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MONETARY TRANSMISSION THROUGH BANK SECURITIES PORTFOLIOS

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ABSTRACT

We study the transmission of monetary policy through bank securities portfolios using granular supervisory data on U.S. bank securities, hedging positions, and corporate credit. Banks that experienced larger losses on their securities during the 2022-2023 monetary tightening cycle extended less credit to firms. This spillover effect was stronger for available-for-sale securities, unhedged securities, and banks that must include unrealized gains and losses in their regulatory capital. A structural model, disciplined by our cross-sectional regression estimates, shows that interest rate transmission is stronger the more banks are required to adjust their regulatory capital for unrealized value changes of securities.

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A data appendix is available at http://www.nber.org/data-appendix/w32449

1 Introduction

In March 2023, the United States experienced one of the largest bank failures in decades as depositors ran on Silicon Valley Bank (SVB). In the lead-up to its failure, SVB had maintained a large portfolio of long-term securities. As interest rates rose rapidly in 2022, market prices of these securities plummeted, generating unrealized losses that were widely believed to have triggered the run.

These events have put the regulatory treatment of bank securities under the spotlight. Under U.S. regulation, unrealized losses on SVB's securities did not pass through to its regulatory capital, making SVB appear relatively well capitalized from a regulatory perspective despite its fragile position. In light of this, a discussion has been sparked among academics and policymakers to enlarge the set of securities whose value changes affect regulatory capital.[1] With such a policy change, banks experiencing market losses on securities would be pressured to improve their capital ratios, for example by raising additional equity, to avoid violating their regulatory capital requirements. In turn, an improved capital position could lower the probability of a subsequent bank run or failure.[2]

At the same time, recognizing security market losses in regulatory capital could have important consequences for the supply of credit. If banks are reluctant to raise capital, they can instead cut lending to households and firms, thereby reducing risk-weighted assets and improving their capital ratios. If so, the resulting contraction in credit supply may also reduce firm investment and household consumption, affecting overall economic activity. As a result, the accounting treatment of unrealized gains and losses can influence the pass-through from bank securities values to the real economy.

In this paper, we explore this channel, studying how the regulatory accounting framework influences transmission from interest rates, through securities values and regulatory capital, into firm credit and investment. Our approach combines granular administrative data with a structural model that allows us to compare policy regimes. For our empirical analysis, we construct a novel data set combining supervisory data on securities portfolios, hedging positions, and corporate credit for large U.S. banks from the Federal Reserve's Y-14Q data set, which is collected for the purpose of stress-testing. These data

[1] See, for instance, a recent survey conducted by the Kent Clark Center at Chicago Booth: `https://www.kentclarkcenter.org/surveys/banks-business-model/`. A similar debate about marking bank assets to market took place after the 2007-09 financial crisis, see, e.g., Allen and Carletti (2008), Heaton, Lucas and McDonald (2010), and Laux and Leuz (2010).

[2] For example, such arguments are made in the Review of the Federal Reserve's Supervision and Regulation of Silicon Valley Bank (page 89) and in a recent speech by Chairman of the FDIC Martin J. Gruenberg, see: `https://www.fdic.gov/news/speeches/2023/spjun2223.html` and `https://www.federalreserve.gov/publications/files/svb-review-20230428.pdf`

give us an unparalleled view, not only into the various credit relationships, but also into the securities holdings of banks, allowing us to observe the specific securities held, their gains and losses over time, as well as their associated accounting hedges.

To begin, we document differences in the regulatory treatment of the banks within our data and their influence on investment decisions. The larger banks, labeled AOCI-Capital (AC) banks, must include unrealized gains and losses on their available-for-sale (AFS) securities in their regulatory capital, while the smaller banks in our sample, referred to as non-AOCI-Capital (NC) banks, are exempt from this requirement.[3] This differential regulatory treatment appears to influence banks' securities choices. During the period of low interest rates in 2020 and 2021, AC banks increased their security holdings by much less than NC banks, and sharply raised both the fraction of their securities recorded as held-to-maturity (HTM) and the portion of their AFS securities that were hedged.[4] These results are consistent with AC banks making efforts to avoid exposure of their regulatory capital to security value fluctuations.

