Banking on Deposits: Can Deposits Drive Risk-Free Maturity Transformation?

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Abstract

This paper challenges the conventional wisdom that maturity transformation inherently exposes banks to interest rate risk. By examining the role of the deposit franchise, it is argued that banks can effectively manage interest rate exposure. A novel theoretical framework suggests that banks, through their market power in retail deposits, can create a synthetic interest rate swap to offset the interest rate risk of their long-term assets. Empirical evidence from Indian banks supports this theory. A negative correlation is found between a bank's interest expense sensitivity and the maturity of its assets, indicating a strategic alignment of asset and liability durations. Moreover, banks exhibit remarkable stability in net interest margins despite significant interest rate fluctuations. These findings suggest that the traditional view of bank risk, primarily focused on balance sheet duration, may be incomplete. By emphasizing the role of the deposit franchise, new insights into bank behavior, monetary policy transmission, and financial stability are offered.

JEL classification: E43, E44, G21, G28, G32

Keywords: Maturity Transformation, Interest Rate Risk, Sensitivity Matching, Monetary Policy Transmission

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1 Introduction

Banks' maturity transformation is a fundamental function within the financial system, enabling banks to match the maturities of their assets and liabilities. Through maturity transformation, banks accept short-term deposits from savers and utilize those funds to provide long-term loans to borrowers. This process allows banks to profit from the interest rate spread between short-term liabilities and long-term assets. Banks play a crucial role in the economy by efficiently allocating capital through maturity transformation, facilitating investment and consumption. However, maturity transformation exposes banks to interest rate risk and liquidity risk, as sudden changes in interest rates or withdrawal demands can disrupt their balance sheets. Interest rate risk is central to banking profitability and stability. It significantly influences how monetary policy impacts banks (refer to Boivin et al. (2010) and Kohn (2010)). Fluctuations in interest rates directly affect banks' earnings through their net interest margin (NIM), the difference between loan interest and deposit interest. Rising rates can squeeze NIM, while falling rates can compress it. Banks manage this risk through asset-liability management strategies, balancing interest-sensitive assets and liabilities. Interest rate changes also impact loan and deposit demand, affecting overall bank performance.

This study demonstrates that despite significant differences in the timing of their assets and liabilities, banks are largely unaffected by interest rate fluctuations. This is primarily attributable to the benefits of their deposit base, which allows them to transform short-term deposits into long-term loans while mitigating interest rate risks. The stability of deposit costs and the high, fixed operating costs of maintaining a deposit base effectively transform these short-term liabilities into a form of long-term, fixed-rate debt. To counterbalance this, banks strategically invest in long-term fixed-rate assets, often on a substantial scale due to their large deposit base. This deliberate maturity mismatch acts as a safeguard, protecting bank earnings from interest rate volatility. Our empirical evidence supports this claim. We found that bank profits remain consistent even in the face of significant interest rate changes. This pattern is evident both overall and among individual banks, with those having a more stable deposit base tending to hold larger long-term asset portfolios. Moreover, we observed a direct correlation: banks with less interest rate sensitivity in their expenses also exhibit similarly stable interest income, creating a perfect hedge against interest rate shocks.

This study offers a new perspective on the long-standing debate about combining deposit-taking and long-term lending. Contrary to the traditional view advocating separation, it was found that these functions are inherently linked. Deposit-taking serves as a natural counterbalance to long-term lending, supporting their integration (refer to Kashyap et al. (2002)). The findings also have implications for understanding how monetary policy operates. It is suggested that protection from the traditional view of monetary policy transmission occurs, where interest rate changes impact lending through changes in net worth (refer to Gertler and Bernanke (1989); Bernanke et al. (1999)). While alternative channels exist (refer to Drechsler et al. (2017)), the research emphasizes the role of the deposit franchise in providing long-term loans without significant exposure to interest rate risk in a volatile environment.

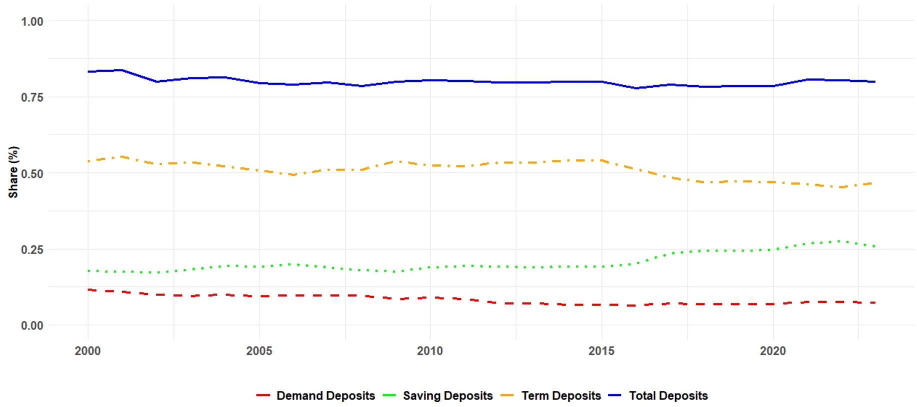
Our analysis starts by highlighting the significant difference in the maturity of banks' assets and liabilities. On average, aggregate bank assets have a maturity of 12.99 years, while liabilities mature in just 3.03 years, resulting in a 9.96-year mismatch. This means a 1% increase in interest rates could lead to a cumulative 9.96% decline in net interest margins over time. This translates to a 9.96% decrease in the book value of assets relative to liabilities, equivalent to four years of profits, given the industry's typical return on assets below 1%. While these losses would take time to materialize in book values, investors would immediately reflect the full 9.96% asset decline in bank market values. Considering banks' leverage of around 10, this could lead to a 99.6% reduction in net worth. In reality, a 100 bp interest rate shock translates to only a 0.05% decrease in banks' net worth, a magnitude significantly smaller than that inferred from their duration mismatch. This empirical finding is derived from regressing the return on a portfolio of bank stocks against the change in the one-year rate around Monetary Policy Committee (MPC) meetings. Notably, this sensitivity is small and similar to the overall market's response of 0.08%. Consequently, banks don't show increased vulnerability to interest rate shocks compared to other companies.[1]

To understand why unaffected by interest rate changes, an examination was conducted on how interest rates impact cash flows. Remarkably, despite low equity sensitivity and contrary to conventional wisdom, aggregate cash flows exhibit notable insensitivity to interest rate changes. Since 2008, NIMs have remained relatively stable between 1.91% and 5.30%, despite significant swings in short-term interest rates from 4% to 13.5% (Appendix A). Furthermore, annual changes in NIMs have been small (0.87% standard deviation) and unrelated to interest rate movements (Appendix **??**). Consequently, fluctuations in NIM have been minuscule and unrelated to interest rate variations. The ability to maintain stable NIMs despite interest rate fluctuations is attributed to the deposit franchise. To clarify, NIM is dissected into two constituents, interest income and interest expense (both normalized by assets), and their interest rate sensitivities are analysed. While interest income exhibits low sensitivity to short rates, as expected due to the predominance of long-term and fixed-rate assets, the surprising revelation is the equally low sensitivity of interest expense. This paradox is explained by significant market power over retail deposits (refer to Drechsler et al. (2017)), allowing deposit rates to remain low even when overall interest rates rise. Since retail deposits constitute over 75% of liabilities (Figure 1), overall interest expense stays stable. As a result, long-term assets can be held while interest income and expense move together, providing protection from interest rate risk.

While a deposit franchise is beneficial, it entails significant costs. Investments are made in branches, marketing, customer service, and technology to maintain the deposit base.

[1] We interpret the impact of interest rates on equity values as a common discount rate shock influencing all firms, as proposed by Bernanke and Kuttner (2005). The key finding is that, despite the substantial duration mismatch and high leverage often linked with banks, this shock does not have an additional impact on banks compared to nonfinancial firms.

Figure 1 Deposits as share of total liabilities.



These expenses contribute to the difference between NIM and bottom-line ROA, typically between 2% and 3%. However, these costs remain stable and unaffected by interest rate changes, similar to other non-financial businesses. As a result, the stability of NIM directly influences overall profitability (ROA). A simplified model is proposed to explain these findings. In this model, banks incur consistent costs to maintain their customer base and pricing power. This allows them to offer lower deposit rates compared to market rates, similar to the findings of Drechsler et al. (2017). Essentially, the bank's relationship with depositors resembles an interest rate swap: the bank pays a fixed cost (operating expense) and receives a variable return (interest spread). The value of this relationship depends on interest rates. When interest rates rise, the bank benefits as the value of its future interest spread increases relative to its fixed costs. Therefore, the bank's deposit franchise is positively linked to interest rates, or conversely, has a negative interest rate sensitivity.

Banks mitigate the interest rate risk associated with their deposit franchise by adopting the opposite exposure on their balance sheets. They achieve this by extending long-term, fixed-rate credit to businesses and households and by investing in long-term, fixed-rate securities (positive duration). In a scenario of free entry into the deposit market, the average deposit spread charged by banks merely covers their operating costs, resulting in zero net deposit rents (i.e., the deposit franchise swap is fairly priced). Consequently, banks operate on thin margins at high leverage, necessitating tight hedging. This entails perfect alignment of the sensitivities of their income and expense to the short rate, ensuring that their NIM and ROA remain unaffected. Consequently, the model elucidates why banks' aggregate interest income and expense exhibit identical sensitivity to the short rate, and why aggregate NIM and ROA remain highly stable. Importantly, the model reveals that a key part of banks' interest rate risk—the risk linked to their customer base—isn't visible on their balance sheet. This is because the profit from deposits and the costs to maintain customer relationships aren't recorded as assets or liabilities. However, these factors significantly impact a bank's profitability, highlighting the need to focus on income and expenses when assessing interest rate risk.

