while bank equity and leverage also remain stable. However, as the loan rate does not decline, loan demand is not stimulated. Therefore, while banks can maintain their equity and lending capacity, the effectiveness of monetary policy gets dampened as demand through lending is not stimulated.

This paper has two policy implications. First, it highlights coordination between monetary policy and fiscal policy, rather than the macroprudential policy suggested in the literature. The main mechanism through which monetary policy loses its effectiveness in the low-interest-rate regime has been understood as the erosion of the banking sector stemming from a narrowed net interest margin. In this mechanism, the loan rate is assumed to respond to policy rate changes while the deposit rate is stuck at its own lower bound. Therefore, the policy implication drawn from this margin is coordination between monetary policy and bank regulation that makes banks more buffered to prevent depletion of capital in the low-interest-rate regime and to maintain the effectiveness of monetary policy. However, this paper shows that the loan rate does not decline and banks keep their lending capacity safe while loan demand is not stimulated. Therefore, this paper instead calls for coordination between monetary policy and other stimulus policies such as government spending.

Second, it highlights that the need for policy coordination arises earlier than suggested in the literature. Under the bank equity erosion mechanism, monetary policy loses its effectiveness below the policy rate zero lower bound. This is because the policy rate has to be low, even negative enough, so that bank equity is depleted enough to lose its effectiveness. However, this paper highlights that this happens much earlier, even above the zero lower bound, because the pass-through from the policy rate to the deposit rate collapses well above zero, around 2% in the case of the U.S., and the loan rate response also stops as the deposit rate stops responding. This implies that policy coordination should be discussed earlier, well above the zero lower bound.

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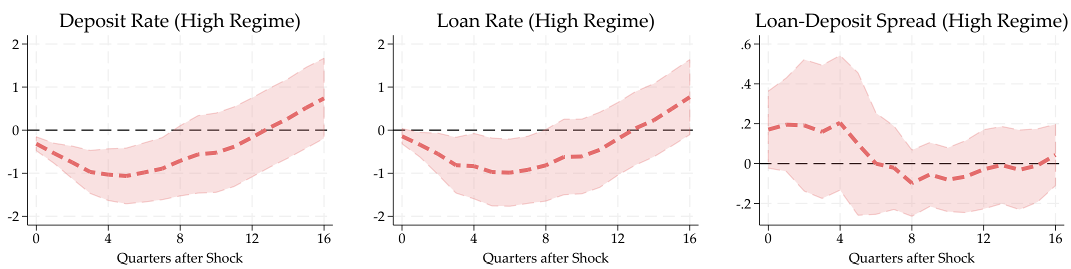
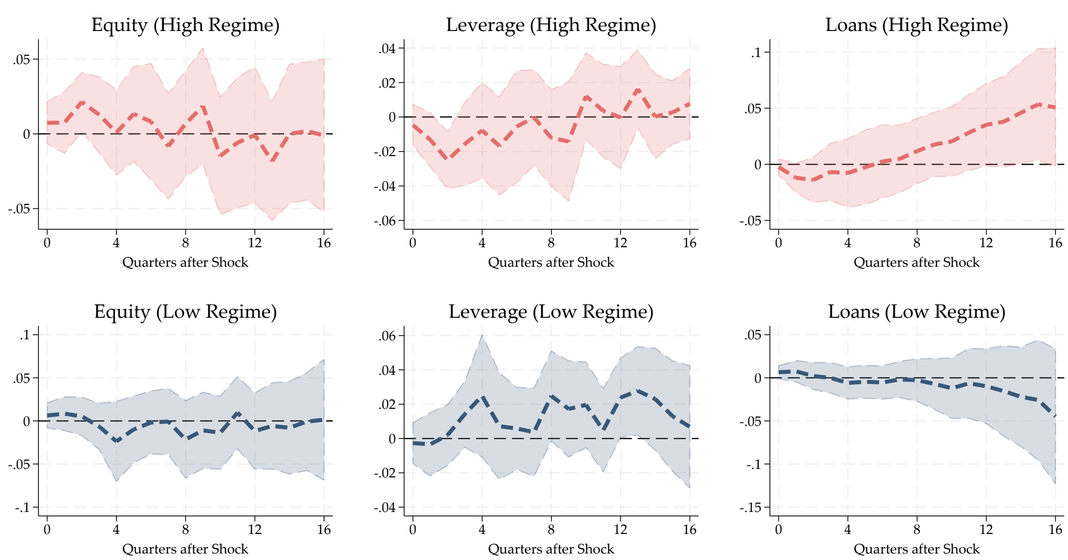
ONLINE APPENDIX

Appendix A. Robustness Check

A.1. Nakamura and Steinsson (2018) Shock

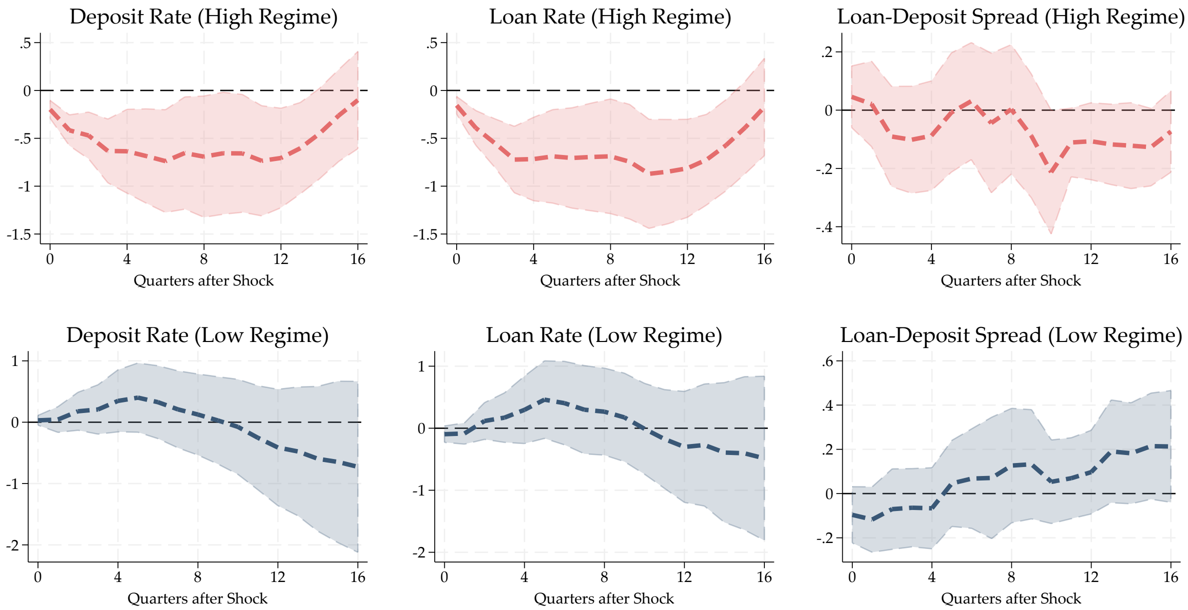
In this section, I utilize Nakamura and Steinsson (2018) shock and presents the impulse responses of each variable of equation (2).