In our main set of empirical results, we measure the effect of changes in securities values on bank credit supply, and how this varies with the regulatory treatment of those securities. We focus on the 2022-2023 monetary tightening episode, which featured large declines in the value of securities, and the consequences for bank credit to nonfinancial firms. Using the fixed effects approach of Khwaja and Mian (2008) that allows us to control for firm credit demand, we find that banks that experienced larger value losses on their AFS portfolios extended relatively less credit to firms. The effect is sizable, with a $1 price decline leading to a relative credit contraction of around 20 cents. However, we obtain substantially smaller and insignificant results for value changes of HTM securities that, unlike AFS securities, do not affect regulatory capital at any bank.[5] Differentiating AFS securities by whether they are hedged against interest rate risk, we further find that our baseline results are driven by unhedged securities, while value changes of hedged securities, which also do not impact regulatory capital, exhibit a smaller and insignificant crowding out effect on firm credit.

Next, we exploit the fact that changes in AFS values at AC banks, but not NC banks, pass through into regulatory capital to directly test our regulatory capital mechanism. We

[3]These regulations have evolved in recent years, and the turmoil around SVB reignited a debate on whether to enlarge the set of banks that need to recognize such unrealized gains and losses in their regulatory capital. See, for example, the Review of the Federal Reserve's Supervision and Regulation of Silicon Valley Bank (page 3) and the proposed reforms to bank capital requirements by Vice Chair for Supervision Michael Barr: https://www.federalreserve.gov/publications/files/svb-review-20230428.pdf and https://www.federalreserve.gov/newsevents/speech/barr20230710a.htm.

[4]See also related evidence by Fuster and Vickery (2018) and Kim, Kim and Ryan (2019).

[5]Orame, Ramcharan and Robatto (2023) find similar results using European data.

reestimate our main regressions, allowing for differential responses to gains and losses on AFS securities at AC vs. NC banks. These interacted regressions show crowding out effects that are several times stronger for AC banks, and we cannot reject the hypothesis of zero response by NC banks. Combined, these results point to changes in regulatory capital as a primary channel of interest rate transmission through security value changes into bank-firm credit under the existing policy regime.

In a final empirical exercise, we estimate the effects of these changes in bank credit supply at the firm level. We find that small firms whose banks experience larger losses on AFS securities display stronger reductions in total debt from all sources. The magnitude of these responses is similar to the direct reductions in bank lending by affected banks, implying that these firms were unable to substitute into alternative forms of credit. In turn, small firms sharply cut investment and reduce their cash holdings. In contrast, we do not find such differential responses for larger firms, suggesting heterogeneity in transmission across the firm size distribution.

Inspired by these empirical findings, we develop a structural model, building on Greenwald, Krainer and Paul (2023), to study how the effects of monetary policy are shaped by the regulatory framework of the banking system in general equilibrium. Banks in our model hold long-term securities that are revalued when interest rates change. Motivated by our empirical evidence, the model features two types of firms that differ in their access to financing: smaller "constrained" firms that are bank-dependent and borrow using term loans at market rates, and larger "unconstrained" firms that finance themselves using corporate bonds at spreads unaffected by bank conditions.

Within this framework, we consider the impact of a rise in interest rates under various policy scenarios. If banks are required to adjust their regulatory capital for unrealized value changes of securities, their capital positions deteriorate when monetary policy tightens and security prices fall. In response, banks cut lending to the nonfinancial corporate sector. Unconstrained firms are shielded from such credit supply reductions since they obtain credit from the corporate bond market. In contrast, constrained firms are unable to find alternative sources of financing and may instead reduce investment.

We discipline the model by calibrating the parameters governing this spillover effect to match our cross-sectional regression evidence—an approach that connects the model with the data and allows us to derive aggregate implications. We find that transmission of an increase in interest rates through measured regulatory capital leads to larger declines in aggregate firm debt and investment compared to a counterfactual economy where regulatory capital ignores unrealized security losses. For instance, following shocks corresponding to the observed tightening cycle, investment is reduced by 1.4pp more on impact in our baseline economy where some securities are marked to market compared with a counterfactual economy where no securities are marked to market. An economy in which *all* securities are marked to market—equivalent to abolishing the HTM classification and converting all NC to AC banks—displays substantially greater amplification, with investment 4.5pp lower on impact compared to a no-mark-to-market policy, even after we account for banks' endogenous decision to hold less securities under this policy.