The model predicts similar sensitivities for both interest income and expense. To test this, data from Indian scheduled commercial banks between 2008 and 2023 was analyzed.[2] For each bank, an interest expense sensitivity (interest expense beta) was estimated by regressing the change in interest expense (normalized by assets) against contemporaneous and lagged changes in the Repo rate, then summing the coefficients. Similarly, each bank's interest income beta was computed. On average, the expense and income betas amounted to 0.328 and 0.611, respectively. The variation in both interest expense beta and interest income beta was considerable, ranging from -4.742 to 9.031 and -4.212 to 8.942, respectively. The findings reveal a robust alignment between expense and income betas across banks. The correlation stands at 67% across all banks (refer to Table A.3). The corresponding slopes derived from a regression of income betas on expense betas is 0.885. Furthermore, these values drop after accounting for time fixed effects in beta estimation or when conducting matching tests within a panel regression framework. This strong one-to-one matching implies that profitability is essentially immune to interest rate risk. Indeed, ROA betas (computed analogously to expense betas) hover close to zero across the spectrum, consistent with the model's predictions.

The analysis indicates that banks with a high sensitivity of interest expenses to interest rate changes (an expense beta of 1) would likely have a similarly high sensitivity of interest income (an income beta close to 1). While no bank in the dataset exhibits such extreme betas, this prediction is supported by the behavior of money market funds. These funds borrow at the short-term interest rate (an expense beta of 1) and invest in short-term assets (an income beta of 1), aligning with the model's expectations. This suggests that the findings can be applied to other financial institutions, such as money market funds, even though these institutions were not included in the study. The analysis of bank stocks corroborates the insensitivity of profits to interest rate shocks. Employing a methodology similar to that used for the bank industry portfolio, firm-level "MPC betas" for all publicly traded commercial banks were estimated. Similar to the aggregate findings, the average MPC beta of banks remains small and closely aligns with that of non-financial firms. Crucially, a roughly flat relationship was observed between MPC betas and expense and income betas. This suggests that asset duration, as traditionally measured, does not accurately predict exposure to interest rate risk. The model explains this by showing that interest rate risk is effectively hedged through the deposit franchise.

The study further explored whether lower interest expense sensitivity correlates with greater investment in long-term, fixed-rate assets. Findings confirm this, revealing a strong negative relationship between interest expense sensitivity and the average maturity of assets before their interest rates can be adjusted.[3] This relationship is significant, with a steep slope of 12.665 years, closely matching the overall average maturity of bank

[2] Based on availability of quarterly data in the Center for Monitoring Indian Economy (CMIE) database.

[3] The repricing maturity of an asset refers to the duration until its interest rate resets, distinct from its remaining maturity, which denotes the duration until the asset matures. For instance, consider a floating-rate bond: its repricing maturity is typically one quarter, while its remaining maturity may extend over several years. Therefore, repricing maturity helps identify assets that are both long-term and fixed-rate.

assets. Importantly, this pattern is also observed when compared to money market funds, which primarily hold short-term assets.

In a final series of tests, direct evidence supporting the market power mechanism posited in the model was provided. Geographic variation in deposit market power was leveraged by considering variation in local market concentration. The analysis reveals that operating in areas with fewer competitors (higher market concentration) results in lower sensitivity to interest rate changes for both income and expenses. This relationship is strong, with a coefficient of 0.465. The analysis demonstrates a strong correlation between market power, as measured by retail deposit beta, and overall interest expense sensitivity. Furthermore, banks offset this interest expense sensitivity by matching it with a similar sensitivity in interest income.

The subsequent sections of this paper are structured as follows: Section 2 discusses the relevant literature, Section 3 analyzes the aggregate time series, and Section 4 presents the risk model. Section 5 describes the data utilized, and the main sensitivity matching results are detailed in Section 6. An examination of asset composition is found in Section 7, while Section 8 links findings to market power. Finally, Section 9 provides concluding remarks.

2 Literature review

Banks traditionally engage in the practice of issuing short-term deposits while simultaneously extending long-term loans. This core banking function is central of modern banking theory, as evidenced by the works of Diamond and Dybvig (1983), Diamond (1984), Gorton and Pennacchi (1990), Calomiris and Kahn (1991), Diamond and Rajan (2001), Kashyap et al. (2002), and Hanson et al. (2015). Central to this body of literature is the concept of liquidity risk, which arises from the issuance of deposits susceptible to runs. While studies such as those by Brunnermeier et al. (2012) and Bai et al. (2017) offer quantitative assessments of liquidity risk, this paper focuses on interest rate risk arising from the maturity mismatch between deposits and loans. These two risks are distinct. For example, a floating-rate bond is susceptible to liquidity risk but not interest rate risk, while a Treasury bond faces interest rate risk but typically has low liquidity risk. Unlike liquidity risk, which often emerges during financial crises, interest rate risk is a persistent concern for banks.[4]

Alternative explanations for banks' maturity transformation often focus on the idea of a term premium—the extra return for holding long-term assets. For example, Diamond and Dybvig (1983) suggests households prefer short-term investments while banks invest long-term, creating a demand for term premiums. More recent dynamic general equilibrium models, such as those by He and Krishnamurthy (2013), Brunnermeier and

[4] We concentrate on contemporary banking systems. Historical studies of banking indicate that in the 19th and early 20th centuries, banks in the United States tended to extend fewer long-term loans and allocate a larger portion of their assets to short-term securities (refer to Bodenhorn (2003)).

Sannikov (2014), Brunnermeier and Sannikov (2016), and Drechsler et al. (2018), highlight the link between maturity transformation and fluctuations in the term premium and risk aversion. Similar to our study, Di Tella and Kurlat (2017), find that deposit rates are relatively unaffected by interest rate changes. However, they attribute this insensitivity to banks' financial constraints rather than market power. As a result, banks are less cautious about interest rate risk and tend to hold more long-term assets to capture potential higher returns. This strategy, though, significantly exposes banks to interest rate fluctuations. Their model suggests a substantial 31% decline in bank net worth for every 1% increase in interest rates, a much larger impact than observed in real-world data.

Unlike existing research that often views maturity transformation as a risk-taking strategy, we propose a risk-management perspective. We argue that banks intentionally create maturity mismatches to mitigate interest rate risk rather than amplify it. Our model predicts a precise one-to-one matching of interest rate sensitivities between bank income and expenses, a pattern supported by our empirical findings.[5]

The empirical banking literature has extensively studied banks' sensitivity to interest rate shocks. In a sample of 15 banks, Flannery (1981) finds that bank profits exhibit surprisingly low exposure to these shocks, framing this as a puzzling outcome. Flannery (1983) confirms this finding with a larger sample of 60 small banks. English (2002) reports mixed results regarding banks' exposure to level and slope interest rate shocks across a sample of 10 countries. Purnanandam (2007) suggests that banks employ interest rate derivatives to mitigate the sensitivity of their lending policies to interest rate fluctuations. Flannery and James (1984b) and English et al. (2018) analyze the cross-sectional stock price exposures of banks but do not compare these exposures to those of other firms to assess whether banks are unique in this regard. The exposures documented by English et al. (2018) are somewhat larger than those found in our study, as their analysis includes unscheduled emergency FOMC meetings. However, their exposures remain significantly smaller than predicted and only marginally larger than those of non-financial firms.[6] Other research explores banks' interest rate risk exposure by analyzing balance sheet data. Begenau et al. (2015) and Begenau and Stafford (2018) emphasize the substantial exposure of bank balance sheets to interest rates. Rampini et al. (2020) note that banks tend to hedge more of their interest rate risk when their net worth is higher. Our findings indicate that banks mitigate their balance sheet exposure through their deposit franchise. This insight contributes to the ongoing discussion on whether bank balance sheets should be marked to market, as explored by Allen and Carletti (2008) and Heaton et al. (2010). We contend that to accurately mark to market banks' interest rate risk, the deposit franchise should be capitalized on the balance sheet. Alternatively, if income from the deposit franchise is recognized gradually, a consistent approach should

[5] In alignment with the risk management rationale, Bank of America BoA (2016) annual report articulates that their overarching objective is to effectively control interest rate risk to prevent substantial adverse impacts on earnings and capital due to fluctuations in interest rates. Our interpretation also aligns with case studies examining bank interest rate risk management, such as those conducted by Backus et al. (1998) and Esty et al. (1994). Moreover, formal models of bank risk management, including those developed by Froot et al. (1994), Freixas and Rochet (1997), and Nagel and Purnanandam (2019), support our explanation.

[6] Bernanke and Kuttner (2005) posit that the heightened exposure of non-financial firms stems from an escalation in the equity risk premium. Conversely, Nakamura and Steinsson (2018) propose that this exposure arises from bolstered growth expectations.

be applied to both the asset and liability sides of the balance sheet.

Our study is consistent with the findings of Drechsler et al. (2017) and Drechsler et al. (2021), providing a comprehensive view of how interest rates affect banks. Banks invest significantly in developing a deposit franchise, which gives them market power. Utilizing this power, banks adjust deposit spreads in response to changes in interest rates, effectively treating deposits as a form of long-term debt. As a result, banks hold long-term assets to hedge their NIM and net worth. However, as highlighted by Drechsler et al. (2017), the need to increase deposit spreads causes banks to shrink their balance sheets, thereby influencing credit supply in response to monetary policy shifts. In this context, banks with greater market power tend to have both a larger maturity mismatch and a more sensitive credit supply. This is in line with the findings of Gomez et al. (2021), which suggest that banks with a wider income gap, indicative of a greater maturity mismatch, reduce lending when interest rates rise. Additionally, our results suggest that banks become less willing to hold long-term assets during deposit outflows, offering insights into the negative correlation between bond returns and the income gap, as observed by Haddad and Sraer (2020). A prominent example of interest rate risk in the financial sector is the Savings and Loan (S&L) crisis of the 1980s. S&Ls were limited to holding mortgages, which created a significant duration mismatch (as discussed by White (1991)). This mismatch was manageable during the 1970s due to deposit rate ceilings imposed by Regulation Q, which effectively neutralized the interest rate sensitivity of deposits. However, the repeal of Regulation Q in the 1980s caused a sudden spike in deposit rates, leaving S&Ls unhedged in the new environment and ultimately leading to their insolvency.[7]

The literature on deposits has extensively documented the limited responsiveness of deposit rates to market rates, a key aspect emphasized in our study (see Hannan and Berger (1991); Neumark and Sharpe (1992); Driscoll and Judson (2013); Yankov (2014); Drechsler et al. (2017)). Some studies have estimated the effective duration of deposits, revealing that it is longer than their contractual maturity, which corresponds to their low sensitivity to interest rates (Flannery and James (1984a); Hutchison and Pennacchi (1996); Jánosi et al. (1999); O'Brien (2000)).[8] Nagel (2016) and Duffie and Krishnamurthy (2016) extend this observation to a wider range of bank instruments. A growing body of research examines the effects of extended periods of low interest rates on bank profitability and lending (see Brunnermeier and Koby (2018); Eggertsson et al. (2019)). Our analysis indicates that prolonged low-interest-rate environments can negatively impact bank profitability if they last longer than the maturity of banks' long-term assets. Wang (2018) finds that banks counteract this effect by increasing the spreads on their loans.