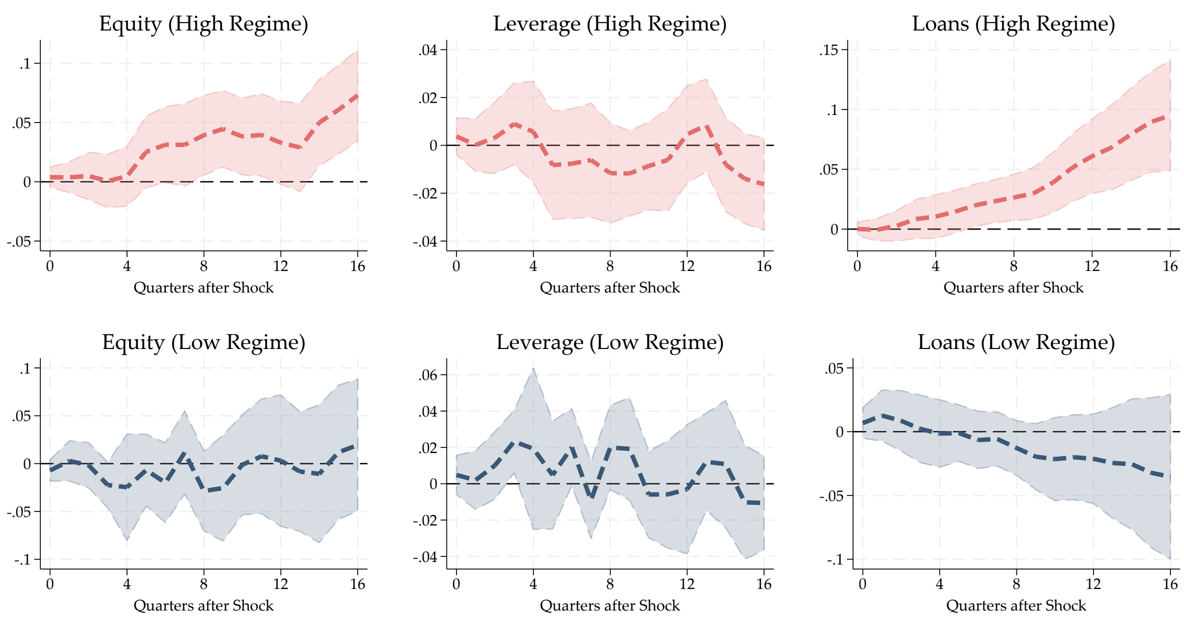




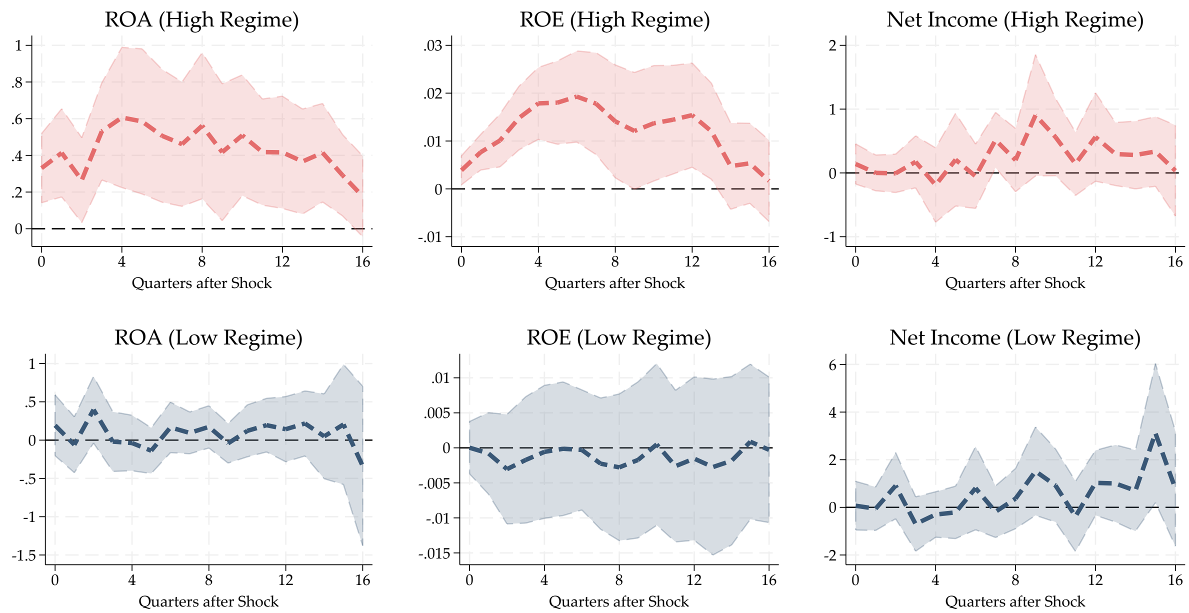
A.2. Acosta et al. (2025) Shock

In this section, I utilize Acosta et al. (2025) shock and presents the impulse responses of each variable of equation (2).



