The impact of banks' interest rate risk on monetary policy transmission

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Abstract

Banks' maturity mismatch exposes them to interest rate movements. Combining detailed supervisory data on Turkish banks' interest rate risk exposure and comprehensive credit register data on the universe of loans, we show that banks with higher exposure to interest rate risk cut their lending and shorten their loan maturities once interest rates begin to rise. This effect is particularly pronounced for banks with low capital ratios, highlighting the importance of bank capital in contractionary periods. We find real effects at the firm level: Firms' total loans decline, and as a result, they decrease their sales and employment. State-owned banks play a stabilizing role, stepping in to provide additional financing to their borrowers. As a result, firms that have a lending relationship with state-owned banks avoid a reduction in their loans and keep their sales and employment unaffected.

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1 Introduction

Banks traditionally have a maturity mismatch on their balance sheets. They finance their long-maturity assets mainly with short-term liabilities. When interest rates begin to rise, the present value of their assets decreases more than the value of their liabilities. As a result, this maturity mismatch exposes them to losses in their net worth. The recent banking turmoil that started in March 2023 and affected several U.S. banks highlighted the importance of banks' interest rate risk for financial stability during periods of tight monetary policy.

One essential question in this context is the impact of banks' interest rate risk on their loan supply and the possible consequences for their borrowers. This paper studies this research question by using comprehensive data on Turkish banks' cash flows from their interest-bearing holdings, both on and off-balance sheet items, provided by the Banking Regulation and Supervision Agency in Türkiye. We measure each bank's exposure to interest rate risk based on the repricing maturity of its reported cash flows. Interest rate risk exposure is calculated as the estimated loss in a bank's net worth due to an increase in nominal interest rates, which is the estimated reduction in the discounted net cash flows. Our interest rate risk measure considers banks' hedging positions, so it measures each bank's exposure to interest rate risk net of hedging.

To measure the impact of rising interest rates, we focus on the tightening of the monetary policy that took place from May 2018 until the end of 2018 in Türkiye. The monetary policy rate increased from 12.86% to 24% between April and September 2018 in this period. It remained stable at 24% until the end of 2018. Our sample period starts at the beginning of 2017 and extends until the end of 2018. June to December 2018 is defined as the treatment period with rising interest rates, and January 2017 to April 2018 is considered as the pre-

treatment period.[1] Figure 1 plots the monetary policy rate during this period.[2]

To provide evidence for the impact of banks' interest rate risk on their loan supply, we control loan demand by using the credit register data that contains the universe of monthly bank-firm level loan data provided by the Central Bank of the Republic of Türkiye (CBRT). The granularity of the credit register data enables us to saturate our models with industry $\times$ province $\times$ size $\times$ year-month fixed effects. This allows us to control for time-varying loan demand and quantify the impact on the loan supply while keeping the single-lender firms in our sample.[3] We use a difference-in-differences approach to compare lending before (January 2017 – April 2018) and after interest rates began to rise (June – December 2018) among banks with different interest rate risk exposure levels.

We present our results in three steps: First, we document that banks with higher exposure to interest rate risk decreased their loan supply significantly when interest rates began to rise. According to our results, a 1 standard deviation higher interest rate risk exposure resulted in almost 3 percent lending cuts on the volume of outstanding loans and a 5.4 percent reduction in banks' newly issued loan volumes. At the same time, it led to a significant decline in loan maturities for the new loans issued in this period. Banks with a 1 standard deviation higher exposure issued loans with 4.5 percent shorter maturities. These findings imply that rising interest rates decrease exposed banks' loan supply and shorten the maturities of their new loans. Lowering the loan maturities might help them narrow their maturity mismatch and reduce their exposure to rising interest rates.

Second, firm-level results show that firms that had lending relationships with high-exposure banks experienced a reduction in their total loans during this period. Our results show that a 1 standard deviation increase in firms' interest rate risk exposure via their banks

[1] We dropped May 2018 from our analysis since interest rates began to rise in May 2018. Undisclosed results show that including May 2018 in the treatment period does not affect our findings.

[2] We use the weighted average funding cost (WAFC) of the Central Bank of the Republic of Türkiye (CBRT) as the policy rate during this period. WAFC is the weighted average interest rate of all CBRT's Turkish lira funding for various instruments at different maturities to meet the market liquidity needs on a particular weekday.

[3] As a robustness check, we follow Khwaja and Mian (2008) and include firm $\times$ year-month fixed effects to control for changes in the loan demand in Section 4.4.

led to a 1.1 percent decline in their total outstanding loans. This implies that firms were not able to switch to other banks when their lenders cut their lending, and, as a result, they could not avoid a reduction in their total loans. We find this to be valid mainly for SMEs, while large firms were able to find other lenders and smooth out the reduction in their loans.

Third, we explore the real effects on firm outcomes through the reduction in their total loans by studying firms' sales and unemployment. According to our results, firms with a 1 standard deviation higher exposure to interest rate risk (through their banks) decreased their sales by around 2.7 percent and cut their employment by around 1.4 percent. This suggests that banks' interest rate risk exposure can have real effects by lowering their borrowers' total loans and pushing them to reduce their sales and employment.

We find that the loan reduction happens mainly for banks with low capital ratios. Banks with high capital ratios, defined as banks in the top quartile of the common equity Tier-1 ratios, did not decrease their loan supply. An increase in their exposure to interest rate risk did not affect their lending during this period. As the interest rate risk exposure is defined as the estimated loss in banks' net worth, this result implies that larger bank capital shields banks against interest rate risk and helps them continue their loan provision role during periods of tight monetary policy.

There are three state-owned banks in Türkiye. They have a unique role in supporting the economy during times of distress. We next investigate whether state-owned banks would support firms when firms experience a reduction in their loans from high-exposure banks. According to our results, state-owned banks with higher exposure increased their lending during rising interest rates. They provided an additional volume of loans when firms experienced a reduction in their loans issued by privately owned banks. As a result, firms that had a lending relationship with a state-owned bank did not have a reduction in their total loans. This implies that these firms could switch to borrowing from state-owned banks and avoid a reduction in their total loans. When we study the impact on firms' sales and employment separately for two subsamples, we find the adverse effect disappears for firms that have a

lending relationship with state-owned banks.

Related literature. Our paper contributes to the literature that studies the impact of banks' interest rate risk exposure on their lending.[4] Gambacorta and Mistrulli (2004) find that interest rate risk has a significant effect on Italian banks' lending between 1992 to 2001 by focusing on the role of bank capital. Beutler et al. (2020) find similar results for Swiss banks from 2001 to 2013 that banks' interest rate exposure strongly impacts their lending, and bank capital is an important driver of this impact. Gomez et al. (2021) study the impact of interest rate risk exposure on US banks between 1986 and 2011. The interest rate risk exposure used in their paper considers the income gap, which captures solely the assets and liabilities repriced in one year. Our interest rate risk exposure, on the other hand, is more comprehensive as it is based on each bank's repricing maturity profile similar to Beutler et al. (2020). Gambacorta and Mistrulli (2004) and Beutler et al. (2020) use bank-level data in their analyses, and Gomez et al. (2021) perform most of their analysis at the bank level. Our contribution to these studies is using the supervisory measure of interest rate risk exposure and studying banks' lending by exploiting comprehensive credit register data, which enables us to control for loan demand and match banks to their lenders to study the real effects of interest rate risk on firm outcomes. In addition, we analyze the results for different firm sizes and study the impact of state-owned banks as liquidity providers.