Additionally, the literature delves into the nexus between deposit funding and bank as-

[7] Drechsler et al. (2020) offer additional insights into how Regulation Q influenced deposit rates for both banks and savings and loan associations (S&Ls).

[8] Adams et al. (2021) conducted a large-scale field experiment in the United Kingdom, revealing that despite being informed about significantly higher deposit rates elsewhere, most households do not transfer their savings accounts to other banks. This finding aligns with the low interest rate sensitivity observed in the study.

sets. Kashyap et al. (2002) highlight the complementary relationship between depositors' liquidity needs and the demands of bank borrowers. Gatev and Strahan (2006) show that banks tend to attract deposits during periods of stress, which allows them to offer more liquidity to borrowers. Hanson et al. (2015) argue that banks are better suited to holding fixed-rate assets compared to shadow banks, owing to the stability of their deposits. Kirti (2020) finds that banks with a higher proportion of floating-rate liabilities are more likely to issue floating-rate loans. Egan et al. (2017) investigate how deposit competition affects financial stability, while Berlin and Mester (1999) demonstrate that deposits help banks manage aggregate credit risk. Our paper focuses on banks' exposure to interest rate risk and offers insights into the coexistence of deposit-taking and maturity transformation.

3 Aggregate Bank Interest rate Risk: Repricing maturity

This section assess the overall exposure of banks to interest rate fluctuations. The evaluation begins by assessing the extent of involvement in maturity transformation by estimating the durations of assets and liabilities. The repricing maturity method is used to estimate duration (see Drechsler et al. (2021)). Repricing maturity serves as a useful proxy for duration because it differentiates between long-term fixed-rate assets and short-term floating-rate assets. The calculation details are provided in Appendix B. However, a potential limitation of using repricing maturity as a proxy for duration is that it may not fully account for the effects of prepayment and amortization, which are common in mortgage scenarios. Figure 2 displays a time series graph showing the repricing maturity of bank assets and liabilities from 2000 to 2023. The graph indicates that the average repricing maturity of assets is 12.99 years, with a slight downward trend over this period. Table 1 provides summary statistics for bank-level repricing maturity. The maximum and minimum average repricing maturity of assets are 13.54 years (2000) and 12.48 years (2017). In contrast, the average repricing maturity of liabilities is 3.03 years, with a slight upward trend, except for a sharp decline in 2001. The maximum and minimum average repricing maturity of liabilities are 3.575 years (2000) and 2.49 years (2001). Thus, according to this measure, there is an approximate duration mismatch of 9.97 years within the aggregate banking sector, with a minimum of 9.41 years (2017) and a maximum of 10.72 years (2001). A duration mismatch of 9.97 years is substantial and carries significant economic implications. It suggests that a 1% interest rate shock would result in a 9.97% decrease in the value of bank assets relative to liabilities. This highlights the increased sensitivity of bank asset values to interest rate changes, emphasizing the potential impact of interest rate volatility on the bank's financial stability.

The commonly used 10-to-1 leverage ratio by banks magnifies the impact of a duration mismatch, potentially leading to a 99% decrease in equity values. This significant effect highlights the importance of examining whether maturity transformation substantially exposes banks to interest rate risk. To explore this, the sensitivity of bank equity prices

Figure 2 Repricing maturity of aggregate bank assets and liabilities.

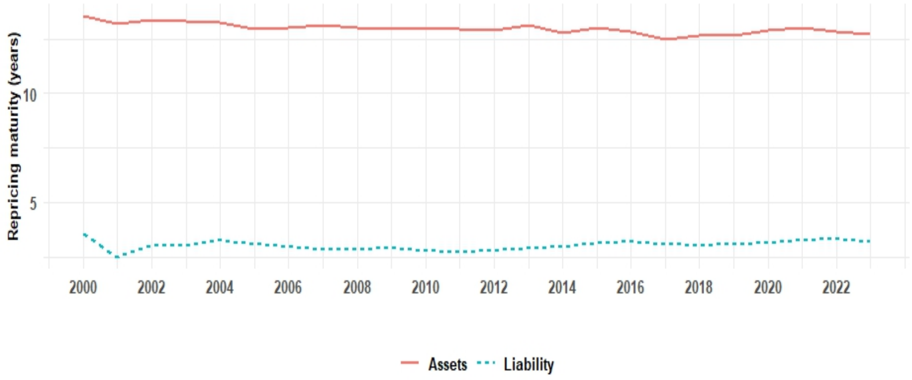


Table 1 Summary statistics on bank level repricing maturity

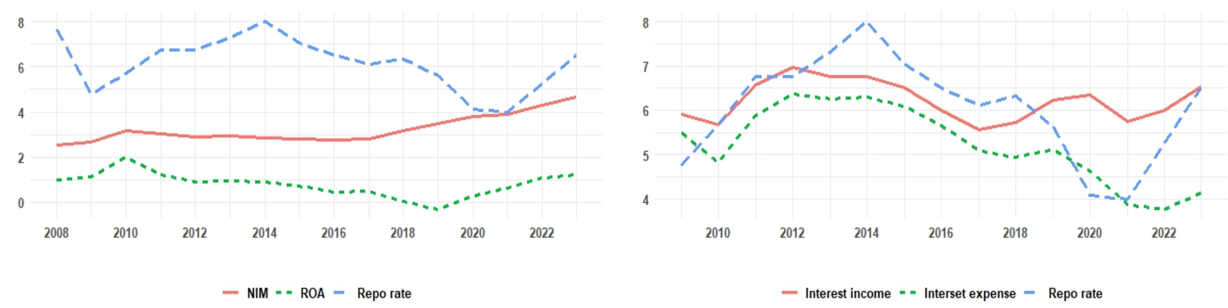
Statistic	N	Mean	St. Dev.	Min	Max
Assets repricing maturity	1073	12.682	2.20	0.003	15.679
Liabilities repricing maturity	1076	3.039	1.579	0.028	16.090
Maturity gap	1073	9.496	2.830	0.003	16.090
Short-term assets repricing maturity	1072	0.190	0.102	0.003	0.753
Short-term liabilities repricing maturity	1074	0.228	0.096	0.009	0.599

to interest rate fluctuations is analyzed by regressing the returns of an industry portfolio of bank stocks against changes in the one-year Treasury rate, particularly around MPC meetings. For broader context and comparison, this sensitivity is also evaluated across the market portfolio. The findings indicate that bank equity returns are not sensitive to interest rate changes (refer to Table A.5). The duration mismatch theory predicts that rising interest rates would typically cause banks' interest expenses to increase more than their interest incomes, thereby reducing the NIM. However, our findings challenge this theory. Figure 3a shows banks' aggregate NIM and ROA alongside Repo rates from 2008 to 2023. Despite significant fluctuations in the short-term Repo rate—from 8% in 2008 to a drop to 4.75% in 2009, rising to 8% in 2014, then falling to 4% after the 2020 COVID crisis, and increasing again to 6.25% in 2023—banks' NIM remained within a stable range of 2.6% to 4.4%. The changes within this range were gradual and showed no clear correlation with the varying interest rates. Similarly, banks' ROA, a key indicator of profitability, also appears unaffected by interest rate changes, reflecting the same stability observed in NIM.

The stability in banks' financial metrics, despite significant theoretical vulnerabilities in their balance sheets to interest rate changes, highlights the critical role of the deposit franchise. As further illustrated in Figure 3b, NIM was break down into its two main components: interest income and interest expense, each expressed relative to assets. Interest income closely follows a moving average of historical interest rates up to 2019, reflecting the long duration of bank assets. Typically, the rates on these assets are fixed at origination and do not change until the assets mature, making the income they gener-

Figure 3 The aggregate time series.

(a) NIM, ROA and Repo rate **(b)** Interest expense, Interest income and Repo rate



ate relatively stable and less sensitive to immediate short-term rate changes. Figure 3b reveals a counter-intuitive yet vital observation: both the interest income and interest expense of banks exhibit a similar level of insensitivity to fluctuations in short-term interest rates. This phenomenon is largely due to the impact of the deposit franchise. Deposits make up more than 70% of banks' liabilities and generally have zero or near-zero maturities, contributing to the overall low duration of these liabilities. However, contrary to what might be expected, the rates banks pay on these deposits remain significantly lower and more stable than the prevailing short-term market rates.

The deposit rate's stability, despite prevailing market conditions, can be attributed to the market power that banks hold in retail deposit markets. As noted by Drechsler et al. (2017), this market power enables banks to keep deposit rates low even during periods of rising market interest rates. This ability to decouple deposit rates from market rates allows banks to effectively manage a large duration mismatch. Thus, despite the theoretical exposure to interest rate risk due to this mismatch, banks' cash flows remain surprisingly stable in practice. The capability to maintain low and stable deposit rates, regardless of market conditions, allows banks to engage in maturity transformation—borrowing short-term and lending long-term—without facing the anticipated level of interest rate risk. This unique attribute of the banking sector, supported by their market power over retail deposits, is a crucial factor that enables banks to navigate different interest rate environments while maintaining consistent profit margins and cash flows.