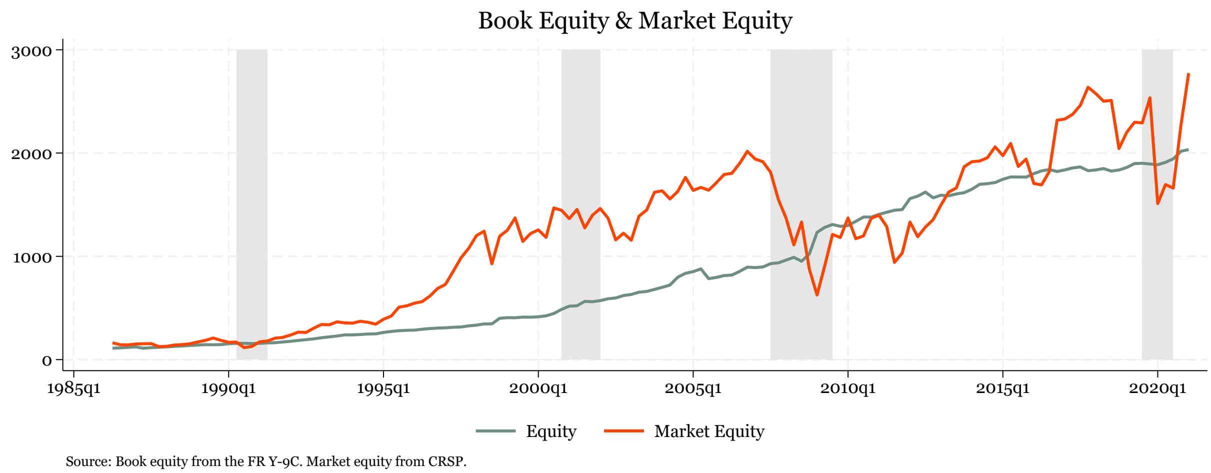


A.3. Other - ROE and Net Income



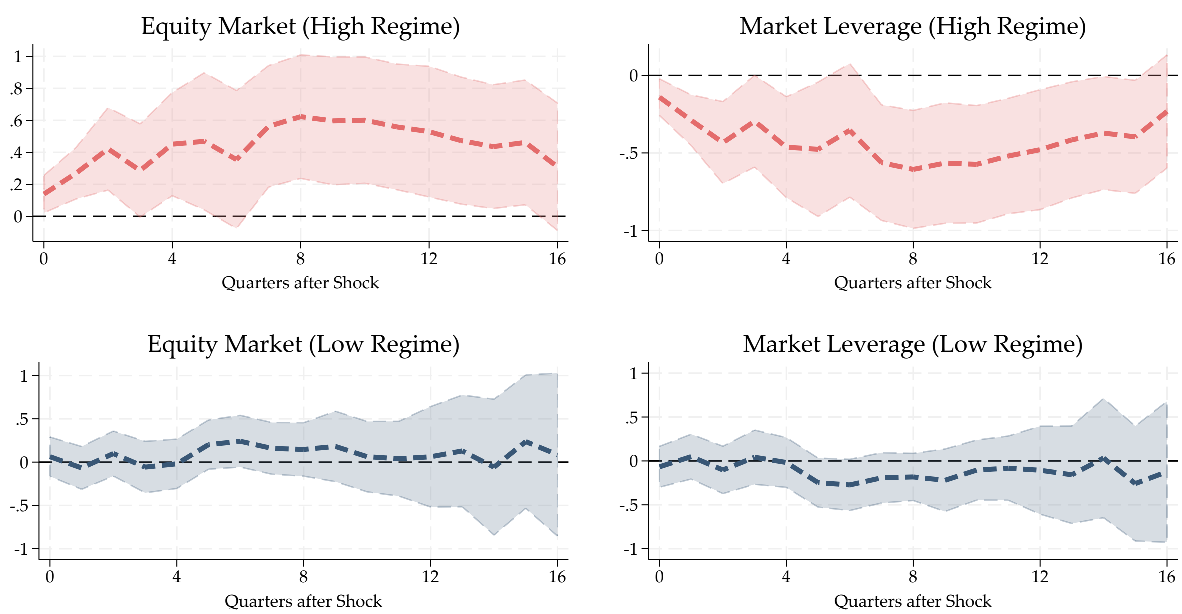
A.4. Other - Market Value

Figure A.1. Book Valued Equity and Market Valued Equity

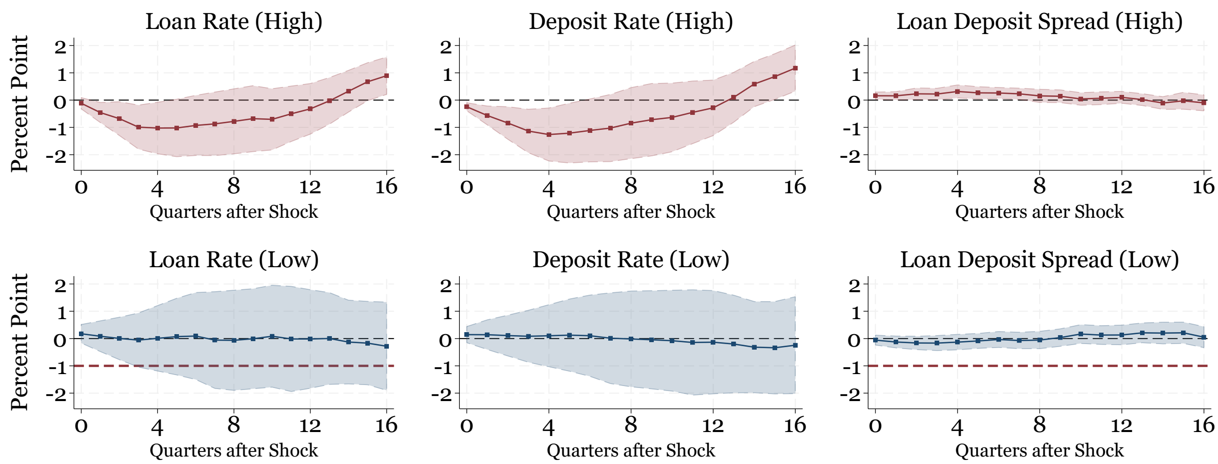


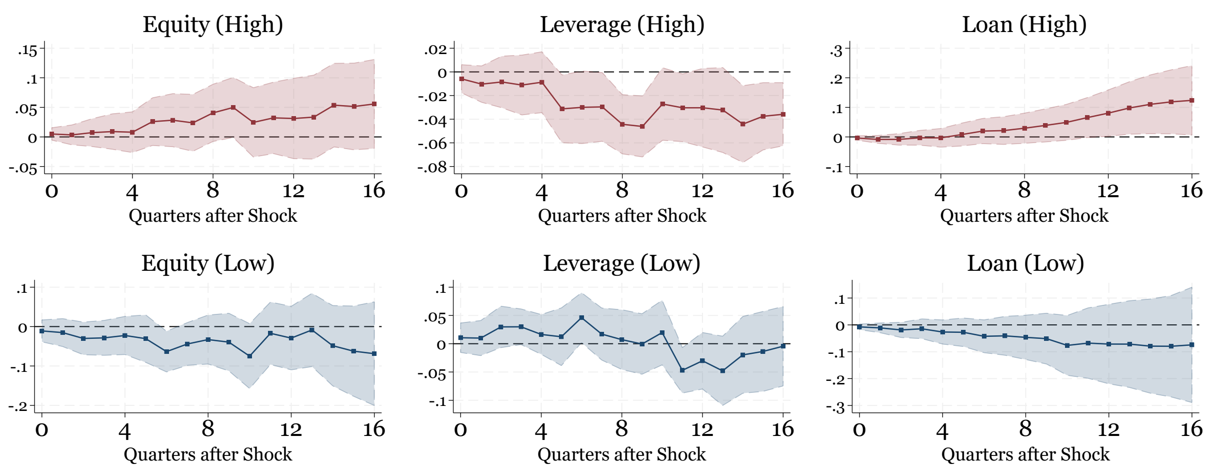
Note. These figures show data on book equity and market equity for an aggregate sample of publicly traded BHCs. Book equity are from the FR Y-9C. Market equity is from CRSP. Market equity equals shares outstanding times the share price, aggregated across publicly traded BHCs.

Figure A.2. Impulse Response of Market Value Equity and Leverage

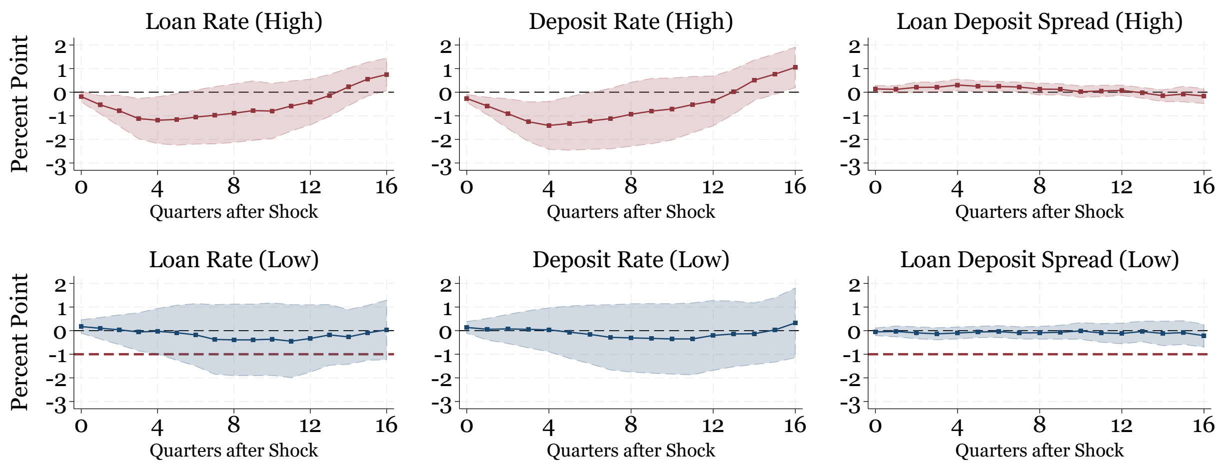


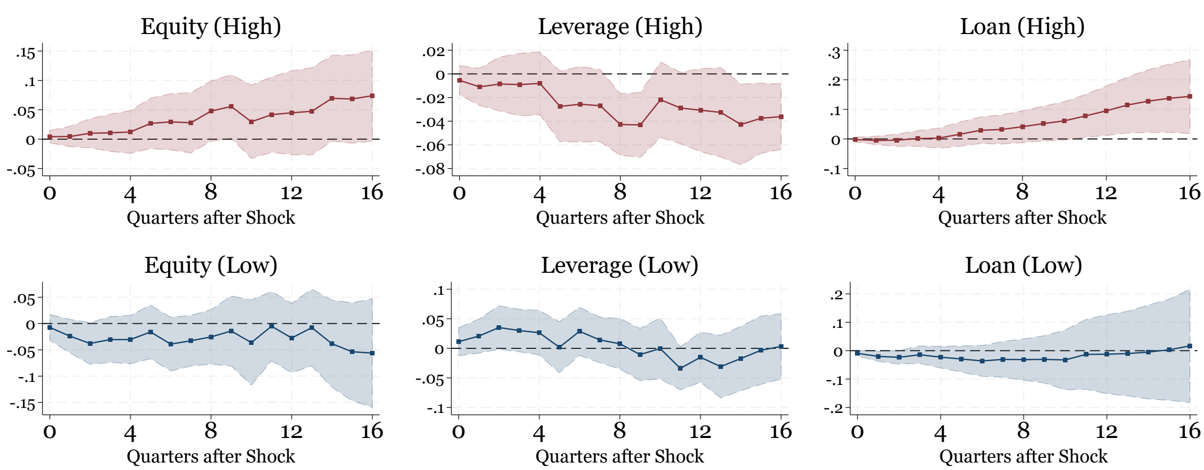
A.5. Different Cutoff: $\gamma = 1.8\%$





A.6. Different Cutoff: $\gamma = 2.4\%$





A.7. Interaction Term

$$y_{t+h,b} = \beta_h^{Direct} \times \varepsilon_t + \beta_h^{Indirect} \times i_{t-1} \times \varepsilon_t + \mathbf{X}'_{b,t-1}\Gamma_h + \alpha_{b,h} + e_{b,t+h} \tag{A.1}$$

Each figure displays $\beta_h^{Indirect}$ from equation (A.1) for each variable. $\beta_h^{Indirect} < 0$ implies that the outcome decreases more in response to the expansionary monetary policy change when interest rates are higher. Conversely, $\beta_h^{Indirect} > 0$ implies that the outcome increases more in response to the expansionary monetary policy change when interest rates are higher.