Our results contribute to the bank capital channel theory that explores how monetary policy shocks affect bank capitalization and, as a result, bank lending (see, e.g., Van den Heuvel, 2002, 2006, 2012). This theory is based on the maturity mismatch between banks' assets and liabilities. Increasing interest rates lowers banks' net worth as a result of losses. Banks choose not to issue new equity since issuing equity is costly due to asymmetric information (Myers and Majluf, 1984; Myers, 2001). Instead, they reduce their lending to

[4]More broadly, our paper is related to the literature on banks' exposure to interest rate risk (See Vuillemey (2016) for a survey of the literature on banks' interest rate risk exposure). It is documented that high exposure to interest rate risk can impose severe losses on the banking system (see, e.g., Flannery and James, 1984; English et al., 2018; Hoffmann et al., 2019; Paul, 2023).

restore their required capital levels. We contribute to this literature by showing that banks with higher interest rate exposure, the ones with larger estimated losses on their net worth, cut their lending when they face rising interest rates. Our results by bank capital further support this theory: We find that the reduction in lending happens only for banks with low capital ratios. High-capital banks, on the other hand, do not decrease their loans with increasing interest rate risk exposure, implying that considering bank capital is essential in the transmission of monetary policy shocks.

Overall, using bank-firm level credit register data enables us to isolate the bank capital channel by saturating our model with several fixed effects that enable us to control other possible channels. One important possible channel is the balance-sheet channel that focuses on the direct impact of the monetary policy on firms' balance sheets, which might have consequences on their loan demand (see, e.g., Bernanke and Gertler, 1995; Bernanke et al., 1996). We control for the firm balance sheet channel by including industry $\times$ province $\times$ size $\times$ year-month fixed effects in our model. Another possible channel is the risk-taking channel, which focuses on the changes in the allocation of lending across firms within a bank's loan portfolio during contraction times (see, e.g., Borio and Zhu, 2012; Jiménez et al., 2014; Ioannidou et al., 2015; Paligorova and Santos, 2017). Incorporating bank $\times$ firm fixed effects allows us to control for the risk-taking channel by studying the impact within the same bank-firm pairs. Thus, our identification contributes to the literature by distinguishing the impact of the bank capital channel from other possible monetary policy channels.

The rest of the paper is organized as follows. Section 2 introduces the data. In Section 3, we describe the empirical analyses. The results are presented in Section 4 and Section 5 concludes.

2 Data

This paper uses the Credit Register data provided by the CBRT, which contains the universe of monthly bank-firm level loan data for Turkish banks. Our main analysis focuses on the loans issued by privately-owned banks, as state-owned banks have less binding financial constraints (Akgunduz et al., 2024).[5] We have 26 privately-owned commercial banks in our sample. The loan data is further merged with the banks' financial statements, collected by the Banking Regulation and Supervision Agency, to include bank size, equity, non-core funding, liquid assets, and non-performing loans, calculated in April 2018, as controls in our analysis. We additionally link the data to firms' end-of-year financial statements from 2017 collected by the Revenue Administration, which enables us to control for the following firm characteristics: leverage, liquidity, tangibility, short-term debt ratio, and profitability.[6] We finally merge the data with firms' monthly employment and sales data provided by the Social Security Institute and the Revenue Administration, respectively.

2.1 Estimating the interest rate risk exposure

We calculate the exposure to interest rate risk using comprehensive data on banks' cash flows from their interest-bearing holdings in their banking book and their securities portfolios, collected by the Banking Regulation and Supervision Agency. These include off-balance sheet items, such as interest rate swaps, in addition to interest rate sensitive positions on the balance sheet. Following Beutler et al. (2020), we measure banks' exposure to interest rate risk based on their repricing maturity profiles. We use 23 time bands, changing from one

[5]We expect that state-owned banks' lending decisions would not be negatively affected by their exposure to interest rate risk. As a robustness check, we include both types of banks in our analysis and show that interest rate risk exposure does not lead to a reduction in state-owned banks' loan supply.

[6]Since we do not have balance sheet information for sole proprietorships and non-incorporated businesses, these are excluded from the sample. These firms make up around 10% of the total revenue and the outstanding loans.

day to above 20 years.[7] Each cash flow is allocated to one of these time bands depending on its repricing maturity. In our analysis, the interest rate exposure is calculated in April 2018, the last month in the pre-treatment period, before the interest rates started to increase in Türkiye.

To capture the exposure of each bank to changing interest rates, we calculate each bank's net cash flow for each time band as the difference between the cash inflows and outflows from its interest-bearing assets and liabilities. We measure the interest rate exposure as the change in a bank's net worth – the change in the present value of its net cash flows for adjustments in the discount rates due to nominal interest rate movements. The exposure of bank i to interest rate risk is calculated as

$$Exposure_i = \frac{Exposure_i^{TL} + Exposure_i^{FX}}{Total\ equity}, \tag{1}$$

where $Exposure_i^{TL}$ ($Exposure_i^{FX}$) is the exposure that comes from bank i's cash inflows and outflows denominated in domestic currency TL (foreign currency).[8]

The interest rate risk exposure that comes from banks' cash flows denominated in the domestic currency, $Exposure_i^{TL}$, is calculated as follows:

$$Exposure_i^{TL} = -\sum_m \left(CF_{i,m} \times DF_m^{+500\ bps} - CF_{i,m} \times DF_m \right), \tag{2}$$

which is the estimated reduction in the present value of the total net cash flows as a result of a 500 bps increase in nominal interest rates. DF_m is the discount factor calculated as

$$DF_m = \frac{1}{(1+r)^{t_m}} \tag{3}$$

[7] We have 23 time bands in total. Nine of them are for repricing below 1 year: up to 1 day, 1 day to 1 month, 1 month to 2 months, 2 months to 3 months, 3 months to 4 months, 4 months to 5 months, 5 months to 6 months, 6 months to 9 months, and 9 months to 12 months. The remaining 14 are yearly time bands for the following repricing maturities: 1 year to 2 years, 2 to 3 years, 3 to 4 years, 4 to 5 years, 5 to 6 years, 6 to 7 years, 7 to 8 years, 8 to 9 years, 9 to 10 years, 10 to 12 years, 12 to 14 years, 14 to 16 years, 16 to 20 years, and above 20 years.

[8] If we normalize our interest rate risk exposure measure with total assets, we find similar results.

using the risk-free interest rates r for each maturity m, and $DF_m^{+500\ bps}$ is the hypothetical discount factor that includes an interest rate increase of 500 bps, measured as

$$DF_m^{+500\ bps} = \frac{1}{(1 + r + 500\ bps)^{t_m}} \tag{4}$$

Banks' interest rate risk exposure coming from their cash flows denominated in foreign currency is calculated similarly:

$$Exposure_i^{FX} = -\sum_m \left(CF_{i,m} \times DF_m^{+200\ bps} - CF_{i,m} \times DF_m \right), \tag{5}$$

where $DF_m^{+200\ bps}$ is the hypothetical discount factor that includes an interest rate increase of 200 bps, measured as

$$DF_m^{+200\ bps} = \frac{1}{(1 + r + 200\ bps)^{t_m}} \tag{6}$$

$Exposure_i^{FX}$ is equivalent to the estimated reduction in the discounted net cash flows denominated in foreign currencies as a result of a 200 bps increase in the nominal interest rates. We use a 500 bps shift in nominal interest rates for cash flows denominated in TL and 200 bps for foreign currencies following the standard interest rate shock definition of the Banking Regulation and Supervision Agency when banks' interest rate sensitivity is measured.[9]

Our interest rate risk exposure measure, $Exposure_i$, includes the interest rate exposure of each bank's cash flows from both on and off-balance sheet items, including the hedging positions. This ensures that the measure takes into account the interest rate risk hedging of each bank. As a result, the exposure measure calculates the interest rate risk of net of hedging.