4 Model of Bank Interest Rate Risk

A simplified model is presented to elucidate the aggregate findings and predict outcomes on a cross-sectional basis. The model assumes discrete time intervals without an endpoint, with the bank financing itself through risk-free deposits. The bank's goal is to maximize the net present value of expected future earnings while maintaining solvency to secure its deposits. For simplicity, equity issuance is excluded, assuming the bank avoids losses, thus eliminating the need for equity financing. The bank incurs a cost, c, per dollar of deposits to maintain its deposit franchise, covering expenses like branch operations, salaries, and marketing. This franchise grants the bank market power, allowing it to offer a deposit rate of

$$r_t^d = \beta^{Exp} f_t, \tag{1}$$

where $0 < \beta^{Exp} < 1$ and f_t is the the prevailing short-term interest rates (Repo rate) in the economy.[9] Drechsler et al. (2018) shows that this deposit rate reflects the bank's market power, with lower β^{Exp} indicating higher market power and a larger spread charged to depositors.

On the asset side, the model assumes complete markets, with prices set by the stochastic discount factor m_t. Banks aim to maximize their profits.[10] Their challenge is thus

$$V_0 = \underset{INC_t}{max} E_0 \left[\sum_{t=0}^{\infty} \frac{m_t}{m_0} (INC_t - \beta^{Exp} f_t - c) \right] \tag{2}$$

$$s.t. E_0 \left[\sum_{t=0}^{\infty} \frac{m_t}{m_0} INC_t \right] = 1 \tag{3}$$

$$INC_t \geq \beta^{Exp} f_t + c \tag{4}$$

where INC_t represents the income or payouts from the bank's asset portfolio, specific to each time and state. The scenario is scaled to a single dollar of deposits for simplicity, as the results can be linearly extended to any deposit amount. Equation 3 establishes the budget constraint, stipulating that the present value of future income must equal the current value of one dollar. Equation 4 imposes the solvency constraint, requiring the bank to generate sufficient income each period to cover both its interest expenses, denoted as $\beta^{Exp} f_t$, and its operating costs, c.

The bank faces a dual aspect of solvency risk. On one side, as the short rate (f_t) increases, so does the bank's interest expense (given $\beta^{Exp} > 0$). To safeguard against the risk of insolvency under high f_t conditions, the bank needs to ensure that its income stream is positively correlated with the short rate. This necessitates holding a substantial portion of assets similar to short-term bonds, whose yields increase with the short rate, addressing the conventional concern regarding banks avoiding excessive maturity mismatches. Typically, this concern stems from the short-term nature of deposits, implying a high sensitivity to the short rate. However, the bank's ability to exert market power allows it to maintain a lower β^{Exp}, thereby requiring a smaller proportion of short-term assets in its portfolio than might otherwise be necessary.

On the flip side, the bank's solvency risk also emanates from its fixed operating costs (c), which remain constant regardless of f_t fluctuations. To manage this risk, it is imperative

[9] Deposits in this model are short-term, as indicated by their reliance on the short-term interest rate. Incorporating long-term debt into the model is feasible but would not alter the underlying mechanism; therefore, we exclude it for simplicity. Moreover, as depicted in Figure 2, the liabilities of banks are predominantly short-term.

[10] Our framework marks a fundamental departure from traditional approaches in the literature, which often depict banks as distinct agents characterized by unique risk preferences or beliefs.

that the bank's income remains stable even when f_t is low. This stability is achieved by holding a significant quantity of long-term fixed-rate assets, which provide a steady income stream that is unaffected by short rate fluctuations. Essentially, in scenarios where the short rate is low, the bank's income from the deposit spread decreases, yet it still faces unchanged operational expenditures. To hedge against such scenarios where the interest income might otherwise be insufficient to cover operating costs, maintaining a considerable allocation in long-term assets is crucial.

We can decompose the bank's value into a balance sheet component and a deposit franchise component:

$$V_0 = E_0 \left[\sum_{t=0}^{\infty} \frac{m_t}{m_0} (INC_t^* - f_t) \right] + E_0 \left[\sum_{t=0}^{\infty} \frac{m_t}{m_0} [(1 - (\beta^{Exp}) f_t - c)] \right] \tag{5}$$

The first term represents the income generated by assets, denoted as INC_t^*, minus the expenses incurred by short-term liabilities, represented by f_t. The second term pertains to the deposit franchise's income from the spread, $(1 - \beta^{Exp}) f_t$, and its fixed costs c. This deposit franchise functions similarly to an interest rate swap where the bank pays a fixed rate c and receives a variable rate $(1 - (\beta^{Exp}) f_t$.[11] The deposit franchise, like an interest rate swap, has negative duration and increases in value as rates rise.

The bank can hedge this risk by aligning its balance sheet exposure to be the inverse of its exposure through deposit franchises. A full hedge becomes essential when there are no excess profits from deposits, which occurs when the banking sector is characterized by free entry.[12] Under these circumstances, the bank needs to earn precisely enough to match its ongoing expenses each period. When there are no surplus earnings from deposit franchises, the future value of the deposit spreads must balance out the future value of operating expenses. Consequently, the bank must allocate its entire income stream to meet its solvency requirements. This leads to the straightforward forecast that a bank will align the interest rate sensitivities of its revenues and expenditures. We will examine this hypothesis in subsequent sections by exploring the differences among various banks. In this scenario, the bank generates only sufficient income to meet its expenses each period.

When there are no excess profits, the future value of the deposit spreads equals the future value of the operating costs. Consequently, the bank must allocate its entire income to meet the solvency requirement. This leads to a straightforward hypothesis: the bank aligns the interest sensitivities of its income and expenses. This hypothesis will be examined in later sections through a cross-sectional analysis of banks. It should be noted that the bank can employ multiple strategies to achieve this alignment due to the completeness of asset markets. The most straightforward approach is by investing in conventional

[11] Jarrow and Van Deventer (1998) similarly draw parallels between the valuation of deposit liabilities and credit card balances in scenarios of imperfect competition and the dynamics of interest rate swaps.

[12] If we incorporate bank equity into the model and it constitutes a small fraction of the total assets, much like in real-world scenarios, banks will continue to hedge the majority of their interest rate risk. This approach ensures that even with a minimal equity base, the primary financial strategy remains focused on stabilizing interest income against fluctuations in interest expenses to maintain solvency and profitability.

bonds. Specifically, the bank could allocate a proportion β^{Exp} of its assets into short-term bonds and the remaining share $(1 - \beta^{Exp})$ into long-term fixed-rate bonds. This investment strategy ensures that the bank is fully protected against any fluctuations in the short-term interest rate or changes in expectations about its future trajectory, including adjustments in the term premium. This hedging is effective in every period and under every possible future state.

5 Data

The sample consists of listed scheduled commercial banks (SCBs) excluding foreign banks and regional rural ranks (RRBs). There are two reasons for limiting the study to SCBs, excluding foreign banks and RRBs. First, while SCBs operate on a nationwide scale and offer a wide array of services, cooperative banks and RRBs are more specialized. Cooperative banks constitute a relatively modest portion of the predominantly bank−centric financial system. Nevertheless, owing to their widespread presence across geographic and demographic segments, they play a pivotal role. Geographically, cooperatives have played a crucial role in bringing formal financial services to villages and small towns in India. From a demographic perspective, these institutions have facilitated financial access for low and middle−income groups in both rural and urban areas.[13] RRBs have a mandate to address the financial requirements of rural communities in less developed regions and foster financial inclusion at the grassroots level. The primary goal of RRBs is to extend credit and various banking services to small and marginal farmers, agricultural laborers, small−scale artisans, and similar segments of the population.[14]

6 Bank Interest Rate Risk Hedging

There are two primary methods for analyzing how banks manage interest rate risk: the present-value approach and the cash flow approach. The present-value approach examines how interest rate changes impact the market value of a bank's equity. In contrast, the cash flow approach assesses how interest rate fluctuations influence the bank's earnings and expenses. Both methods yield consistent results because a bank's equity value is essentially the present value of its expected income minus the present value of its expected expenses. To illustrate these methods, consider a bank with a portfolio that includes a fixed-rate bond with a five-year maturity and a face value of 1, paying a coupon of C%, and a liability in the form of a floating-rate bond with the same five-year maturity and a face value of 1, where the coupon rate adjusts annually to match the short-term interest rate r_t. This setup creates a duration mismatch of about five years. If an interest rate shock uniformly raises rates, the impact can be analyzed using both approaches.

[13] RBI−Report on Trend and Progress of Banking in India 2011 − 12

[14] Master Circular on Branch Licensing−Regional Rural Banks

Table 2 Key variables description and data sources.

Variables	Descriptions	Frequency	Source
Panel A: Bank-level data			
Deposits	Total deposits held by bank	Quarterly	CMIE Prowess IQ
Interest income	Total interest income received by bank	Quarterly	CMIE Prowess IQ
Interest expense	Total interest expense incurred by bank	Quarterly	CMIE Prowess IQ
Return on assets	Return on assets for bank	Quarterly	CMIE Prowess IQ
Net interest margin	Total interest income - Total interest expense	Quarterly	CMIE Prowess IQ
Loans	Total loan disbursed by bank	Quarterly	CMIE Prowess IQ
Equity	Equity held by bank	Quarterly	CMIE Prowess IQ
No. of branches	Number of operational branches of bank	Annual	CMIE Prowess IQ
Salary	Salary paid to the employees for banking operation	Annual	CMIE Prowess IQ
Rent	Rent paid by the banks for banking operations	Annual	CMIE Prowess IQ
Fee based income	Income from fee based activities	Annual	CMIE Prowess IQ
Total non-interest income	Total income minus income from interest bearing assets	Annual	CMIE Prowess IQ
Panel B: Market-level data			
Bank stock return	Retun of stocks of each bank	Daily	Bloomberg
NIFTY50	Return on NIFTY50 index	Daily	NSE−India
NIFTYBANK	Daily return on NIFTYBANK index	Daily	NSE−India
India 1 year bond	Yield on 1 year Indian government securities	Daily	Refinitiv−Datastream
India 10 year bond	Yield on 10 year Indian government securities	Daily	Refinitiv−Datastream
Panel C: RBI funds data			
Repo rates	Rate at which the RBI lends money to banks or FI	Quarterly	DBIE−RBI

Under the present-value approach, an increase in interest rates by Δr does not affect the price of the floating-rate liability, which remains at 1. However, the fixed-rate bond's price decreases due to the immediate effect of the rate hike, with the price drop being approximately equal to the present value of a five-year annuity paying Δr, which is around $5\Delta r$. This leads to a decrease in the bank's equity value by about $5\Delta r$, corresponding to the five-year duration mismatch. The cash flow approach, on the other hand, focuses on changes in future income and expenses resulting from the bank's assets and liabilities. The fixed-rate bond's cash flows remain unchanged, so there is no additional interest income. However, the interest expenses on the floating-rate liability increase by Δr annually over the five years. The total increase in future interest expenses is equivalent to a five-year annuity paying Δr. As a result, the bank's net future cash flows decrease by the same amount as the present-value approach indicated—a four-year annuity paying Δr.