Figure A.3. Loan Rate, Deposit Rate, and Spread

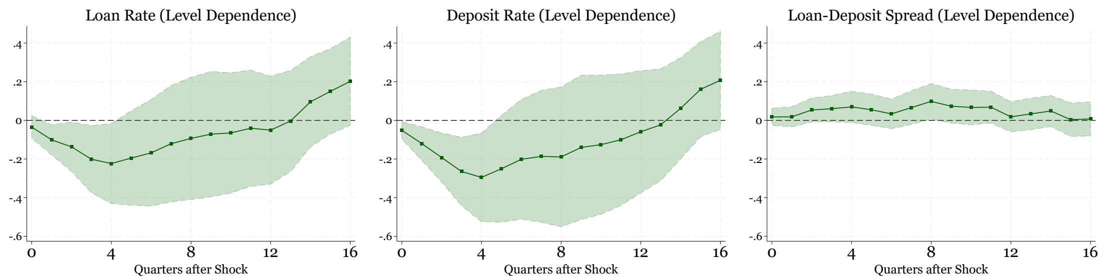


Figure A.4. Equity, Leverage, and Loan

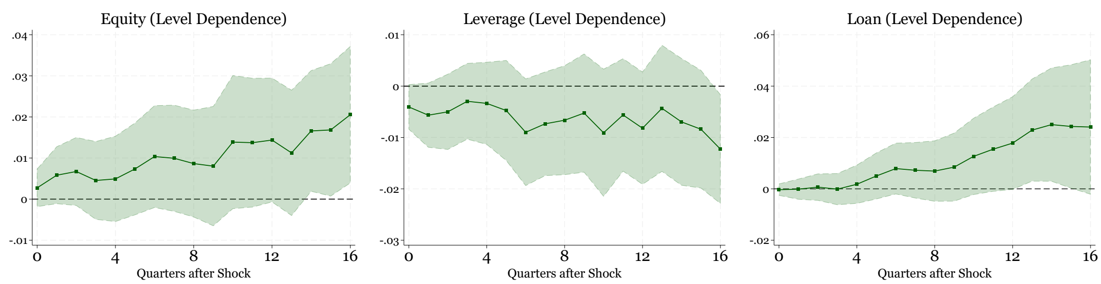
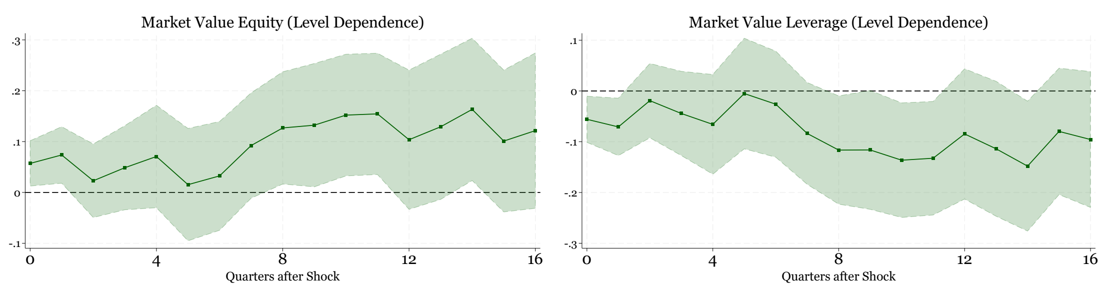


Figure A.5. Market Value Equity and Leverage

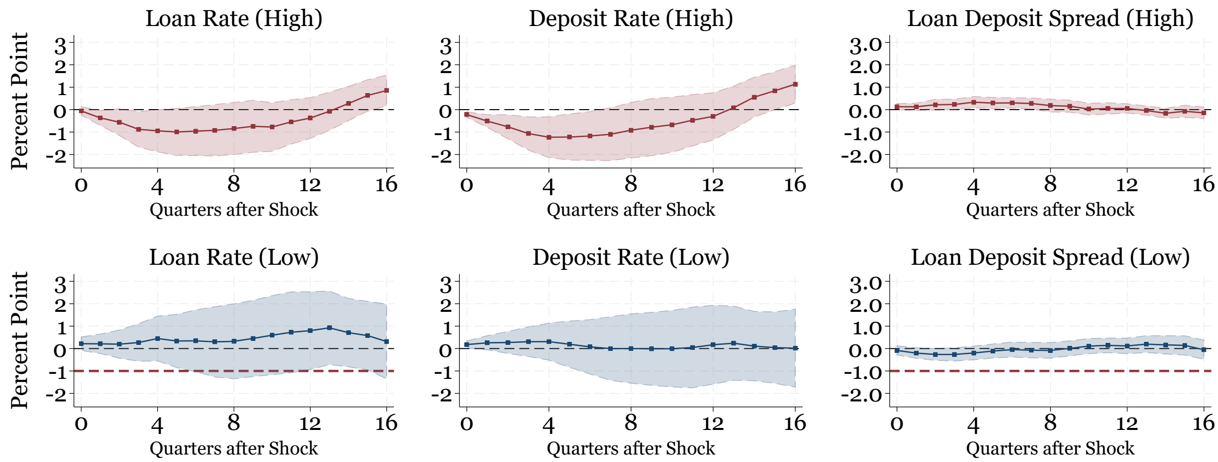


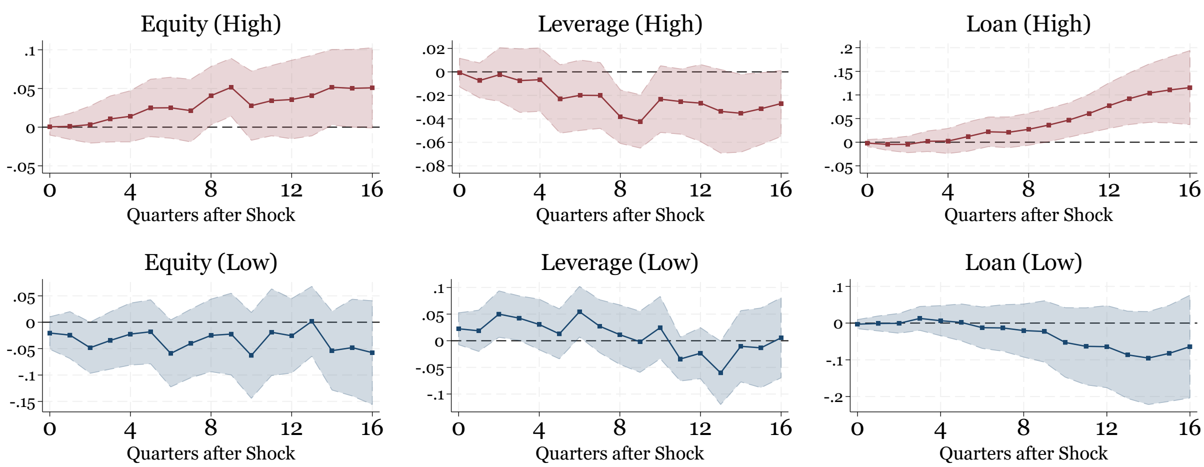
A.8. Controlling Confounding Effect

$$
\begin{aligned}
y_{t+h,b} = {} & \beta_h^H \times \mathbb{I}\left[i_{t-1} > \gamma\right] \times \varepsilon_t + \beta_h^L \times \mathbb{I}\left[i_{t-1} \leq \gamma\right] \times \varepsilon_t \\
& \underbrace{+\gamma_h \times C_{b,t-1}}_{\text{Confounding Factor } \varepsilon_t} + \underbrace{\gamma_h^C \times C_{b,t-1} \times \varepsilon_t}_{\text{Interaction Term with } \varepsilon_t} + \mathbf{X}'_{b,t-1}\Gamma_h + \alpha_{b,h} + e_{b,t+h}
\end{aligned} \tag{A.2}
$$