[9]We find similar results for smaller interest rate change thresholds from 100 bps to 700 bps as shown in Section 4.4.

2.2 Final sample and summary statistics

Our final data contains 7,685,687 monthly bank-firm level observations for 24 months from January 2017 to December 2018. This corresponds to 26 privately-owned banks and 227,923 firms. Table 1 presents the summary statistics. The banks in our sample have an average size of around 76.7 billion TL, and the average equity ratio is 17%. Banks' exposure to interest rate risk is, on average, 9% at the bank level, which implies that a 500 bps increase in interest rates (200 bps for foreign currency denominated cash flows) would incur a reduction in banks' net worth of around 9% of their total equity. Almost 40% of banks' balance sheets constitute liquid assets. When we look at their funding, banks finance almost 30% of their assets with non-core liabilities. In our sample, the average outstanding loan is 1.97 million TL, and banks have non-performing loans to total loans ratio of around 6%. During our sample period, newly issued loans have an average maturity of around 5 years and a spread of around 6.5%.

3 Methodology

We study the impact of increasing interest rates on bank lending, focusing on the volume of loans, loan maturities, and spreads. Using a difference-in-differences estimation method, we compare lending before (January 2017 – April 2018) and after the beginning of the interest rate increases in Türkiye (June 2018 – December 2018) among banks with different levels of exposure to interest rate risk. To control for loan demand, we follow Degryse et al. (2019) and saturate our models with industry × province × size × year-month fixed effects. We define size as an indicator variable for whether the firm is micro, small, medium, or large, defined as smaller or larger than 10, 50, and 250 employees in April 2018, the last month of the pre-treatment period. This empirical setting enables us to control for loan demand while

keeping the firms borrowing from only one bank in our sample.[10] In addition, to account for unobserved time-invariant characteristics for firm-bank pairs, we include firm × bank fixed effects (see, e.g., Baskaya et al., 2017; Akgunduz et al., 2024).

To estimate the impact of increasing interest rates on banks' lending, we use the following model:

$$log(Loans_{i,j,t}) = \alpha Exposure_i \times Post_t + \beta B_i \times Post_t + \gamma F_j \times Post_t + \delta_{n,p,s,t} + \delta_{i,j} + u_{i,j,t}, \quad (7)$$

where $log(Loans_{i,j,t})$ is the logarithm of firm j's outstanding loans from bank i in year-month t, $\delta_{n,p,s,t}$ are industry × province × size × year-month fixed effects, and $\delta_{i,j}$ are bank × firm fixed effects. $Exposure_i$ measures the interest rate risk exposure of bank i, calculated as in equation 1. The time period captures 24 months from January 2017 to December 2018, excluding May 2018. We exclude May 2018 since the first interest rate increase happened on May 23, 2018.[11] $Post_t$ takes a value of one for the post-treatment period from June 2018 to December 2018 and zero for the pre-treatment period from January 2017 to April 2017. We cluster the standard errors at the bank × year-month level.[12]

The following end-of-year firm characteristics from 2017, F_j, are included in the regressions: leverage, liquidity, tangibility, short-term debt, and profitability.[13] Similarly, B_i denotes the pre-treatment bank characteristics: capital ratio, size, liquidity, NPL ratio, and

[10] As an additional analysis, we follow Khwaja and Mian (2008) and include firm × year-month fixed effects to control for changes in the loan demand. Our results are robust, as presented in Section 4.4. This more stringent estimation model decreases our sample size by almost 30% to 5,441,410 as a result of dropping firms with single lenders.

[11] Undisclosed results show that including May 2018 in the treatment period does not affect our findings.

[12] Clustering at the bank level or two-way clustering at the bank and firm level yield similar results, as reported in Section 4.4.

[13] "Firm leverage" is the ratio of liabilities to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of operating income to total assets.

non-core funding.[14] Including these firm and bank characteristics interacted with the *Post* dummy enables us to control for possible effects of pre-treatment firm and bank characteristics on the loan issuances during the treatment period.

The coefficient of interest is α, which captures the impact of an increase in banks' interest rate risk exposure on their lending during the treatment period with rising interest rates. In addition to outstanding loans, we study the impact on the volume of newly issued loans, loan maturities, and the spreads charged.

Our main analysis focuses on privately-owned banks' lending by excluding state-owned banks from our analysis. The reason behind this is state-owned banks' less binding financial constraints as they are supported by the government to provide liquidity to the real economy. To investigate the impact of rising interest rates on state-owned banks' lending, we examine whether state-owned banks behave differently than privately-owned banks by estimating the following regression:

$$\begin{aligned} log(Loans_{i,j,t}) = {} & \alpha_1 Exposure_i \times State_i \times Post_t + \alpha_2 B_i \times State_i \times Post_t \\ & + \alpha_3 State_i \times Post_t + \alpha_4 Exposure_i \times Post_t + \beta B_i \times Post_t \\ & + \gamma F_j \times Post_t + \delta_{n,p,s,t} + \delta_{i,j} + u_{i,j,t}, \end{aligned} \tag{8}$$

where $State_i$ is an indicator variable equal to one for state-owned banks. Other variables and fixed effects are the same as the main regression in equation 7. Our coefficient of interest is α_1, which captures the differential impact of interest rate risk exposure on state-owned banks' lending relative to privately-owned banks.

We next investigate the impact of a firm's banks' interest rate risk exposure on the firm's total volume of outstanding loans. This helps us examine whether firms are able to switch to other banks to avoid a reduction in their loans when their existing lender has high exposure

[14] "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding.

to interest rate increases. We use the following estimation model:

$$log(Total\ loans_{j,t}) = \alpha Exposure_j^w \times Post_t + \beta F_j \times Post_t + \gamma B_j^w \times Post_t + \delta_j + \delta_{n,p,t} + u_{j,t}, \quad (9)$$

where $log(Total\ loans_{j,t})$ is the logarithm of total outstanding loans of firm j from all banks in year-month t, δ_j are firm fixed effects, and $\delta_{n,p,t}$ are industry $\times$ province $\times$ year-month fixed effects. We include firm fixed effects, δ_j, to absorb all time-invariant observed and unobserved firm characteristics. Moreover, including industry $\times$ province $\times$ year-month fixed effects allows us to control for loan demand by accounting for all time-varying observed and unobserved characteristics for industry-province pairs that might be correlated with changes in loan demand for that industry in that province. Thus, we compare changes in the total loans for firms within the same industry-province that have heterogeneous levels of exposure to the shock via their banks.

The firm-level interest rate risk exposure, $Exposure_j^w$, measures firm j's exposure to the interest rate shock via its banks, calculated as the weighted average interest rate exposure of all privately-owned banks that firm j had an outstanding loan with before the interest rate increases started:

$$Exposure_j^w = \sum_i \frac{Loans_{i,j}}{Total\ loans_j} Exposure_i. \quad (10)$$

The weights are the pre-treatment loan portfolio shares calculated as the volume of outstanding loans issued by each privately-owned commercial bank i to firm j, $Loans_{i,j}$, divided by the total volume of outstanding loans of firm j, $Total\ loans_j$, from all privately-owned banks, where both are calculated in April 2018.