It's important to note that the cash flow approach only considers the bank's future income and expenses, excluding any unrealized capital gains or losses. The capital loss from the interest rate increase, calculated as the present value of a five-year Δr annuity, aligns with the decrease in the bank's future net income. Including the capital loss again would result in double counting. Conversely, the present-value approach directly accounts for the impact on bank equity as the capital loss itself. Essentially, the difference between these methods lies in timing: the cash flow approach spreads the impact on income over five years, while the present-value approach captures the entire effect immediately. The cross-sectional analysis begins with a cash flow approach, chosen to separately analyze income and expenses, which are explicitly reported in bank call reports. The present-value approach does not allow for such separation, as it combines the present value of future income and expenses into a net figure. After independently examining income and expenses, the overall impact on bank income and expenses is evaluated using both the cash flow and present-value approaches. This comprehensive analysis is enabled by access to key data points such as NIM and ROA for the cash flow approach, and the market value of bank equity for the present-value approach.

6.1 Cash Flow Approach

6.1.1 Interest Expense, Interest Income, and ROA Betas

The income approach is applied by evaluating how changes in interest rates impact expenses, interest income, and ROA. Initially, the focus is on the expense side by conducting a time-series regression for each bank i as follows (similar to Drechsler et al. (2021)):

$$\Delta IntExp_{it} = \alpha_i + \eta_t + \sum_{\tau=0}^{3} \beta_{i,t}^{Exp} \Delta RepoRates_{t-\tau} + \epsilon_{it} \tag{6}$$

where $\Delta IntExp_{it}$ is the change in bank i's interest expense rate from t to $t{+}1$, $\Delta RepoRates_t$ is the change in the Fed funds rate from t to $t+1$, α_i are bank fixed effects, and η_t are time fixed effects. The interest expense rate is calculated by dividing the total quarterly interest expense, which includes interest on deposits, wholesale funding, and other liabilities, by the quarterly average assets. This ratio is then annualized by multiplying it by four. The overall expense beta for bank i, denoted as $\beta_i^{Exp} = \sum_{\tau=0}^{3} \beta_{i,t}^{Exp}$, is calculated as the sum of the coefficients from the regression model expressed in equation 6.[15]

To determine the NIM betas, the expense betas are subtracted from the income betas. This method aligns with the definition of NIM, which measures the difference between interest incomes generated and interest expenses incurred, relative to average earning assets. Essentially, this approach to calculating NIM betas mirrors running regressions similar to equation 6, but directly for NIM. The outcome of this analysis provides us with a comprehensive set of betas, including income betas (β_i^{Inc}), NIM betas (β_i^{NIM}), and ROA betas (β_i^{ROA}), alongside the previously computed expense betas (β_i^{Exp}).

Figure 4 displays histograms of banks' betas for interest expenses (see Figure 4a) and interest incomes (see Figure 4b). The data reveal that the average beta for interest expenses is 0.328 and for interest incomes is 0.611. This indicates that for every 100 basis point rise in the Repo rate, both interest expenses and incomes of banks typically decrease by approximately 33 and 61 basis points. These figures suggest that, on average, banks typically have interest incomes that are nearly double their interest expenses. This pattern reinforces the earlier observation that the banking sector generally maintains a financial structure that effectively aligns income and expense sensitivities.

[15] To estimate the betas for interest income and ROA for banks, we conduct similar time-series regressions as outlined in equation 6. For interest income, we use the total interest income divided by quarterly average assets, and for ROA, we use net income divided by quarterly average assets. The coefficients from these regressions are summed to calculate the respective betas for income and ROA. Additionally, for ROA, we account for seasonal variations which often occur due to how loss provisions and other items are reported at year-end. To adjust for this seasonality, we average the ROA across the current and previous three quarters before calculating the quarterly changes.

Figure 4 The distributions of interest expense and income betas.

(a) Interest expense beta **(b)** Interest income beta

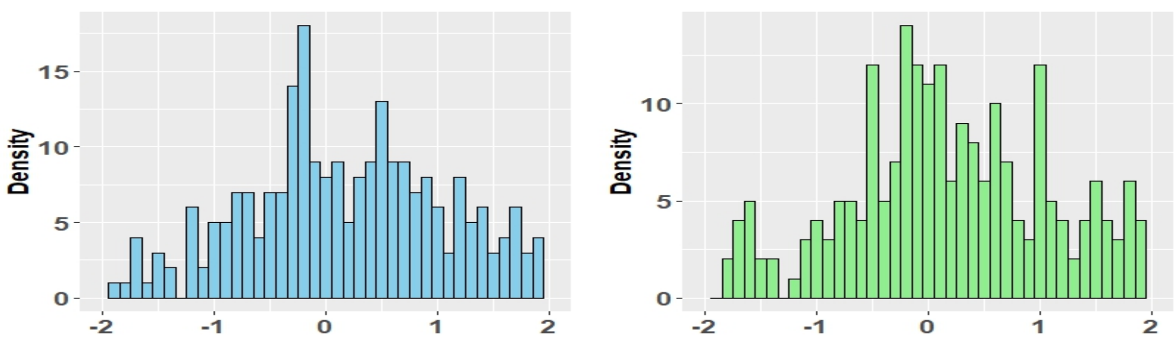


Table 3 displays summary statistics for interest expense beta, interest income beta, NIM beta, and ROA beta across the entire sample, winsorized at the 5% level. These characteristics are averaged over time for each bank. The average interest income and expense betas are nearly identical, resulting in a very small NIM beta of 0.225. The ROA beta is high at 3.065. This indicates that, on average, banks' cash flows are almost perfectly hedged against interest rate risk, as reflected by NIM metric. The findings hold consistent even when accounting for time fixed effects in the analysis.

Table 3 Summary statistics on interest rate sensitivity

Statistic	N	Mean	St. Dev.	Min	Max
Interest Expense Beta	431	−0.008	0.862	−2.316	3.318
Interest Income Beta	431	0.217	1.108	−2.120	5.312
NIM Beta	431	0.225	0.897	−1.593	4.662
ROA Beta	431	5.963	61.507	−18.881	985.400
Interest Expense Beta (Time FE)	431	0.328	1.465	−4.742	9.031
Interest Income Beta (Time FE)	431	0.611	1.697	−4.212	8.942
NIM Beta (Time FE)	431	0.283	1.396	−3.438	6.484
ROA Beta (Time FE)	431	3.065	20.111	−39.949	162.497

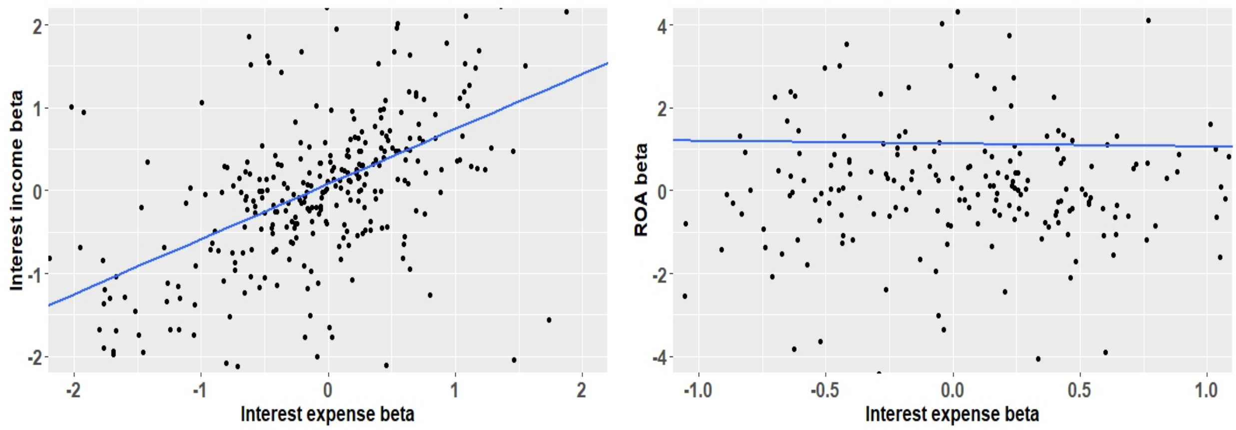
6.1.2 Does banks match the interest sensitivity of their income and expense?

This section conducts a formal analysis to determine if banks effectively align the interest sensitivity of their income with their expenses through cross-sectional regressions. According to the theoretical model, the beta values for income and expenses should correspond directly and uniformly across different banks. This prediction, inherent to the model, provides a robust basis for the empirical examination.

Figure 5a provide a graphical representation of the relationship between the income and expense betas across banks. The relationship's magnitude is nearly one-to-one, aligning

Figure 5 Interest expense, interest income, and return on assets (ROA) matching.

(a) Interest income Vs Interest expense beta **(b)** ROA Vs Interest expense beta



with our model's prediction, with the slope for all banks calculated at 0.885. This confirms that, particularly for large and economically significant banks, the model's forecast is substantiated. Moreover, the correlation between income and expense betas is 67%, indicating that expense betas significantly account for the variations in income betas across the banking sector. Figure 5b provide a graphical representation of the relationship between the ROA and expense betas across banks. The ROA betas remain near one throughout the range of expense betas, and the matching coefficient being slightly below one. This observation suggests that non-interest income items aptly counterbalance to maintain profitability regardless of interest rate fluctuations. Consequently, the close alignment of interest expense and income betas successfully shields bank profitability from the impact of changes in interest rates.