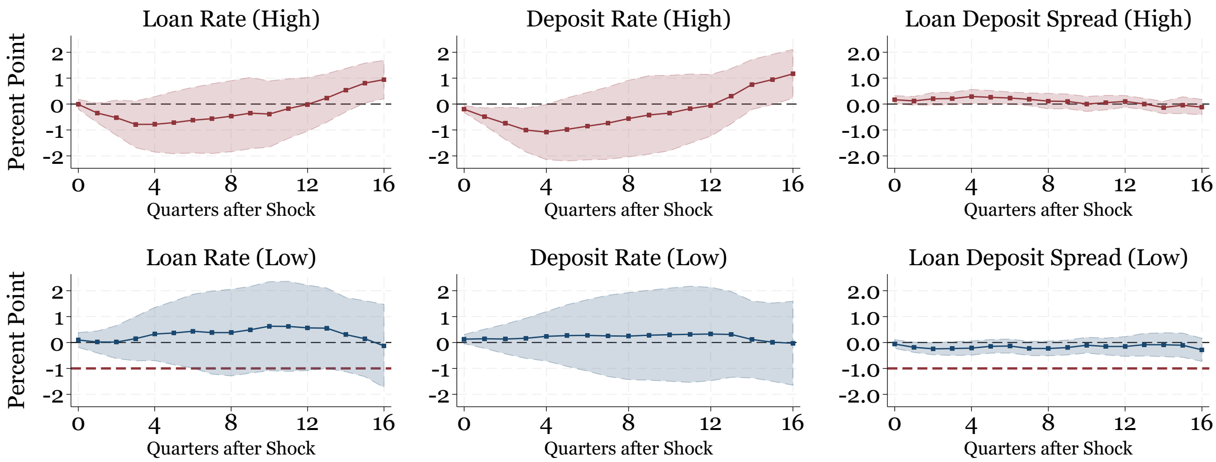
This section displays the re-estimated results of β_h^H and β_h^L of equation (A.2) after including covariates ($C_{b,t-1}$) and interaction terms between these covariates and the monetary policy variable, $(C_{b,t-1}) \times \varepsilon_t$. As potentially confounding factors, I consider the excess bond premium (Gilchrist and Zakrajšek 2012), a recession indicator, the Great Financial Crisis period, total macroeconomic uncertainty and total financial market uncertainty (Ludvigson et al. 2021), monetary policy uncertainty (Baker et al. 2016), and bank-level loan loss provision. This approach aims to isolate the effect of the policy rate on bank behavior while accounting for economic conditions and bank characteristics that may be correlated with low-interest-rate states.

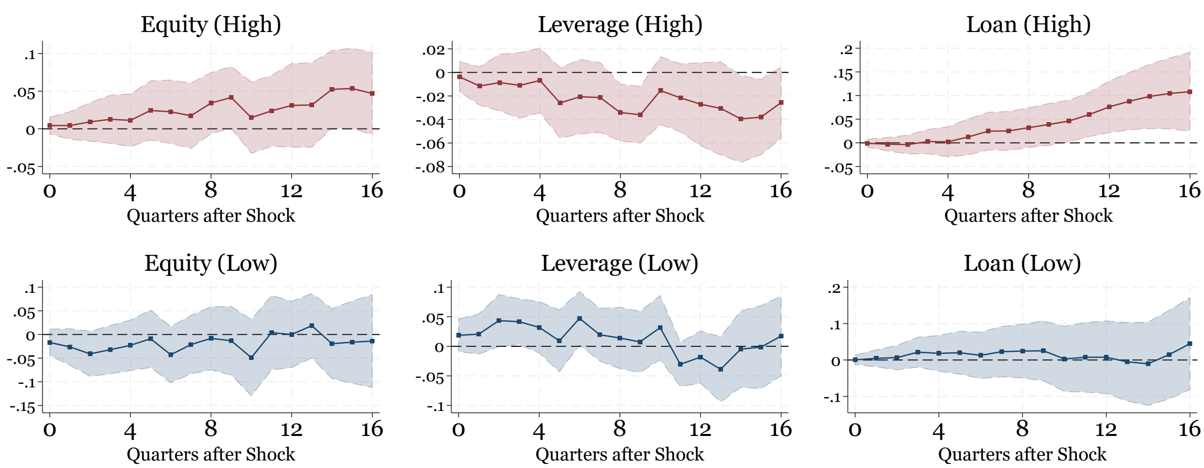
A.8.1. $C_{b,t-1}$: Excess Bond Premium by Gilchrist and Zakrajšek (2012)