The firm-level regressions include all firm and bank controls interacted with the $Post_t$ dummy similar to the main regression in equation 7. One additional firm control is "Firm size" which is defined as an indicator variable for whether the firm is SME, defined as smaller than 250 employees. Bank characteristics at the firm level, B_j^w, are calculated similarly to

the exposure measure as the weighted average bank characteristics of all banks that the firm has an outstanding loan in April 2018. In addition to total loans, we study the effect on firms' real outcomes, such as sales and employment, by replacing the dependent variable accordingly in equation 9.[15][16]

4 Results

This section presents the empirical findings. We start with the main results from our first specification at the bank-firm level to investigate the impact of interest rate risk exposure on banks' loan supply. As a following analysis, we study state-owned banks' lending behavior relative to privately-owned banks. Next, we present our firm-level results to examine the effect on firms' total loans and whether this has an impact on firm outcomes. As the final step, we examine cross-sectional results and introduce several robustness checks.

4.1 Main results

We first study the impact of higher interest rate risk exposure on a bank's loan supply during the period with increasing interest rates, from June 2018 to December 2018. As shown in Figure 1, the policy rate of the CBRT started to increase in May 2018, and the last increase during this period was in September 2018. We use the weighted average funding cost (WAFC) of the CBRT as the policy rate during this period. WAFC is the weighted average interest rate of all CBRT's Turkish lira funding for various instruments at different maturities to meet the market liquidity needs on a particular weekday. The policy rate increased from 12.86% in April 2018 to 24% in September 2018, and it remained at 24% until the end of the year.

[15] "Sales" is the logarithm of real net sales deflated by the consumer price index. "Employment" is the logarithm of the number of employees.

[16] When we analyze the real effects, the firm-level interest rate risk exposure is normalized with the total assets of each firm to provide a measure that takes into account the importance of bank loans with respect to total firm balance sheet size.

Table 2 presents the bank-firm level results from the regression model estimation in equation 7. Column (1) shows the coefficient estimates with no bank or firm controls, and we gradually add bank characteristics from column (2) to column (6), and column (7) finally includes all bank and firm characteristics interacted with the *Post* dummy as in the model specification in equation 7. Using the coefficient estimates from the full specification in column (7), we find that a 1 percentage point increase in a bank's interest rate risk exposure leads to a 0.86 percent reduction in the outstanding loan volume by that bank. This implies that a 1 standard deviation increase in banks' exposure to the interest rate risk (0.035) results in lending cuts by almost 3 percent, which is economically relevant.[17] When we study the monthly effects from March to December 2018, we find that the significant reduction in loans starts in June 2018 and continues until the end of the year, as reported in Figure 2.

When we examine the newly issued loans rather than the outstanding loans, we find similar results. As reported in column (1) of Table 3, a 1 percentage point higher exposure to the interest rate risk leads to a significant decrease in banks' newly issued loan volumes by 1.54 percent. This translates into a 5.4 percent reduction for a 1 standard deviation increase in banks' interest rate risk exposure, which is statistically significant and economically relevant. We further study whether banks change loan maturities and spreads on these newly issued loans. Although loan spreads are not affected, we find a significant decline in loan maturities. Column (2) shows the results: Banks shorten the maturities of these new loans by 1.3 percent for a 1 percentage point increase in their exposure. This implies that 1 standard deviation higher exposure to interest rate risk leads to almost a 4.5 percent reduction in loan maturities. This is consistent with Black and Rosen (2018) that tightening monetary policy significantly shortens loan maturity.

Our findings show that banks' higher exposure to interest rate risk leads to a reduction in their loan supply when interest rates begin to increase. Higher interest rate risk exposure

[17] According to the coefficient estimates of our control variables, on average, large banks with less liquid assets and more non-core funding are more likely to have larger outstanding loans to profitable firms with higher leverage ratios, less tangible assets, and less short-term debt.

results in losses in their net worth due to increasing interest rates, and our results imply that banks that experience larger losses respond by cutting their lending. This enables them to narrow their maturity mismatch and decrease their interest rate risk exposure. Moreover, in an effort to close their repricing maturity gap further, they decrease the loan maturities for their newly issued loans during this period.

4.2 Results with state-owned banks

There are 3 state-owned banks in Türkiye. State-owned banks are known to have less binding financial constraints as they have a unique role of supporting the economy through several different lending programs subsidized by the government. This role becomes essential during times of distress when privately-owned banks decrease their loan supply. To investigate this further, we next study whether state-owned banks' lending behavior with respect to their exposure to interest rate risk was different from that of privately-owned banks during the period of increasing interest rates.

Table 4 presents the results. Including state-owned banks in our outstanding loans data increases the number of observations to 10,805,296, which implies that 3 state-owned banks represent almost 30% of the lending market during our sample period. Column (1) shows that the coefficient estimate (-0.44) becomes much smaller, almost half of the above-reported coefficient (-0.86), when we include all banks in our analysis. More importantly, as reported in column (2), we find that state-owned banks' exposure to interest rate risk does not decrease their lending; they significantly increase their loan supply relative to privately-owned banks. We show that a 1 percentage point increase in a state-owned bank's interest rate risk exposure leads to a 5.20 percent increase in its outstanding loan volume.

This result implies that state-owned banks increase their lending as their exposure to interest rate risk increases, which is not surprising given their role as liquidity providers during contraction periods. According to our findings, they supply an additional volume of loans when firms experience a reduction in their loans issued by privately-owned banks.

4.3 Firm-level results

We next examine whether firms can switch to other banks to avoid a reduction in their loans. To investigate this, we define each firm's exposure to the interest rate risk as the weighted average exposure of its banks, where the weights are the proportions of its outstanding loans from each bank, as in equation 10. Using this firm-level exposure measure, we study the impact of a firm's banks' interest rate risk exposure on the firm's total outstanding loans. Table 5 presents the results. We find that firms, on average, experience a significant reduction in their total loans as their banks' exposure to interest rate risk increases. According to the coefficients reported in column (1), a 1 percentage point increase in a firm's interest rate risk exposure leads to a 0.4 percent decline in the firm's total outstanding loans. This implies almost a 1.1 percent reduction for a 1 standard deviation higher exposure (0.028).

Following the results related to state-owned banks' lending, we divide our sample into two groups of firms: the firms with a lending relationship with state-owned banks, i.e., that have an outstanding loan from state-owned banks, and the ones without a lending relationship with state-owned banks. We expect that firms that had an outstanding loan from state-owned banks might be more likely to borrow from state-owned banks when their privately-owned lenders cut lending due to their exposure to increasing interest rates (Akgunduz et al., 2024). As reported in column (2), firms that did not have an outstanding loan from state-owned banks experienced a significant decrease in their total loans, whereas the negative impact disappeared for firms that had an outstanding loan from state-owned banks. This finding is in line with the results of Akgunduz et al. (2024) – firms that had a lending relationship with state-owned banks before the onset of the pandemic were able to avoid a reduction in their loans by switching to state-owned banks for borrowing, which enabled them to smooth out the negative impact of the pandemic on their total loans.

The next interesting question is whether the reduction in firms' total loans has a real impact on their sales or employment. To investigate this, we repeat the same regression model in equation 9 and replace the dependent variable with sales and employment, respectively.

Sales is calculated as the logarithm of real net sales deflated by the consumer price index, and employment is the logarithm of the number of employees. When we analyze the real effects, the firm-level interest rate risk exposure is normalized with the total assets of each firm to provide a measure that takes into account the importance of bank loans with respect to the total firm balance sheet size. The results are reported in Table 6. On average, an increase in firms' exposure to the interest rate risk through their banks results in a significant reduction in their sales and employment. According to the coefficient estimates reported in columns (1) and (2), we find that a 1 percentage point increase in a firm's interest rate risk exposure leads to around a 1 percent reduction in sales and a 0.5 percent reduction in employment. According to the coefficient estimates reported in columns (1) and (2), we find that a 1 percentage point increase in a firm's interest rate risk exposure decreases its sales and employment by around 1 and 0.5 percent, respectively. This is translated to almost a 2.7 percent reduction in sales and a 1.4 percent reduction in employment for a 1 standard deviation higher exposure.