Next, the concept of matching is explored through the application of ordinary least squares (OLS) regression analysis. Specifically, the beta-on-beta regression is estimated

$$\beta_i^{Inc} = \alpha + \gamma \beta_i^{Exp} + \epsilon_i \tag{7}$$

In our analysis, we regress the interest income beta (β_i^{Inc}) of each bank i against its corresponding interest expense beta (β_i^{Exp}), including a constant α in our model. According to the theoretical framework proposed by Drechsler et al. (2021), we expect the matching coefficient γ, which represents the slope in this regression, to be close to 1, indicating a near-perfect match between the sensitivity of banks' income and expenses to interest rate changes.

Table 4 reports the results of the beta-on-beta regression analysis. Columns (1) and (2) present the results using betas calculated with and without time fixed effects for the entire sample of banks. The matching coefficients, which are 0.885 and 0.650 respectively, are relatively consistent across both specifications and are close to the ideal value

Table 4 Interest sensitivity matching

	Interest income beta	
	(1)	(2)
Interest expense beta	0.885***	0.650***
	(0.028)	(0.030)
Constant	0.065	−0.005
	(0.053)	(0.139)
FE (Time)	N	Y
Observations	431	431
R^2	0.692	0.522
Adjusted R^2	0.691	0.521
Note:	*p<0.1; **p<0.05; ***p<0.01	

of one.[16] This consistency suggests that the observed matching is not merely a product of common time-series variations among the banks. Additionally, the intercept is notably small, with a coefficient of 0.065, indicating that a bank with no sensitivity in its interest expenses would also exhibit almost no sensitivity in its interest income, further supporting the robustness of the matching effect observed across the banking sector.

Table 5 Interest sensitivity of ROA

	ROA beta	
	(1)	(2)
Interest expense beta	0.164	0.215
	(1.536)	(1.704)
Constant	16.807	16.231
	(14.907)	(15.400)
FE (Time)	N	Y
Observations	344	344
R^2	0.001	0.0001
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 5 depicts the findings from analyzing the impact of interest rate changes on banks' ROA, a key profitability indicator. This analysis substitutes the interest income beta with the ROA beta in regression (Equation 7). The coefficients remain near zero and statistically insignificant across all subsamples. Including time fixed effects in the beta estimation does not alter these results. This suggests that noninterest income and expenses are largely unaffected by changes in interest rates, which aligns with the predictions of our model.

Tables 4 and 5, when considered collectively, underscore a significant empirical finding: banks effectively align the interest rate sensitivities of their income and expenses on a one-to-one basis. This strategic alignment is observed even amidst substantial cross-sectional variation in the sensitivity levels of individual banks. As a direct outcome of this matching strategy, the profitability of banks remains predominantly shielded from the fluctuations in interest rates, thereby stabilizing their financial performance across different economic conditions.

[16] A matching coefficient of 0.885 suggests that a regression of NIM betas on expense betas would yield a coefficient of $0.885-1=-0.115$. Consistent with this implication, our findings, as detailed in Appendix A.4, confirm that the coefficient for the regression of NIM betas against expense betas indeed stands at -0.115.

6.1.3 Panel analysis

In this section, panel regressions are conducted to provide a more rigorous test of sensitivity matching compared to the cross-sectional regressions discussed in Section 6.1.2. A two-stage procedure is implemented to achieve this:

$$\Delta IntExp_{i,t} = \alpha_i + \eta_t + \sum_{\tau=0}^{3} \beta_{i,t}^{Exp} \Delta RepoRates_{t-\tau} + \epsilon_{i,t} \tag{8}$$

$$\Delta IntInc_{i,t} = \lambda_i + \sum_{\tau=0}^{3} \gamma_\tau \Delta RepoRates_{t-\tau} + \delta \Delta \widehat{IntExp}_{i,t} + \epsilon_{i,t} \tag{9}$$

In the first stage, the approach remains the same as outlined in equation 6. However, the subsequent stage diverges from previous methods. Instead of conducting a cross-sectional regression of income betas on expense betas as in equation 7, a panel regression of interest income on the predicted interest expense values derived from the first stage is performed, represented as $\widehat{IntExp}_{i,t}$. The coefficient δ obtained from this regression serves a similar purpose to γ in equation 7. A δ value close to one indicates that banks adjust their interest income to precisely match fluctuations in their interest expenses that are triggered by changes in the Repo rate. Additionally, the coefficients γ_τ measure the direct impact of Repo rate changes on interest income, independent of interest expense influences, akin to the constant α in the cross-sectional regression 7. In certain models, direct effects are substituted with time fixed effects to ensure they do not skew the estimation of the matching coefficient δ.

The primary distinction between the two methods lies in how they handle lag coefficients, ($\beta_{i,t}^{Exp}$). In cross-sectional regression, these coefficients are summed for each bank, whereas in panel regression, they are treated separately. Consequently, panel regression assesses whether banks align their sensitivities to interest income and expense on a lag-by-lag basis, rather than just averaging them across all lags. This approach imposes a more rigorous evaluation. Moreover, panel regression inherently accounts for the varying number of observations per bank, eliminating the need for filtering or adjusting beta values to mitigate measurement errors. As a result, panel regression enhances the robustness of our main findings. Table 6 presents the findings of panel regression, structured similarly to Tables 4 and 5. The Column (1) display the collective direct impact of changes in the Repo rate, while the Column (2) incorporates time fixed effects.

Δ $Interest\ Income\ Rate$, specifically in columns (1) and (2) of Table 6, the coefficient estimates for the entire bank sample are 1.092 and 0.796 in models with a direct effect and time fixed effects, respectively. The figures closely resemble those from the cross-sectional regression and are nearly equal to one. The direct effect of changes in the Repo rate in column (1) is minimal, indicating that a bank with no exposure to interest expenses is also predicted to have no exposure to interest income, implying it holds only long-term fixed-rate assets. Moving to Δ $ROA\ Rate$ of Table 6, which focuses on ROA,

Table 6 Interest Sensitivity Matching: Panel Estimation

	Δ *Interest Income Rate*		Δ *ROA Rate*	
	(1)	(2)	(1)	(2)
$\Delta \widehat{IntExp}$	1.092***	0.796**	0.117	0.159
	(0.376)	(0.032)	(0.079)	(0.280)
$\sum \gamma_\tau$	0.013		0.059	
	(0.036)		(0.085)	
FE (Bank)	Y	Y	Y	Y
FE (Time)		Y		Y
Observations	1,695	1,695	1,695	1,695
R^2	0.037	0.373	0.0004	0.037
Adjusted R^2	0.036	0.352	−0.001	0.004
Note:		*p<0.1; **p<0.05; ***p<0.01		

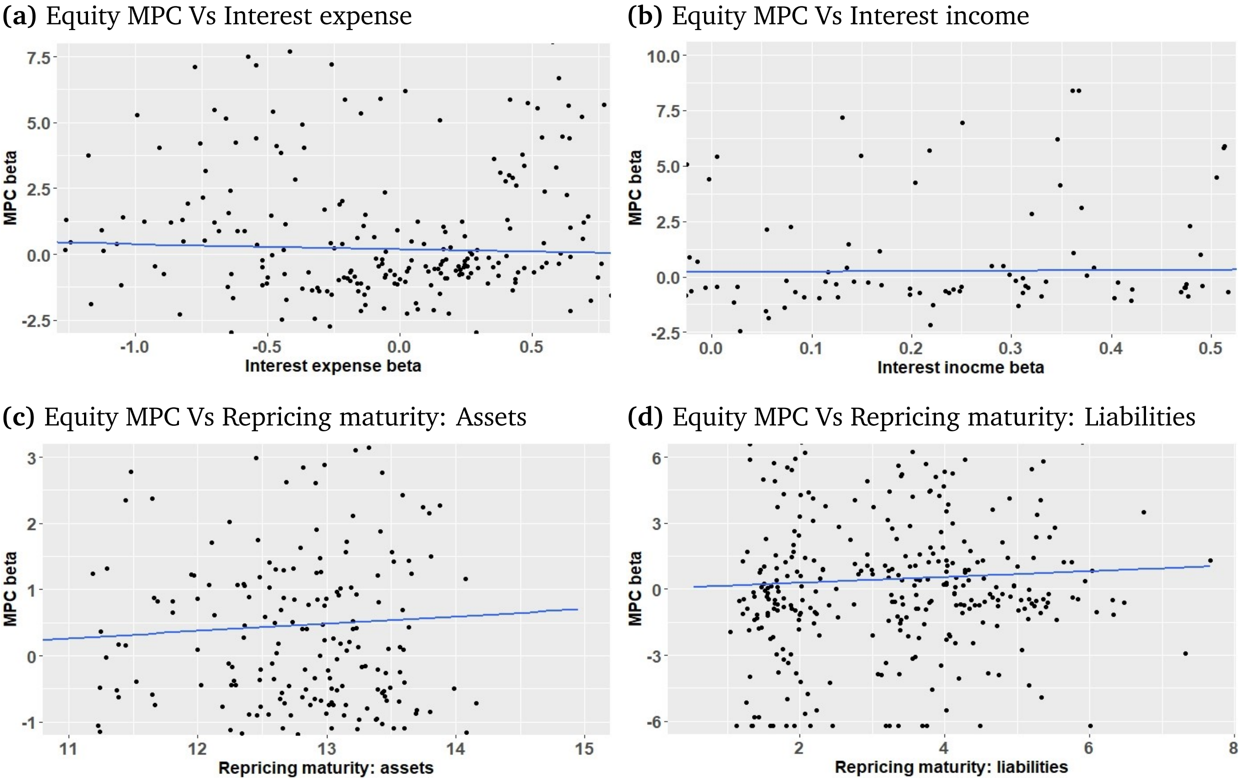
the same two-stage approach is employed, but with the substitution of the change in ROA for the change in interest income in Equation 9. Across all columns, the resulting coefficients are nearly zero and insignificant. Their consistency remains unaffected by whether the direct effect of Fed funds rate changes (Columns (1)) or time fixed effects (Columns (2)) are incorporated. These findings validate those from the cross-sectional regressions in Table 5, indicating that noninterest components do not disrupt the alignment of interest income and expense sensitivities. Consequently, banks' bottom lines remain insulated from interest rate fluctuations. In summary, the panel regression outcomes in Tables 4 and Table 5 reinforce the evidence of one-to-one matching, demonstrating its persistence across various specifications and on a lag-by-lag basis.