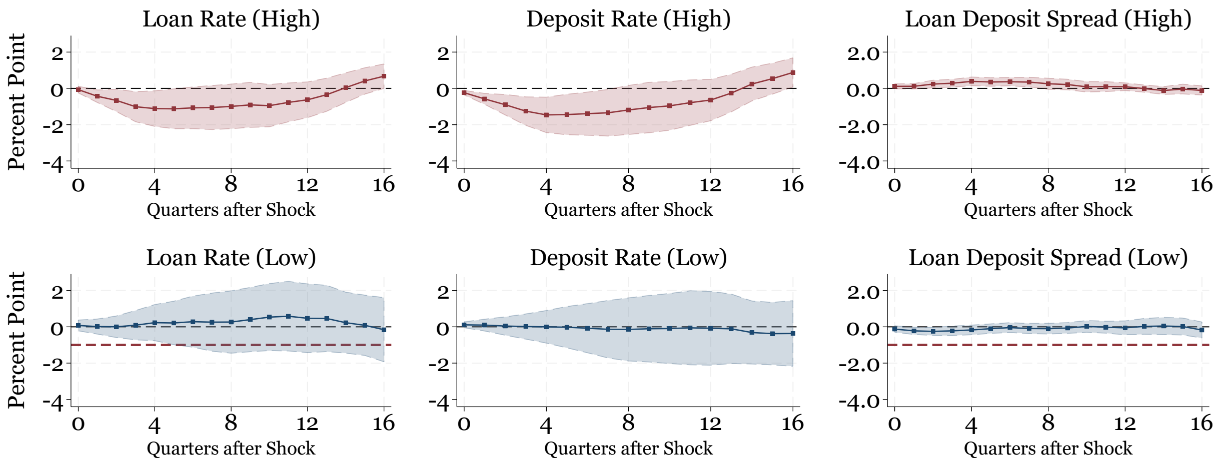


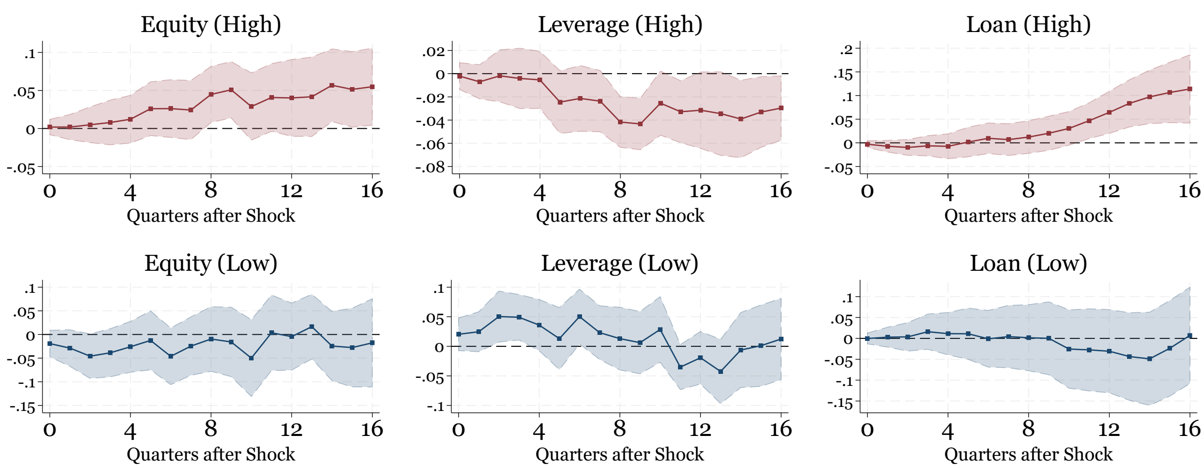
A.8.2. $C_{b,t-1}$: Recession Indicator



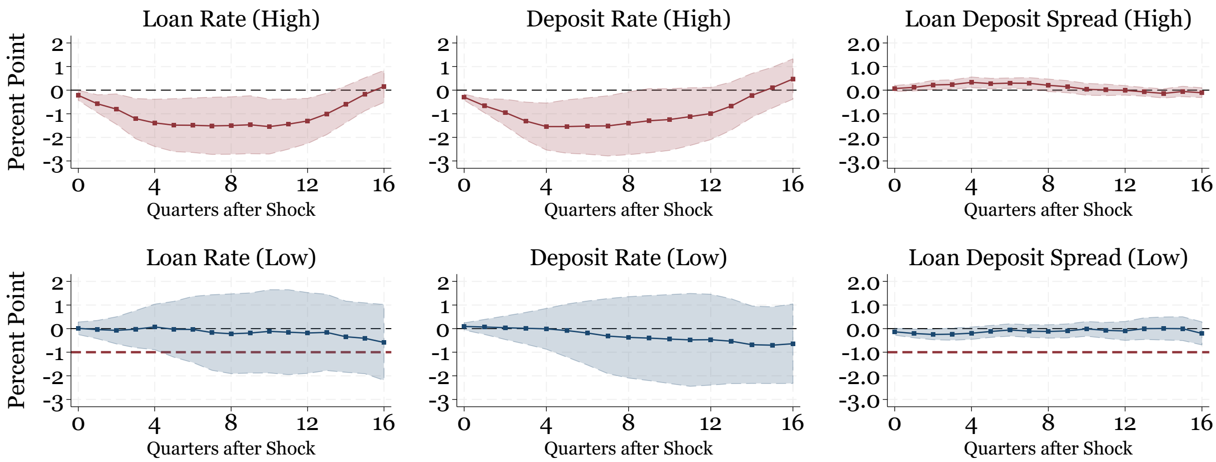


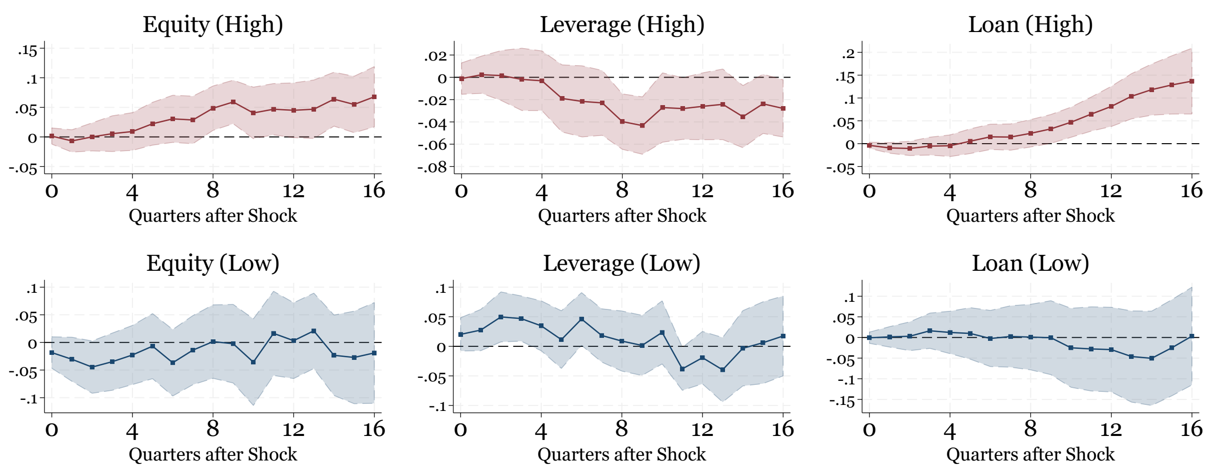
A.8.3. $C_{b,t-1}$: Great Financial Crisis Period



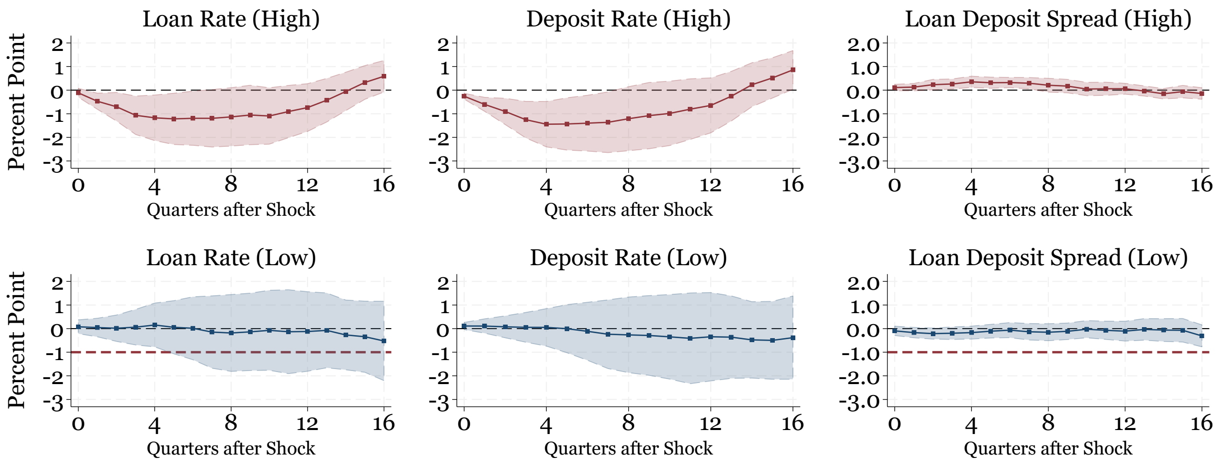


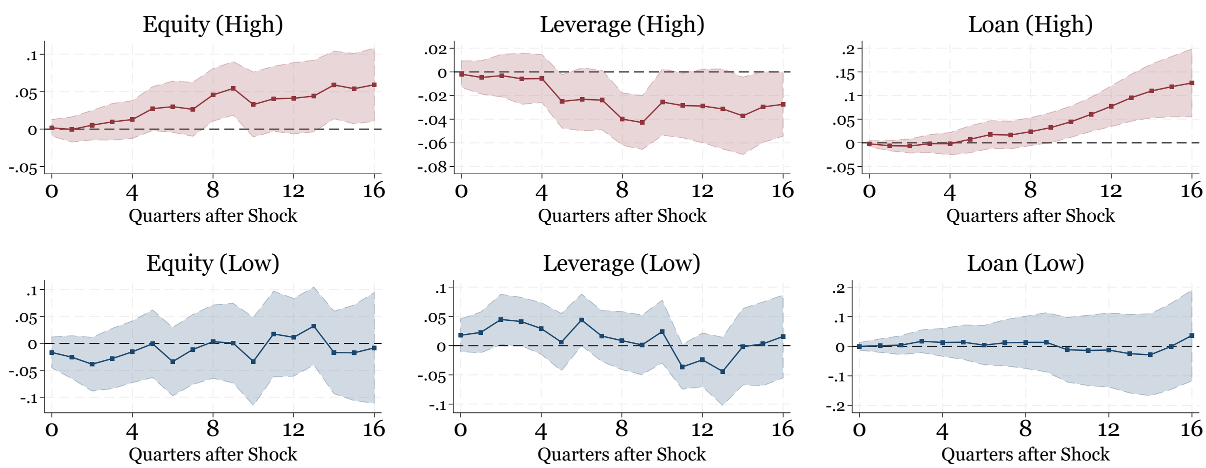
A.8.4. $C_{b,t-1}$: Total Macro Uncertainty by Ludvigson et al. (2021)