When we look at the firms with and without a lending relationship with state-owned banks, we find that the reduction in sales and employment mainly happens for firms that do not have a lending relationship with state-owned banks. On the other hand, the sales of the firms that have outstanding loans from state-owned banks did not decrease. These findings are consistent with our results on firms' total loans that only firms with no state-owned bank lending relationship show a reduction in their loans when their exposure to interest rate risk increases.

Overall, we find that firms' exposure to interest rate risk via their banks has a negative impact on their total loans when interest rates rise. This is particularly strong for firms without a lending relationship with state-owned banks. This aligns with our previous findings that state-owned banks increase their lending during contraction periods when firms need additional funding as their other lenders cut their loan supply. According to our results, this has real effects. Firms with higher exposure to interest rate risk experience a reduction

in their sales and employment, which is mainly valid for firms that did not have a lending relationship with state-owned banks as a result of the reduction in their total loans.

4.4 Further results and robustness checks

4.4.1 Results by bank capital

When interest rates increase, banks with higher exposure to interest rate risk experience losses in their net worth. We expect that the banks that have relatively low regulatory capital ratios would be more reluctant to issue loans as they might have the fear of getting closer to the minimum regulatory requirements. To study this, we divide our sample into banks with high and low capital, where high-capital banks are defined as the banks in the top quartile of the capital ratios, and the rest are low-capital banks.

Table 7 presents the results. We find that high-capital banks' loan supply is not affected by their exposure to the interest rate risk, whereas low-capital banks decrease their lending significantly. This implies that bank capital might act as a shield against interest rate risk and enable banks to continue their role as loan providers during contraction periods. This is consistent with the earlier findings that a higher capitalized banking system can protect the borrowers from changes in interest rates (see, e.g., Kishan and Opiela, 2000, 2006) and help them to avoid a reduction in lending (see, e.g., Kashyap and Stein, 2000; Meh and Moran, 2010; Dursun-de Neef, 2019).

4.4.2 Results by firm size

Large firms are expected to be more likely to find alternative borrowing opportunities from other banks (see, e.g., Khwaja and Mian, 2008; Iyer et al., 2014).[18] This would enable them to alleviate the impact of the interest rate shock on their total loans. To investigate this, we repeat our analysis for large versus small firms, where small firms are SMEs with

[18]Yarba and Güner (2019), Yarba and Güner (2020), and Akgunduz et al. (2024) provide evidence for Turkish banks.

below 250 employees, and the rest are defined as large firms.

Although banks decreased their loans to both SMEs and large firms at similar magnitudes, as shown in Table 8, we find that the reduction in firms' total loans happens mainly for SMEs, whereas large firms' total loans are not affected, as reported in columns (1) and (2) in Table 9. This implies that large firms were able to find financing from other banks. This finding is consistent with the literature that large firms are able to switch to other lenders and manage to avoid a reduction in their total borrowing.

In addition, SMEs that had a lending relationship with state-owned banks before the onset of the pandemic were able to avoid a reduction in their loans by switching to state-owned banks for borrowing, as shown in column (5) of Table 9. Column (3) reports that the decline in lending is observed mainly for SMEs without a state-owned bank lending relationship. These findings imply that, for SMEs, having a lending relationship with a state-owned bank determines whether they experience a decrease in their total loans when interest rates increase substantially. Large firms, on the other hand, could avoid a reduction in their total loans independent of having a lending relationship with a state-owned bank, as presented in columns (4) and (6).

4.4.3 Alternative interest rate shocks

We define the interest rate risk exposure of a bank as the estimated reduction in the sum of the discounted net cash flows of the bank for a 500 bps shift in nominal interest rates for cash flows denominated in TL and a 200 bps shift for the ones in foreign currencies. These thresholds are used by the Banking Regulation and Supervision Agency as interest rate shocks for their standard interest rate sensitivity calculations. As a robustness check, we repeat our analysis with different thresholds changing from 100 bps to 700 bps.

The results are reported in Table 10. Our results are robust to using different thresholds for interest rate shocks. As expected, the coefficient estimate is larger for smaller exposure measures that use a smaller interest rate rise.

4.4.4 Alternative fixed effects

In our main analysis, we saturate our models with industry × province × size × year-month and bank × firm fixed effects. Including industry × province × size × year-month enables us to control loan demand while keeping single-lender firms in our analysis (Degryse et al., 2019). To check the robustness of our results, we follow Khwaja and Mian (2008) and include firm × year-month fixed effects to control for changes in the loan demand. Firm controls multiplied with the *Post* dummy are omitted in this setting due to the addition of the new fixed effects. Including firm × year-month fixed effects enables us to study the changes in the volume of loans that the same firm receives from two banks with different levels of exposure to interest rate risk.

This more stringent estimation model decreases our sample size by almost 30% to 5,441,410 as a result of dropping firms with single lenders. Table 11 presents our results. All our results are robust to including firm × year-month fixed effects.

4.4.5 Alternative clusters

Standard errors are clustered at the bank × year-month level in our main analysis. As a robustness check, we use two different alternatives: two-way cluster at the bank and firm level and clustering at the bank level. As reported in Table 12, our results are robust to using these alternative clusterings.

5 Conclusion

This paper investigates the impact of banks' exposure to interest rate risk on their lending during contractionary periods. We measure each bank's interest rate risk exposure by using detailed supervisory data on the repricing maturity of banks' reported cash flows. It is calculated as the estimated reduction in the discounted cash flows when nominal interest rates increase, i.e., the estimated loss in banks' net worth. Using this comprehensive interest

rate risk exposure, we show that banks with higher exposure decrease their loans and shorten the maturity of their newly issued loans when interest rates rise. According to our findings, a 1 standard deviation increase in exposure leads to an almost 3 percent reduction in banks' outstanding loans and a 5.4 percent decline in their newly issued loans. In addition, banks shorten the maturity of their new loans by 1.3 percent.

Using our comprehensive credit register data provided by the CBRT, we further investigate the impact on their borrowers. According to our results, firms with higher exposure to interest rate risk via their banks experience a significant reduction in their total loans. This implies that firms cannot switch to other banks when their lenders cut loans due to their exposure to rising interest rates. This results in declines in affected firms' sales and employment. A 1 standard deviation increase in firms' exposure leads to around a 2.7 percent reduction in their sales and a 1.4 percent decline in their employment. This finding suggests that banks' exposure to interest rate risk has negative consequences on their borrowers by affecting their total borrowing, sales, and employment. The results hold mainly for SMEs, whereas they disappear for larger firms. This is consistent with the literature that larger firms are more likely to switch to alternative lenders when their existing lender cuts their loans.

Using Türkiye's unique setting, we investigate whether state-owned banks alleviate the negative impact on firms by providing liquidity to these firms in need. According to our results, interest rate risk exposure does not affect state-owned banks' lending during contractionary periods. Firms that have a lending relationship with state-owned banks could switch to borrowing from them when their high-exposure lenders cut their loans. As a result, they avoid a reduction in their total loans, which enables them to keep their sales and employment unaffected. Thus, banks' exposure to interest rate risk mainly impacts firms without a lending relationship with state-owned banks.