In summary, our findings provide evidence for a powerful monetary transmission mechanism working through bank securities portfolios that is shaped by the regulatory framework of the banking system. Our findings have implications for current policy debates, showing that the regulatory treatment of securities may have important effects on the dynamics of the macroeconomy outside of its direct financial stability role. If banks were required to pass through all unrealized gains and losses of securities to their regulatory capital, changes in interest rates would have a larger effect on credit supply to all but the largest firms in the economy, with important consequences for aggregate investment.

Related Literature. Our paper connects to the literature on the bank lending channel of monetary policy, which studies the impact of monetary policy actions on the supply of loans by depository institutions (Bernanke and Gertler, 1995). In earlier work, Kashyap and Stein (2000) and Jiménez et al. (2012) find that banks with less liquid balance sheets, measured by the ratio of securities to assets, contract lending more after a monetary tightening. In contrast, we find that banks with *larger* securities holdings respond more to changes in interest rates, all else equal. Our findings likely differ from these existing works for two reasons. First, our Y14 sample includes only banks large enough to be subject to stress tests, and therefore excludes the extensive set of smaller banks that are likely more influenced by liquidity channels. Second, we study a period where some banks must include unrealized gains and losses in their regulatory capital, a requirement that was not in place for the periods considered by these earlier papers. Our regulatory capital channel may therefore coexist with the liquidity mechanisms studied previously.

More recently, Drechsler, Savov and Schnabl (2017, 2021) and Gomez et al. (2021) investigate alternative monetary transmission channels through bank balance sheets. Drechsler, Savov and Schnabl (2017, 2021) show that banks widen spreads between the policy rate and rates on liquid deposits after a monetary tightening, leading to deposit outflows and lending contractions, but relatively stable net interest margins. Gomez et al. (2021) find that banks with relatively more assets that reprice or mature in the near term experience higher cash flows after a monetary tightening and cut their lending relatively less. These results are separate from, and complemented by, our findings on the importance of the regulatory capital channel, as we show that our results hold even after directly controlling for changes in bank deposits and net income.

Several other studies have used loan-level data to establish a credit supply effect originating from banks' security exposures.[6] Closest to our work is Orame, Ramcharan and Robatto (2023), who show that the effects of the European Central Bank's quantitative easing programs varied with the accounting treatment of AFS securities. Relative to this literature, we are able to study the transmission from security value changes into credit supply in greater detail, as our data allow us to distinguish securities by their classifications, to what extent they are hedged, and whether security value changes affect regulatory capital at the holder banks.[7] Our cross-sectional estimates further enable us to calibrate a macroeconomic model and show how bank regulation shapes the transmission of monetary policy in general equilibrium.

We also provide new empirical evidence on the use and economic importance of derivative contracts for banks, which are particularly challenging to measure. Prior studies on U.S. data find little evidence that banks hedge their interest rate risk exposure.[8] We contribute to these existing studies by using new data on designated accounting hedges, which allow us to determine hedged positions security-by-security. The data confirm prior findings, but also show that a subset of banks—the AC banks that are subject to the distinct regulation we highlight—hedge a larger fraction of their AFS securities. For hedged securities, we find negligible spillover effects from security price changes to banks' loan portfolios, echoing prior evidence by Purnanandam (2007).

Finally, we connect with an evolving literature sparked by the turmoil around SVB. Jiang et al. (2023*b*) compute that the market value of U.S. bank assets was around $2.2 trillion lower than its book value following the 2022 monetary tightening. The combination of these unrealized losses and uninsured depositors posed run risk for many banks, explored theoretically by Drechsler et al. (2023) and Haddad, Hartman-Glaser and Muir (2023). Our work shows that changing regulatory accounting practices to promote financial stability may have important consequences for the transmission of monetary policy.

[6] Among others, examples include Bottero, Lenzu and Mezzanotti (2020), Popov and Van Horen (2015), Acharya et al. (2018), De Marco (2019), Rodnyansky and Darmouni (2017), Chakraborty, Goldstein and MacKinlay (2020), and Luck and Zimmermann (2020).

[7] Abbassi et al. (2016), Peydró, Polo and Sette (2021), Carpinelli and Crosignani (2021), Peydró et al. (2023), and Abbassi et al. (2023) also use security- and loan-level data in combination. However, their focus is on the trade-off that banks face from investing in securities of different risk categories, and vis-á-vis loans.