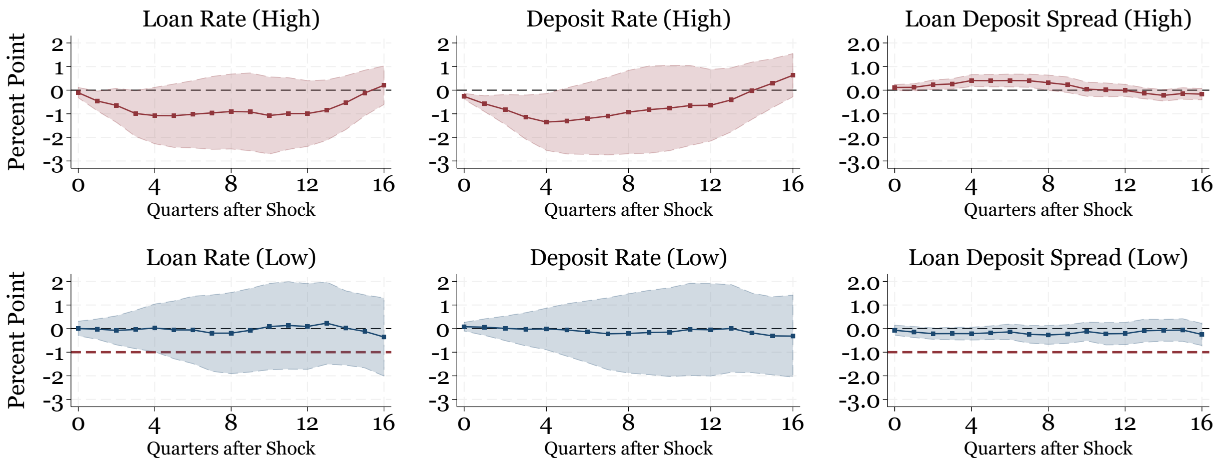


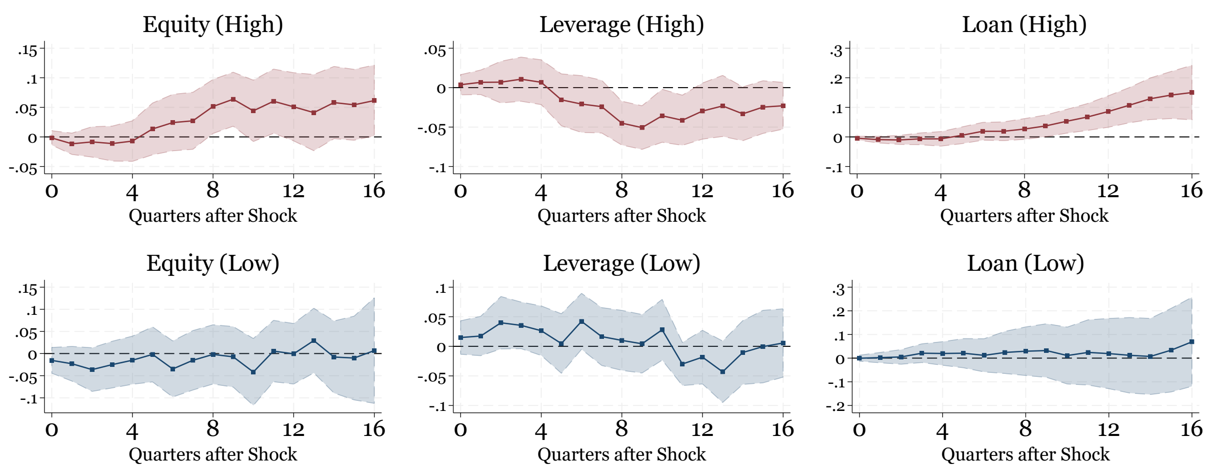
A.8.5. $C_{b,t-1}$: Total Financial Market Uncertainty by Ludvigson et al. (2021)



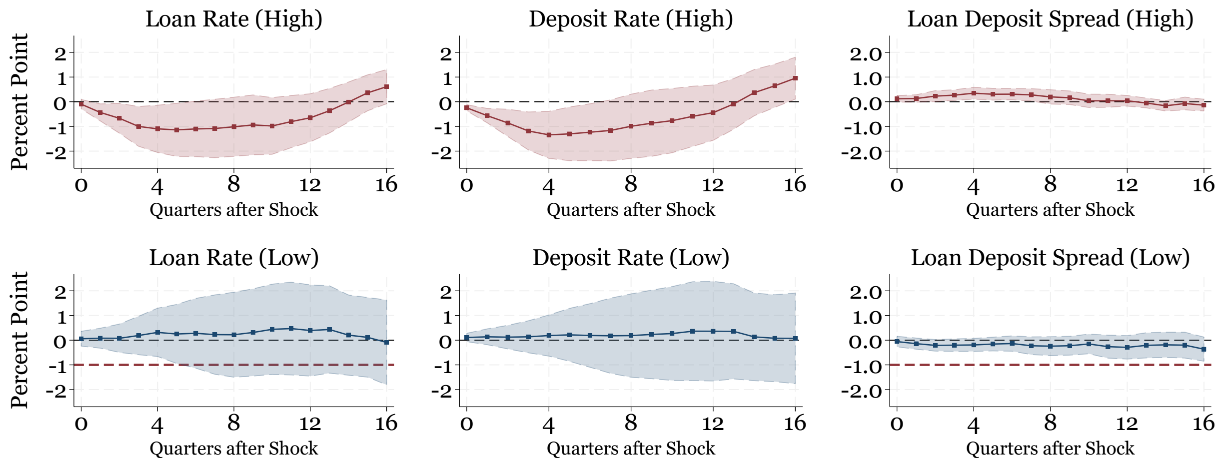


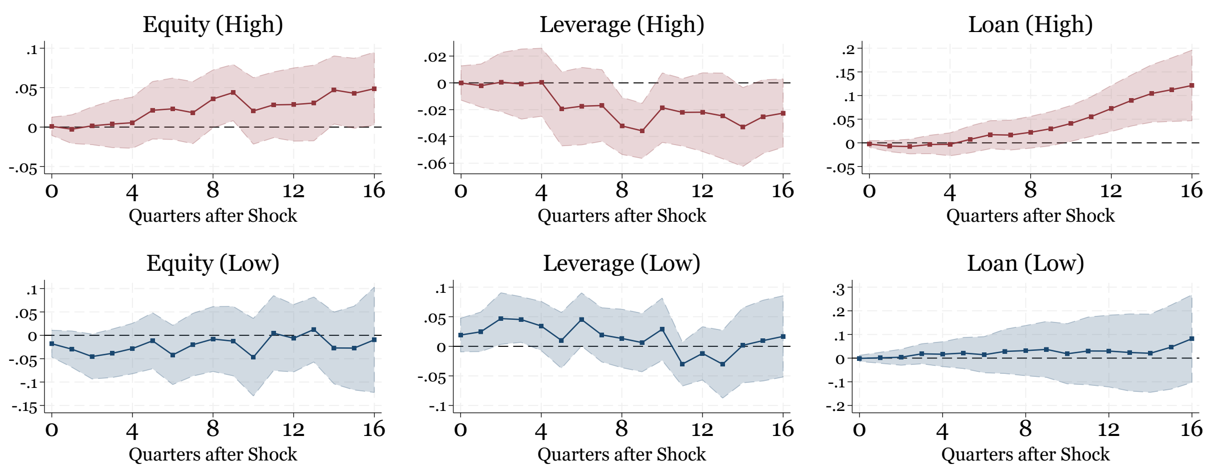
A.8.6. $C_{b,t-1}$: Monetary Policy Uncertainty by Baker et al. (2016)