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Figures

Figure 1. CBRT policy rate
This figure plots the policy rate of the CBRT during our sample period from January 2017 until December 2018. We use the weighted average funding cost (WAFC) of the CBRT as the policy rate during this period. WAFC is the weighted average interest rate of all CBRT's Turkish lira funding for various instruments at different maturities to meet the market liquidity needs on a particular weekday.

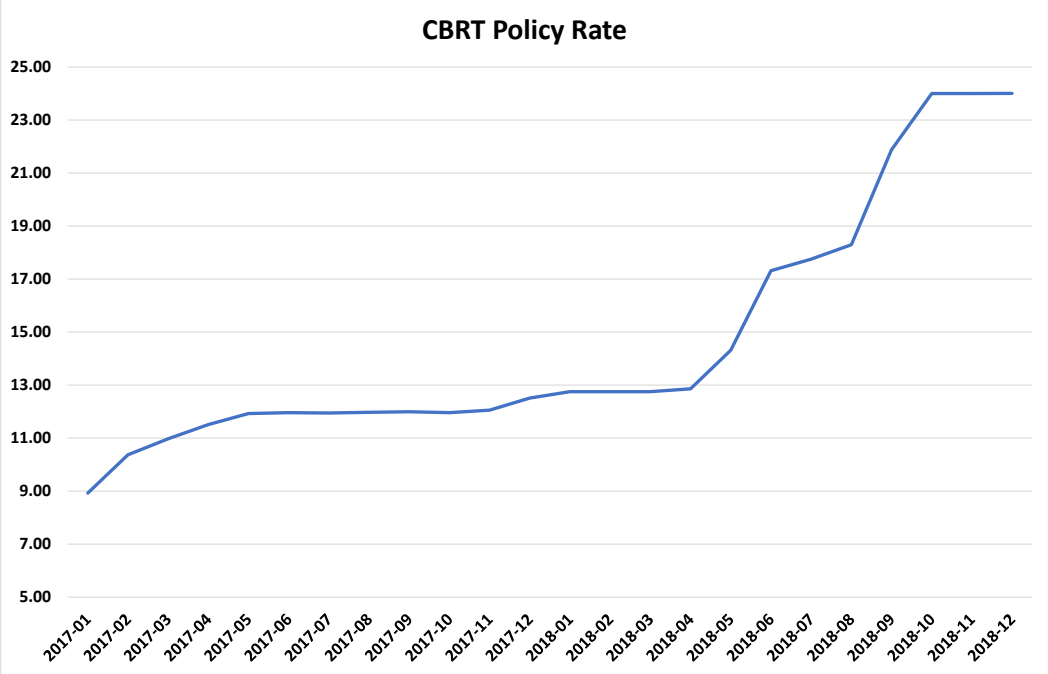
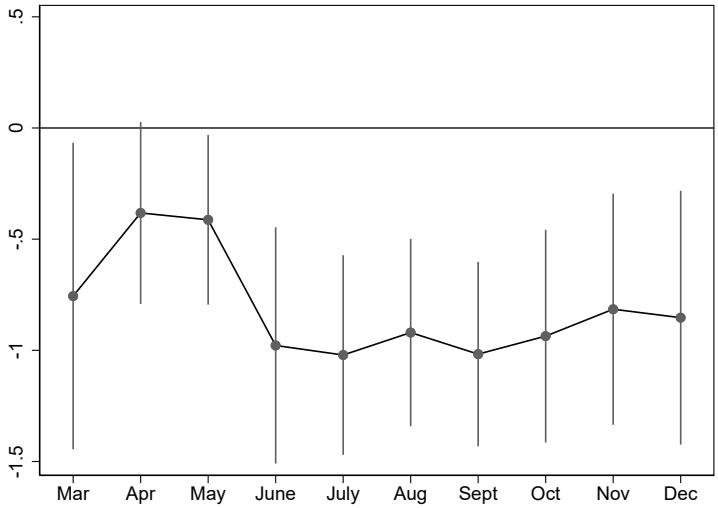


Figure 2. The impact on the volume of outstanding loans: Coefficient estimates for each month
This figure plots the coefficient estimates of the regressions that examine the monthly effects. The dependent variable is the logarithm of the volume of outstanding loans. The sample period is from January 2017 to December 2018, where January 2017 - February 2018 is used as the control period, and the monthly effects are calculated from March 2018 onward. The identification is similar to equation 7.



Tables

Table 1. Summary statistics
This table reports the summary statistics. Panel A reports the characteristics at the bank-firm-month level between January 2017 and December 2018. Outstanding loans, newly issued loans, maturity, and size are log-transformed. *Exposure* measures each bank's exposure to interest rate risk, calculated as in equation 1. Panel B reports the bank characteristics from the April 2018 balance sheets collected by the Banking Regulation and Supervision Agency. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Panel C reports the firm characteristics using the December 2017 balance sheets reported to the Revenue Administration. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. Employment and sales data are provided by the Social Security Institute and the Revenue Administration, respectively. "Sales" is the logarithm of real net sales deflated by the consumer price index. "Employment" is the logarithm of the number of employees. "Exposure^w" measures each firm's exposure to interest rate risk, defined as in equation 10. "Sales", "Employment" and "Exposure^w" are reported at the firm-month level.

	Mean	Std. Dev.	p10	p25	Median	p75	p90	N
Panel A: Characteristics (bank-firm-month variation)								
Outstanding loans	5.170	2.205	2.708	4.159	5.313	6.516	7.656	7,685,687
Newly issued loans	5.046	1.673	3.135	3.951	5.011	6.078	7.102	1,264,302
Loan maturity (years)	5.323	1.049	4.263	4.718	5.204	5.900	6.597	1,104,680
Loan spread (%)	6.384	3.633	3.488	4.448	5.610	7.250	9.996	1,104,680
Exposure	0.132	0.035	0.103	0.103	0.107	0.159	0.177	7,685,687
Panel B: Bank Characteristics								
Capital ratio	0.170	0.102	0.093	0.115	0.138	0.163	0.385	26
Size	15.668	1.912	13.179	14.350	15.657	17.238	18.461	26
Liquidity	0.387	0.171	0.231	0.288	0.310	0.480	0.583	26
NPL ratio	0.060	0.129	0.000	0.022	0.033	0.048	0.053	26
Non-core funding	0.343	0.236	0.135	0.205	0.248	0.489	0.700	26
Exposure	0.089	0.072	0.000	0.025	0.095	0.144	0.187	26
Panel C: Firm Characteristics								
Firm leverage	0.468	0.292	0.065	0.227	0.465	0.691	0.845	227,923
Firm liquidity	0.097	0.171	0.001	0.008	0.040	0.142	0.323	227,923
Firm tangibility	0.212	0.224	0.010	0.043	0.130	0.309	0.563	227,923
Firm short-term debt	0.816	0.263	0.379	0.694	0.973	1.000	1.000	227,923
Firm profitability	0.061	0.137	-0.030	0.013	0.048	0.106	0.205	227,923
Sales	11.254	1.895	8.889	10.042	11.245	12.507	13.669	2,763,233
Employment	2.568	1.237	1.099	1.609	2.398	3.332	4.263	2,763,233
Exposure^w	0.131	0.028	0.103	0.107	0.126	0.159	0.161	3,227,467