6.2 Present-Value Approach

The analysis is extended using the present-value method, which evaluates how interest rates influence the market value of bank equity. For this approach, daily stock returns from all publicly listed banks are gathered, and MPC betas are calculated. Specifically, regressions are conducted for each bank's stock returns against changes in the one-year Treasury rate during the one-day period surrounding MPC announcements. These MPC betas are then integrated with previously obtained interest expense and income betas. The final dataset includes 50 publicly listed banks, with an average MPC beta of 1.388.

Figure 6 displays scatter plots that correlate MPC betas with both interest expense and income betas, as well as with the repricing maturities of assets and liabilities, which serve as a rough measure of duration. Despite the inherent noise from the volatile nature of stock returns, the small standard errors allow for the identification of significant trends. For example, considering the typical 10-to-1 leverage ratio of banks, the MPC betas are expected to decrease by 10 for each additional year in asset duration, according to standard duration calculations. Despite the theoretical predictions, the observed relationship between MPC betas and the two key variables (repricing maturitie for asset, and interest

Figure 6 Equity MPC betas vs Interest beta and Repricing maturity



(a) Equity MPC Vs Interest expense

(b) Equity MPC Vs Interest income

(c) Equity MPC Vs Repricing maturity: Assets

(d) Equity MPC Vs Repricing maturity: Liabilities

expense betas) appears flat across the data presented in Figure 6. If there are any trends, they indicate a slight increase in MPC betas towards zero as repricing maturitiy lengthen and income betas decrease, though these effects are minor and statistically insignificant, consistent with the findings of English et al. (2018). This pattern reinforces the findings related to NIM and ROA, which show uniformly low interest rate exposure across all bank sizes. Such findings align with the underlying theoretical framework suggesting that banks effectively mitigate interest rate risk by closely aligning the sensitivities of their income and expenses. This consistency in findings between the present-value and cash flow approaches further solidifies the model's validity.

6.3 Robustness Test

The model predicts that banks' operating costs remain insensitive to changes in interest rates, resembling long-term fixed-rate liabilities. Direct evidence for this prediction is provided by analyzing the interest rate sensitivity of the main components of banks' noninterest expense and income. Banks typically incur substantial operating expenses and generate fee-based income. The focus is on four main categories: salaries, rent, fee-based income, and total noninterest income.

Table 7 Robustness test: Interest rate change and interest expense rate sensitivity

Panel A: Sensitivity to interest rate change

	Salary	Rent	Fee based income	Non-interest income
	(1)	(2)	(3)	(4)
Repo rate	−0.00003	−0.0001*	0.001	−0.001
	(0.0003)	(0.00004)	(0.001)	(0.002)
FE (Bank)	Y	Y	Y	Y
Observations	1,525	1,519	1,446	1,531
R^2	0.00001	0.002	0.001	0.0003
Note:				*p<0.1; **p<0.05; ***p<0.01

Panel B: Sensitivity to interest expense rate

	Salary	Rent	Fee based income	Non-interest income
	(1)	(2)	(3)	(4)
Interest expense	−0.0087**	−0.002	−0.100	−0.308
	(0.025)	(0.004)	(0.095)	(0.202)
FE (Bank)	Y	Y	Y	Y
Observations	536	536	535	536
R^2	0.024	0.001	0.002	0.005
Note:				*p<0.1; **p<0.05; ***p<0.01

To estimate the interest rate betas for each category, an approach similar as in Equation 6 is used.[17] The results are presented in Table 7. These table illustrate that the betas for all categories are nearly zero for sensitivity towards the interest rate change. Additionally, there is no correlation observed between these betas and banks' interest expense rate. These findings provide empirical support for the model's prediction that noninterest income and expense are largely insensitive to changes in interest rates.

7 Interest Rate Risk Hedging and Bank Assets

In this section, we examine how banks implement interest sensitivity matching by looking at the composition of their assets. We test our model's prediction by assessing whether banks with low expense betas implement sensitivity matching through the duration of their assets. We employ repricing maturity as a rough approximation for duration in this analysis.[18] The scatter plot in the left panel of Figure 7 illustrates a negative relationship between the average repricing maturity of banks' loans and their interest expense betas. This finding aligns with the model's prediction, indicating that banks with lower expense betas tend to hold assets with considerably higher duration compared to banks with higher expense betas. The slope of this relationship is approximately -12.7 years, which corresponds closely to the average repricing maturity of bank assets. The analysis indicates that a bank with an expense beta of 0.1 is expected to have a repricing maturity of approximately 12.6 years. In contrast, a bank with an expense beta of one is projected to have a slightly shorter repricing maturity, around 12.3 years. Figure 7b illustrates a

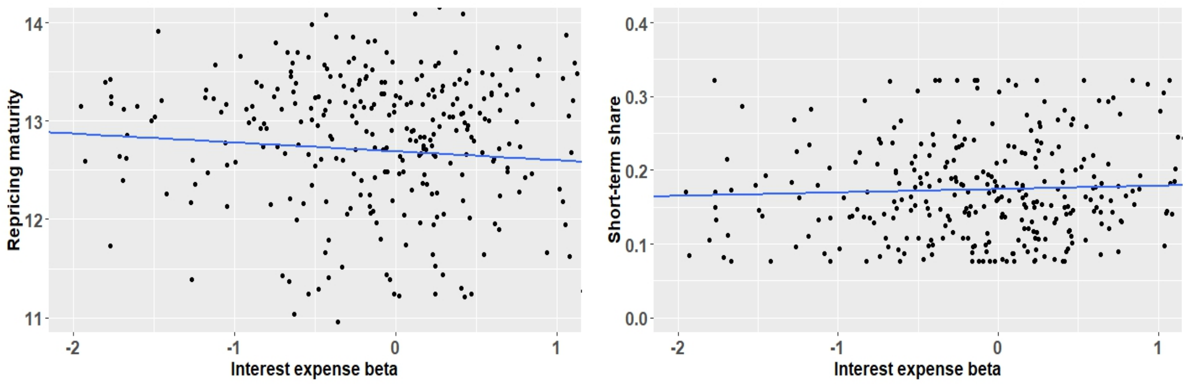
[17] Due to non-availability of quarterly data, we used the annual data for this case.

[18] To compute the repricing maturity of bank assets, we derive the weighted average of the repricing maturities of bank loans.

nearly flat relationship between banks' share of short-term assets and their expense betas. This relationship contradicts the prediction of the model: banks with higher expense betas tend to have a greater proportion of short-term assets compared to banks with lower expense betas. This finding underscores the negligible impact of expense betas on maturity transformation practices across banks.

Figure 7 Interest expense betas and proxies for asset duration.

(a) Repricing maturity Vs Interest expense beta **(b)** Short-term share Vs Interest expense beta



To formally test the relationship between expense betas and repricing maturity, panel regressions of the form (similar to Drechsler et al. (2021)) is conducted:

$$RepricingMaturity_i = \alpha + \delta\beta_i^{Exp} + \gamma X_i + \epsilon_i \tag{10}$$

where $RepricingMaturity_i$ represents the average repricing maturity of bank i's loans, β_i^{Exp} denotes its interest expense beta, and X_i comprises a set of controls. The controls under consideration include the average wholesale funding share (composed of large time deposits, RBI funds purchased, and Repo), the equity ratio, and the natural logarithm of assets.

Table 8 Maturity transformation and expense betas

	Repricing Maturity				
	(1)	(2)	(3)	(4)	(5)
Interest expense beta	−0.278***	−0.042	−0.283***	−0.284***	−0.041**
	(0.036)	(0.050)	(0.036)	(0.037)	(0.049)
Funding ratio		0.362			−0.922
		(0.549)			(0.613)
Equity ratio			−7.002**		−8.018***
			(3.257)		(3.015)
Log asset				−0.194	−0.516***
				(0.125)	(0.123)
Constant	12.665***	12.564***	12.746***	13.862***	16.535***
	(0.068)	(0.305)	(0.078)	(0.775)	(0.973)
Observations	416	414	416	416	414
R^2	0.095	0.045	0.109	0.105	0.075
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 8 reports the regression outcomes for the entire sample of banks. In column (1), the coefficient for the interest expense beta is -0.278, statistically significant at the 1% level. As control variables are introduced in columns (3) and (4), the coefficient remains robust and even experiences a slight increase. Column (5) conducts a comprehensive analysis incorporating all right-hand-side variables. Here, the coefficient for the interest expense beta is -0.041, indicating its reduced explanatory capability for repricing maturity once bank characteristics are considered.

8 Market Power and Bank Interest Rate Risk

The model suggests that banks with greater market influence in retail deposit markets tend to exhibit lower interest expense betas, aligning them with lower interest income betas. To assess these assertions, geographic discrepancies in market influence are leveraged. Initially, disparities in market influence are investigated to determine whether they translate into variations in expense betas. Subsequently, the analysis explores whether banks adjust their income betas to correspond with these variances. The number of bank branches is used as a source of geographic variation in market power that is progressively more restrictive, within the same empirical framework employed in Section 6. Specifically, instrumental variables regressions are conducted as follows (refer to Drechsler et al. (2021)):

$$\beta_i^{Exp} = \alpha + \gamma HHI_i + \epsilon_i \tag{11}$$

$$\beta_i^{Inc} = \alpha + \delta \widehat{\beta_i^{Exp}} + \epsilon_i \tag{12}$$

where HHI_i is bank i's market power, $\Delta IntExp_{i,t}$, β_i^{Inc}, and β_i^{Exp} are estimated according to Equation (6), and $\widehat{\beta_i^{Exp}}$ is the predicted interest expense beta from the Equation (11). The distinction from previous regressions lies in our parameterization of the interest expense rate, which now depends on a designated proxy for market power, denoted as $MP_{i,t}$. In the initial stage, we investigate the correlation between market power and the interest expense rate. Subsequently, in the second stage, our focus shifts to the matching coefficient, δ.