A.8.7. $C_{b,t-1}$: Loss Provision

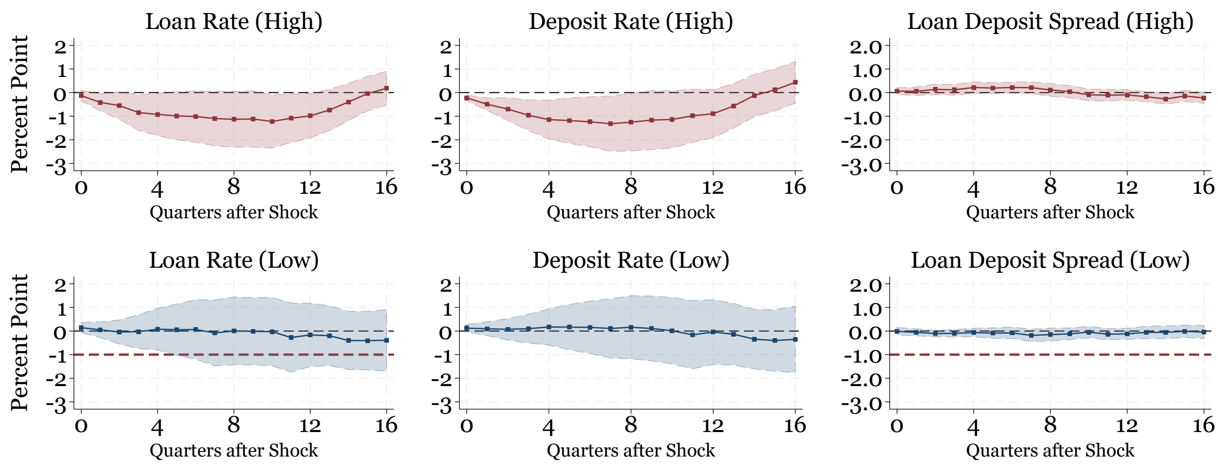


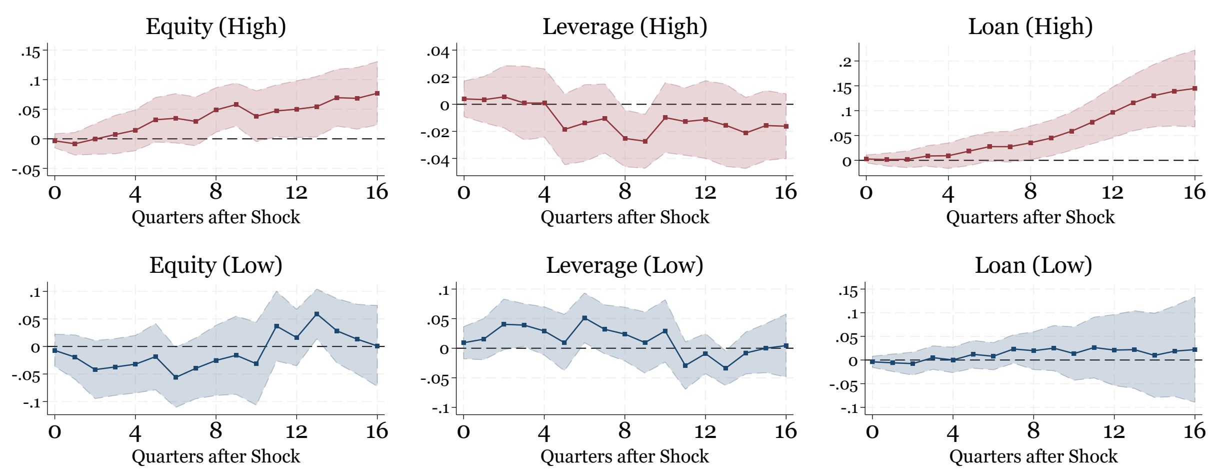


A.9. Ramey and Zubairy (2018) Local Projection

$$y_{t+h,t-1,b} = \mathbb{I}[i_{t-1} > \gamma\%] \times \left[\boldsymbol{\beta_h^H} \boldsymbol{\varepsilon_t} + \Gamma_h^{H'} \boldsymbol{X}_{b,t-1}\right] + \mathbb{I}[i_{t-1} \leq \gamma\%] \times \left[\boldsymbol{\beta_h^L} \boldsymbol{\varepsilon_t} + \Gamma_h^{L'} \boldsymbol{X}_{b,t-1}\right] + \alpha_{b,h} + e_{b,t+h} \tag{A.3}$$

This section displays the reestimated results of β_h^H and β_h^L of equation (A.3), which allows the covariates I consider in both aggregate level and bank level to affect the outcome differently following Ramey and Zubairy (2018).





Appendix B. Firm Financing with Bank Loans and Corporate Bonds

This appendix extends the baseline model by allowing firms to finance capital holdings through bank loans and corporate bonds. I assume that aggregate external financing is a CES composite of these two sources, capturing imperfect substitution between bank-based and market-based financing.

Let L_t denote bank-loan financing and B_t^c denote corporate-bond financing, both expressed in nominal terms. The financing aggregate X_t is defined by

$$X_t = \left[\omega_L^{1/\sigma_X} L_t^{(\sigma_X-1)/\sigma_X} + (1-\omega_L)^{1/\sigma_X} B_t^{c\,(\sigma_X-1)/\sigma_X}\right]^{\sigma_X/(\sigma_X-1)}, \tag{B.1}$$

where $\omega_L \in (0,1)$ is the weight on bank finance and $\sigma_X > 0$ is the elasticity of substitution between bank-loan and corporate-bond financing. This elasticity governs the adjustment of firms' financing mix to changes in relative borrowing costs.

B.1. Firm problem

For a required level of aggregate financing X_t, the firm chooses bank loans and corporate bonds to minimize total repayment, including principal. Taking the gross financing rates R_t^L and R_t^B as given, it solves

$$C_t(X_t) = \min_{L_t, B_t^c \geq 0} \left\{R_t^L L_t + R_t^B B_t^c\right\} \quad \text{subject to} \quad F(L_t, B_t^c) \geq X_t, \tag{B.2}$$

where $F(\cdot)$ is the CES aggregator in equation (B.1). Let R_t^X denote the multiplier on the financing requirement. It measures the marginal repayment required to obtain an additional unit of aggregate financing. Because the aggregator has constant returns to scale, minimized total repayment is

$$C_t(X_t) = R_t^X X_t. \tag{B.3}$$

The first-order conditions imply

$$\frac{L_t}{B_t} = \frac{\omega_L}{1-\omega_L}\left(\frac{R_t^L}{R_t^B}\right)^{-\sigma_X}. \tag{B.4}$$

The corresponding unit-cost index is

$$R_t^X = \left[\omega_L (R_t^L)^{1-\sigma_X} + (1-\omega_L)(R_t^B)^{1-\sigma_X}\right]^{1/(1-\sigma_X)}. \tag{B.5}$$

for $\sigma_X \neq 1$. The conditional financing demands are

$$L_t = \omega_L X_t \left(\frac{R_t^L}{R_t^X}\right)^{-\sigma_X}. \tag{B.6}$$

and

$$B_t^c = (1-\omega_L) X_t \left(\frac{R_t^B}{R_t^X}\right)^{-\sigma_X}. \tag{B.7}$$

The firm's aggregate financing requirement equals the nominal value of its capital holdings:

$$X_t = Q_t K_{t+1}, \tag{B.8}$$

where Q_t is the nominal price of capital and $q_t = Q_t/P_t$ is its real price. The minimized total repayment associated with this capital position is $R_t^X Q_t K_{t+1}$.

A unit of capital yields real rental income r_{t+1}^k and the undepreciated real value $(1-\delta)q_{t+1}$ in period $t+1$. After substituting the minimized financing cost and dividing the nominal capital optimality condition by P_t, the capital choice satisfies

$$R_t^X q_t = \mathbb{E}_t \left[\Pi_{t+1} \left(r_{t+1}^k + (1-\delta) q_{t+1}\right)\right]. \tag{B.9}$$

This condition extends the baseline capital-demand condition by replacing the gross bank-loan rate with the gross composite financing rate.

B.2. Corporate bond financing rate

Corporate-bond financing is distinct from the one-period government bond in the household problem. The variable B_t^c in this extension is a market-financing input supplied by a competitive capital-market sector and is not the household's risk-free government-bond holding. The government-bond Euler equation and the zero-net-supply condition therefore continue to apply only to government bonds.

I assume the pricing of market finance with a reduced-form pass-through rule

$$\frac{R_t^B}{\bar{R}^B} = \left(\frac{R_t}{\bar{R}}\right)^{\phi_B}. \tag{B.10}$$

where $\phi_B > 0$ governs the pass-through from the policy rate to the marginal cost of corporate-bond financing. The capital-market sector supplies the bond-financing input elastically at this rate, so firm demand in equation (B.7) determines the quantity of market finance used. The benchmark sets $\phi_B = 0.70$. Its role is to allow market-based borrowing costs to remain responsive to monetary policy even when bank retail-rate pass-through is impaired.

B.3. Calibration and log-linear implementation

The loan expenditure share is

$$s_t^L = \frac{R_t^L L_t}{R_t^X X_t}. \tag{B.11}$$

and the bond expenditure share is $s_t^B = 1 - s_t^L$. The calibration targets a high-rate steady-state loan expenditure share of $\bar{s}_H^L = 0.60$, so bond financing accounts for the remaining 40 percent of financing expenditure. For a given σ_X, define $\bar{q}_R = \bar{R}_H^L / \bar{R}_H^B$. The distribution parameter that reproduces the target share is

$$\omega_L(\sigma_X) = \frac{\bar{s}_H^L}{\bar{s}_H^L + (1 - \bar{s}_H^L)\bar{q}_R^{1-\sigma_X}}. \tag{B.12}$$

The benchmark uses $\sigma_X = 0.50$. The distribution parameter is fixed across interest-rate regimes, while the endogenous financing shares can vary with relative borrowing costs.