Table 2. The impact on the volume of outstanding loans

The dependent variable is the logarithm of the volume of outstanding loans. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. All standard errors are clustered at the bank × year-month level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × Exposure	-0.359*	-0.741***	-0.745***	-0.870***	-0.876***	-0.931***	-0.861***
	(0.213)	(0.227)	(0.235)	(0.213)	(0.215)	(0.208)	(0.207)
Post × Capital ratio		-0.910***	-0.909***	-1.456***	-1.447***	-1.639***	-0.432
		(0.310)	(0.308)	(0.270)	(0.281)	(0.291)	(0.389)
Post × Size			-0.020	-0.817**	-0.860**	-0.542	0.059***
			(0.360)	(0.375)	(0.394)	(0.389)	(0.008)
Post × Liquidity				0.063***	0.062***	0.055***	-1.652***
				(0.007)	(0.008)	(0.008)	(0.292)
Post × NPL ratio					-0.189	-0.074	-0.036
					(0.645)	(0.628)	(0.628)
Post × Non-core funding						0.480***	0.490***
						(0.141)	(0.141)
Post × Firm leverage							0.119***
							(0.015)
Post × Firm liquidity							-0.007
							(0.006)
Post × Firm tangibility							-0.112***
							(0.009)
Post × Firm short-term debt							-0.046***
							(0.007)
Post × Firm profitability							0.131***
							(0.014)
R-squared	0.893	0.893	0.893	0.893	0.893	0.893	0.893
N	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687

*** p<0.01, ** p<0.05, * p<0.1

Table 3. The impact on the volume of newly issued loans, loan maturities, and spreads
The dependent variable is the logarithm of the volume of newly issued loans, loan maturities and spreads from column (1) to (3), respectively. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. All standard errors are clustered at the bank × year-month level.

	Newly issued loans (1)	Loan maturity (2)	Loan spread (3)
Post × Exposure	-1.553***	-1.304***	-1.131
	(0.324)	(0.439)	(3.498)
Post × Capital ratio	0.816	0.899	7.480
	(0.560)	(0.689)	(7.992)
Post × Size	0.029**	0.052***	-0.184
	(0.011)	(0.016)	(0.139)
Post × Liquidity	-1.384***	-1.207***	4.944
	(0.414)	(0.430)	(4.512)
Post × NPL ratio	-2.021*	2.983**	-2.736
	(1.065)	(1.192)	(12.045)
Post × Non-core funding	0.493**	-0.131	-1.950
	(0.218)	(0.289)	(2.618)
Post × Firm leverage	-0.185***	-0.088***	0.467***
	(0.021)	(0.018)	(0.067)
Post × Firm liquidity	0.102***	0.025*	0.018
	(0.018)	(0.013)	(0.067)
Post × Firm tangibility	0.133***	0.000	0.058
	(0.023)	(0.019)	(0.067)
Post × Firm short-term debt	0.132***	0.120***	-0.171***
	(0.019)	(0.016)	(0.038)
Post × Firm profitability	0.330***	0.001	-0.339***
	(0.039)	(0.029)	(0.099)
R-squared	0.743	0.630	0.780
N	1,264,302	1,104,451	1,104,451

*** p<0.01, ** p<0.05, * p<0.1

Table 4. The impact on the volume of outstanding loans including state-owned banks
The dependent variable is the logarithm of the volume of outstanding loans. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. *State* dummy indicates state-owned banks. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. In addition to double interactions, regressions include triple interactions of *Post*, *State*, and all bank characteristics, which are not reported for brevity. All regressions include industry × province × size × year-month and bank × firm fixed effects. All standard errors are clustered at the bank × year-month level.

	(1)	(2)
Post × Exposure	-0.442**	-0.912***
	(0.218)	(0.210)
Post × State		0.940***
		(0.219)
Post × State × Exposure		5.986***
		(0.798)
Post × Capital ratio	-0.867**	1.097***
	(0.403)	(0.213)
Post × Size	0.059***	0.055***
	(0.008)	(0.008)
Post × Liquidity	-1.784***	-1.615***
	(0.273)	(0.288)
Post × NPL ratio	-1.743**	-0.131
	(0.734)	(0.658)
Post × Non-core funding	0.891***	0.482***
	(0.146)	(0.130)
Post × Firm leverage	0.116***	0.113***
	(0.012)	(0.012)
Post × Firm liquidity	-0.006	-0.006
	(0.006)	(0.006)
Post × Firm tangibility	-0.096***	-0.092***
	(0.008)	(0.007)
Post × Firm short-term debt	-0.049***	-0.047***
	(0.006)	(0.006)
Post × Firm profitability	0.152***	0.146***
	(0.011)	(0.011)
R-squared	0.892	0.892
N	10,805,296	10,805,296

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Firm-level results: The impact on the volume of total loans

The dependent variable is the logarithm of the volume of total loans for each firm. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. $Exposure^w$ measures each firm's exposure to interest rate risk, defined as in equation 10. Bank characteristics are obtained from the balance sheets reported in April 2018. All bank characteristics are calculated as the weighted average bank characteristics at the firm level, similar to the weighted average exposure measure calculation in equation 10. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm size" is an indicator variable for whether the firm is an SME, defined as smaller than 250 employees. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × year-month and firm fixed effects. All standard errors are clustered at the firm level.

	All firms	**No lending relationship with state-owned banks**	**Lending relationship with state-owned banks**
	(1)	(2)	(3)
Post × Exposure^w	-0.397***	-0.253**	-0.138
	(0.080)	(0.111)	(0.105)
Post × Capital ratio^w	-0.003	0.063	0.640**
	(0.184)	(0.242)	(0.257)
Post × Size^w	0.020***	0.028***	0.027***
	(0.004)	(0.006)	(0.005)
Post × Liquidity^w	-0.349***	-0.397***	-0.102
	(0.091)	(0.124)	(0.121)
Post × NPL ratio^w	0.788***	0.936***	2.104***
	(0.277)	(0.356)	(0.354)
Post × Non-core funding^w	0.126*	0.150	0.134
	(0.071)	(0.095)	(0.102)
Post × Firm size	-0.110***	-0.060*	-0.069***
	(0.014)	(0.031)	(0.013)
Post × Firm leverage	0.143***	0.121***	0.032***
	(0.007)	(0.008)	(0.010)
Post × Firm liquidity	-0.029***	-0.019	0.012
	(0.011)	(0.015)	(0.015)
Post × Firm tangibility	-0.059***	-0.059***	-0.062***
	(0.009)	(0.012)	(0.012)
Post × Firm short-term debt	-0.083***	-0.046***	-0.024***
	(0.006)	(0.009)	(0.008)
Post × Firm profitability	0.266***	0.214***	0.237***
	(0.014)	(0.016)	(0.028)
R-squared	0.942	0.910	0.951
N	3,227,467	1,925,812	1,301,655

*** p<0.01, ** p<0.05, * p<0.1

Table 6. Firm-level results: The impact on sales and employment

The dependent variable is sales and employment, respectively. "Sales" is the logarithm of real net sales deflated by the consumer price index. "Employment" is the logarithm of number of employees. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. $Exposure^{w}$ measures each firm's exposure to interest rate risk, defined as in equation 10. Bank characteristics are obtained from the balance sheets reported in April 2018. All bank characteristics are calculated as the weighted average bank characteristics at the firm level, similar to the weighted average exposure measure calculation in equation 10. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm size" is an indicator variable for whether the firm is an SME, defined as smaller than 250 employees. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × year-month and firm fixed effects. Coefficients of firm and bank controls are not reported for brevity. All standard errors are clustered at the firm level.