The instrumental variables approach offers the advantage of mitigating potential attenuation bias stemming from estimation errors in our expense betas. As detailed in Section 6, while estimation error is a greater concern for income betas due to the noise inherent in interest income, it's still relevant for expense betas. Should expense betas also be subject to notable estimation error, the matching coefficient in the instrumental variables regression would be expected to exceed the OLS matching coefficients. This discrepancy serves as a valuable diagnostic tool. Furthermore, the instrumental variables approach aids in isolating the causal impact of β^{Exp} on β^{Inc}, assuming that market power exclusively influences β^{Inc} through its impact on β^{Exp}.[19]

[19] For instance, this phenomenon could arise from market segmentation if banks with greater market power over deposits also encounter more long-term lending opportunities. In alignment with this notion, Scharfstein and Sunderam (2016) discovered evidence suggesting that banks possess market power in lending.

Table 9 Market power and interest sensitivity matching

	First stage		Second stage	
	(1)	(2)	(3)	(4)
HHI score	−0.106**	−0.090**		
	(0.021)	(0.054)		
$\widehat{IntExpBeta}$			0.765*	0.717**
			(0.013)	(0.028)
FE (Time)		Y		Y
Observations	406	406	406	406
R^2	0.055	0.054	0.301	0.378
Note:				*p<0.1; **p<0.05; ***p<0.01

The results of the first stage are presented in the first two columns of Table 9. The first-stage estimates in the top panel demonstrate a significant positive relationship between market concentration and the interest expense beta, contrary with our expectations. The first-stage coefficient in column (1) is −0.106. This coefficient remains nearly unchanged −0.090 when we incorporate time fixed effects in the beta estimation in column (2). The second-stage coefficients in columns (3) and (4) are 0.765 and 0.717, respectively. These coefficients indicate that the variation in interest expense beta induced by market concentration is effectively matched on the income side. Furthermore, the fact that the second-stage coefficients do not surpass those in Table 6 indicates that attenuation bias resulting from estimation error in expense betas is not a significant issue.

9 Conclusion

The conventional wisdom suggests that banks, by borrowing short and lending long, inherently expose themselves to significant interest rate risk. However, this research challenges this notion by arguing that banks actually mitigate their interest rate risk through maturity transformation. This is achieved by ensuring that the interest rate sensitivities of their income and expense are closely matched, despite maintaining a substantial maturity mismatch. On the expense side, banks leverage their market power in retail deposit markets to secure low sensitivity to interest rate changes. By offering deposit rates that are relatively insensitive to market fluctuations, they stabilize their interest expense. Meanwhile, on the income side, banks achieve a low sensitivity by investing in long-term fixed-rate assets. This strategic allocation of assets allows them to generate stable interest income even as interest rates fluctuate.

The result of this sensitivity matching is the maintenance of stable NIMs and ROAs for banks, regardless of wide fluctuations in interest rates. This finding has profound implications for monetary policy and financial stability. Traditionally, monetary policy's impact on banks has been viewed through the lens of interest rate risk exposure stemming from their maturity mismatch. However, the research demonstrates that by actively managing interest rate sensitivities, banks largely insulate themselves from this risk. Moreover, the maturity mismatch inherent in banks' operations has often raised concerns about financial stability, leading to suggestions for narrow banking where institutions would only hold short-term assets. Findings suggest that, as long as banks maintain market power, adopting a narrow banking approach could potentially increase exposure to risk rather than reduce it.

In essence, the research provides a compelling explanation for why banks continue to engage in both deposit-taking and maturity transformation activities within a single institution. Rather than being viewed as sources of instability, this coexistence contributes to overall financial stability by allowing banks to effectively manage interest rate risk and maintain stable financial performance over time.

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A Summary statistics of key variables

Table A.1 Statistics of key variables

Statistic	N	Mean	St. Dev.	Min	Max
Interest income	3,728	27,863	51,845	−16,023	645,237
Interest expense	4,258	21,486	41,264	0	525,586
Log (Total assets)	2,192	6.143	0.574	3.880	7.742
Deposits	2,167	0.057	0.009	0.001	0.122
Loans	2,164	0.043	0.007	0.000	0.080
Equity	1,710	0.005	0.002	0.003	0.010
NIM	1,990	3.169	0.869	1.914	5.300
ROA	1,574	0.683	0.763	−1.117	1.933
Repo rate	4,286	6.657	1.540	4.000	13.500

Note: Interest income and Interest expense are in INR Millions.

Table A.2 Correlation among balance sheet and income statement variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Interest income	1								
(2) Interest expense	0.984	1							
(3) Log(Total assets)	0.764	0.759	1						
(4) Deposits	0.974	0.977	0.729	1					
(5) Loans	0.992	0.981	0.745	0.991	1				
(6) Equity	0.951	0.901	0.746	0.918	0.949	1			
(7) NIM	-0.041	-0.107	-0.269	-0.079	-0.055	0.012	1		
(8) ROA	0.037	0.002	-0.047	0.001	0.023	0.075	0.298	1	
(9) Repo rate	-0.091	-0.055	-0.066	-0.154	-0.13	-0.179	-0.214	0.026	1

Table A.3 Correlation among variables beta

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Interest expense β	1							
(2) Interest income β	0.676	1						
(3) Interest expense β (Time)	0.401	0.335	1					
(4) Interest income β (Time)	0.338	0.549	0.657	1				
(5) NIM β	-0.26	0.536	-0.02	0.331	1			
(6) NIM β (Time)	-0.066	0.269	-0.393	0.435	0.428	1		
(7) ROA β	0.115	0.157	0.145	0.227	0.074	0.104	1	
(8) ROA β (Time)	-0.094	-0.02	-0.132	-0.122	0.081	0.01	0.417	1

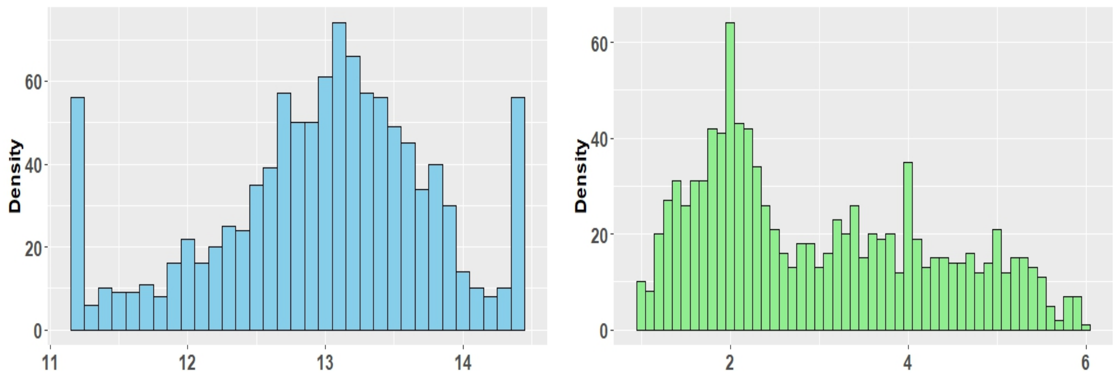
B Repricing maturity of bank assets and liabilities

To calculate the repricing maturity of bank assets and liabilities, we follow the methodology of English et al. (2018) and Drechsler et al. (2021). Starting in 2000, banks report their holdings of three asset categories (loans, investments, and foreign currency assets) separated into five bins by repricing maturity interval (0 to 3 months, 3 to 12 months, 1 to 3 years, 3 to 5 years, and over 5 years). To calculate the overall repricing maturity of a given asset category, we assign the interval midpoint to each bin (and 10 years to the last bin) and take a weighted average using the amounts in each bin as weights. We compute the repricing maturity of a bank's assets as the weighted average of the repricing maturities of all of its asset categories, using their rupee amounts as weights. We assign zero repricing maturity to cash and Fed funds sold.

We follow a similar approach to calculate the repricing maturity of liabilities.Starting in 2000, banks report their holdings of three liabilities categories (loans, investments, and foreign currency assets) separated into five bins by repricing maturity interval (0 to 3 months, 3 to 12 months, 1 to 3 years, 3 to 5 years, and over 5 years). We assign the midpoint to each interval and 10 years to the last one. We assign zero repricing maturity to demandable deposits such as transaction and savings deposits. Table 1 provides summary statistics for repricing maturity by asset category. We note in particular that securities have a substantially higher repricing maturity (12.68 years on average, 12.99 years in the aggregate) than loans (3.04 years on average, 3.03 years in the aggregate). Figure A.1 plots the distribution of asset and liabilities repricing maturity across banks, showing that it exhibits substantial variation.

Figure A.1 The distributions of repricing maturities of assets and liabilities.

(a) Repricing maturity assets **(b)** Repricing maturity liabilities



C Interest sensitivity of NIM

Table A.4 Interest sensitivity of NIM

	NIM beta	
	(1)	(2)
Interest expense beta	−0.115***	−0.350***
	(0.028)	(0.030)
Constant	0.065	−0.005
	(0.053)	(0.139)
FE (Time)	N	Y
Observations	431	431
R^2	0.037	0.241
Adjusted R^2	0.035	0.239
Note:	*p<0.1; **p<0.05; ***p<0.01	

D Bank equity returns and interest rate changes

Table A.5 Effect of interest rate shocks on bank equity values on MPC dates

	NIFTY BANK	NIFTY50
	(1)	(2)
Δy^{1yr}	0.007	−0.002
	(0.021)	(0.015)
Constant	0.198	0.116
	(0.208)	(0.144)
Observations	90	90
Industry	Bank	Market
R^2	0.001	0.0002
Note:	*p<0.1; **p<0.05; ***p<0.01	