	All firms		**No lending relationship with state-owned banks**		**Lending relationship with state-owned banks**	
	Sales	Employment	Sales	Employment	Sales	Employment
	(1)	(2)	(3)	(4)	(5)	(6)
Post × $Exposure^{w}$	-0.952***	-0.510***	-1.057***	-0.585***	-0.668	-0.430
	(0.283)	(0.155)	(0.352)	(0.189)	(0.491)	(0.277)
R-squared	0.826	0.946	0.806	0.938	0.827	0.950
N	2,763,233	2,763,233	1,574,611	1,574,611	1,188,622	1,188,622

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Results by bank capital

The dependent variable is the logarithm of the volume of outstanding loans. High-capital banks are defined as the banks in the top quartile of the common equity Tier-1 ratios, and the rest are low-capital banks. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. *State* dummy indicates state-owned banks. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. All standard errors are clustered at the bank × year-month level.

	Low capital	**High capital**
	(1)	(2)
Post × Exposure	-0.679***	4.761
	(0.225)	(3.316)
Post × Capital ratio	-1.214**	0.413
	(0.567)	(0.267)
Post × Size	0.064***	-0.027
	(0.011)	(0.040)
Post × Liquidity	-1.497***	1.302***
	(0.309)	(0.334)
Post × NPL ratio	-0.102	-2.784***
	(0.633)	(0.758)
Post × Non-core funding	0.426**	0.434
	(0.170)	(0.324)
Post × Firm leverage	0.112***	0.162***
	(0.017)	(0.023)
Post × Firm liquidity	-0.008	0.003
	(0.007)	(0.010)
Post × Firm tangibility	-0.100***	-0.158***
	(0.010)	(0.019)
Post × Firm short-term debt	-0.052***	-0.013
	(0.007)	(0.013)
Post × Firm profitability	0.094***	0.327***
	(0.014)	(0.026)
R-squared	0.894	0.888
N	6,357,327	1,276,384

*** p<0.01, ** p<0.05, * p<0.1

Table 8. Results by firm size

The dependent variable is the logarithm of the volume of outstanding loans. SMEs are firms with below 250 employees, and the rest are defined as large firms. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. *State* dummy indicates state-owned banks. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. All standard errors are clustered at the bank × year-month level.

	SME	**Large**
	(1)	(2)
Post × Exposure	-0.867***	-0.690***
	(0.213)	(0.203)
Post × Capital ratio	-0.471	0.172
	(0.408)	(0.287)
Post × Size	0.059***	0.071***
	(0.009)	(0.008)
Post × Liquidity	-1.643***	-1.693***
	(0.307)	(0.221)
Post × NPL ratio	-0.072	0.250
	(0.676)	(0.471)
Post × Non-core funding	0.489***	0.539***
	(0.152)	(0.140)
Post × Firm leverage	0.120***	0.038
	(0.015)	(0.033)
Post × Firm liquidity	-0.007	-0.010
	(0.006)	(0.062)
Post × Firm tangibility	-0.111***	-0.124***
	(0.009)	(0.027)
Post × Firm short-term debt	-0.044***	-0.162***
	(0.006)	(0.028)
Post × Firm profitability	0.126***	0.369***
	(0.014)	(0.083)
R-squared	0.887	0.894
N	7,430,390	255,297

*** p<0.01, ** p<0.05, * p<0.1

Table 9. Firm-level results by firm size

The dependent variable is the logarithm of the volume of total loans for each firm. SMEs are firms with below 250 employees, and the rest are defined as large firms. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. $Exposure^w$ measures each firm's exposure to interest rate risk, defined as in equation 10. Bank characteristics are obtained from the balance sheets reported in April 2018. All bank characteristics are calculated as the weighted average bank characteristics at the firm level, similar to the weighted average exposure measure calculation in equation 10. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm size" is an indicator variable for whether the firm is an SME, defined as smaller than 250 employees. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × year-month and firm fixed effects. Coefficients of firm and bank controls are not reported for brevity. All standard errors are clustered at the firm level.

	All firms		**No lending relationship with state-owned banks**		**Lending relationship with state-owned banks**	
	SME	Large	SME	Large	SME	Large
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Exposure^w	-0.394***	-0.165	-0.232**	-0.486	-0.116	-0.038
	(0.081)	(0.767)	(0.111)	(1.569)	(0.107)	(0.922)
R-squared	0.938	0.948	0.907	0.925	0.944	0.968
N	3,159,526	67,941	1,900,994	24,818	1,258,532	43,123

*** p<0.01, ** p<0.05, * p<0.1

Table 10. Robustness: Alternative interest rate shocks

The dependent variable is the logarithm of the volume of outstanding loans. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1, where the shift in interest rates is replaced by different thresholds, as indicated in each column. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. Coefficients of firm and bank controls are not reported for brevity. All standard errors are clustered at the bank × year-month level.

	TL: 100 bps FX: 100 bps	TL: 200 bps FX: 200 bps	TL: 300 bps FX: 300 bps	TL: 300 bps FX: 100 bps	TL: 400 bps FX: 100 bps	TL: 600 bps FX: 300 bps	TL: 700 bps FX: 300 bps
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × Exposure	-1.937***	-0.987***	-0.670***	-0.875***	-0.681***	-0.427***	-0.381***
	(0.668)	(0.341)	(0.232)	(0.345)	(0.277)	(0.160)	(0.146)
R-squared	0.893	0.893	0.893	0.893	0.893	0.893	0.893
N	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687	7,685,687

*** p<0.01, ** p<0.05, * p<0.1

Table 11. Robustness: Alternative fixed effects

The dependent variable is the logarithm of the volume of outstanding loans, newly issued loans, loan maturities and spreads from column (1) to (4), respectively. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include firm × year-month and bank × firm fixed effects. Firm controls are omitted due to the fixed effects, and coefficients of bank controls are not reported for brevity. All standard errors are clustered at the bank × year-month level.

	Outstanding loans (1)	Newly issued loans (2)	Loan maturity (3)	Loan spread (4)
Post × Exposure	-0.755*** (0.211)	-0.678** (0.289)	-0.960** (0.433)	-3.332 (3.053)
R-squared	0.925	0.863	0.786	0.897
N	5,441,410	542,717	458,417	458,417

*** p<0.01, ** p<0.05, * p<0.1

Table 12. Robustness: Alternative clusters

The dependent variable is the logarithm of the volume of outstanding loans and newly issued loans, respectively. The time period is from January 2017 to December 2018. *Post* dummy indicates the post-treatment period between June and December 2018. *Exposure* measures each bank's interest rate risk exposure, defined as in equation 1. Bank characteristics are obtained from the balance sheets reported in April 2018. "Capital ratio" is the common equity Tier 1 capital ratio defined as common equity Tier 1 capital divided by risk-weighted assets. "Size" is the log transformation of total assets. "Liquidity" is the ratio of liquid assets (cash and equivalents) to total assets. "NPL ratio" is the ratio of non-performing loans to all loans. "Non-core funding" is the ratio of non-core funding to total funding. Firm characteristics are obtained from the balance sheets reported in December 2017. "Firm leverage" is the ratio of total debt to total assets. "Firm liquidity" is the ratio of liquid assets to total assets. "Firm tangibility" is the ratio of net tangible assets to total assets. "Firm short-term debt" is the ratio of short-term debt to total debt. "Firm profitability" is the ratio of earnings before interest, tax, and depreciation to total assets. All regressions include industry × province × size × year-month and bank × firm fixed effects. Coefficients of firm and bank controls are not reported for brevity.

	Outstanding loans		Newly issued loans	
	(1)	(2)	(3)	(4)
Post × Exposure	-0.861***	-0.861***	-1.553***	-1.553***
	(0.235)	(0.235)	(0.474)	(0.474)
Cluster	Two-way	Bank	Two-way	Bank
R-squared	0.893	0.893	0.743	0.743
Observations	7,685,687	7,685,687	1,264,302	1,264,302

*** p<0.01, ** p<0.05, * p<0.1