[8] Examples of such findings can be found in Begenau, Piazzesi and Schneider (2015), Jiang et al. (2023*a*), and McPhail, Schnabl and Tuckman (2023). For European banks, Hoffmann et al. (2019) document a more widespread use of interest rate swaps.

Overview. The remainder of the paper is organized as follows. Section 2 lays out the institutional setting and U.S. regulatory framework for the banks in our data. Section 3 illustrates balance sheet dynamics following security price changes and develops hypotheses that we aim to test empirically. Section 4 describes the data set, while Section 5 presents some key stylized facts. Section 6 summarizes our main empirical findings. Section 7 presents the macroeconomic model and studies counterfactual policy scenarios. Section 8 concludes.

2 Institutional Setting

In this section, we provide an overview of the institutional environment, describing how banks can classify their securities, if and how gains and losses pass through into measured regulatory capital, and details of hedging interest rate risk.

Security Classifications. Banks hold debt securities on their balance sheets in the trading book or in the investment portfolio of the banking book, where they can be marked as HTM or as AFS. In this paper, we focus on the investment portfolio, since trading securities constitute only a small fraction of bank assets and we lack disaggregated data on these securities.[9] Classifying a security as HTM or AFS implies a different treatment for the recognition of valuation changes and has distinct implications for bank capital. HTM securities are held at amortized costs, or book value, and are not updated as market prices change.[10] In contrast, AFS securities are held at fair value and are marked to market. While balance sheets are not affected as market prices of HTM securities change, unrealized gains and losses of AFS securities affect book equity as part of the account "accumulated other comprehensive income" (AOCI).

AOCI and Regulatory Capital. Importantly for this paper, a differential treatment of AOCI for *regulatory capital* across banks of different sizes exists, and this treatment has varied over time. Prior to 2013, U.S. bank regulators permitted a so-called AOCI filter,

[9] Banks hold securities in the trading book as both trading assets and trading liabilities. On net, the median bank in our data holds around 0.7 percent of assets in trading securities. Securities inventories associated with market making activity are typically booked in trading.

[10] If a bank classifies a security as HTM, it should have the intention to hold the security until it matures. However, the HTM classification is not necessarily permanent. A bank may sell a security out of HTM, but doing so risks "tainting" the entire remaining HTM portfolio and forcing a reclassification of *all* HTM securities into AFS. Under certain conditions a holder can sell HTM securities and avoid tainting (see Appendix C for such instances). A bank can also redesignate a security from AFS to HTM under certain conditions, though a similar tainting rule does not exist.

which removed AOCI from the calculation of regulatory capital (CET1). Starting in 2013 with the final rule for Basel III, the AOCI filter was removed for larger U.S. banks using the advanced approaches capital framework, plus any banks that voluntarily chose to opt-in to the rule change, leading AOCI to be included in CET1 capital for these banks (Fuster and Vickery, 2018).[11] Finally, with the Federal Reserve's tailoring rule in 2019, the filter was restored for all banks except the global systemically important banks (GSIBs) and the largest non-GSIB banks (Kim, Kim and Ryan, 2023).[12] To provide clarity in the presence of these changing rules, we refer to banks whose regulatory capital includes unrealized gains and losses on AFS securities at a given time as AOCI-Capital (AC) banks, and banks whose regulatory capital is not affected by these unrealized gains and losses as non-AOCI-Capital (NC) banks.

Hedging. To avoid balance sheet and AOCI volatility as interest rates change, banks can hedge their AFS securities. One of the most common ways to hedge interest rate risk exposure is via interest rate swaps. For example, if a bank has a long-dated fixed-rate security, it can agree to pay a fixed rate to the swap counterparty and receive a floating rate. If interest rates increase, the expected stream of floating-rate cash flows grows, increasing the value of the bank's swap position, and offsetting losses on the underlying security.

Such interest rate swaps that closely track changes in security values can qualify as fair value accounting hedges and are the most common hedges in our data, as shown in Section 5. Specifically, we observe qualified accounting hedges that are directly associated with certain securities. The benefit of such links between hedges and securities is that price fluctuations of AFS securities and their associated hedging instrument offset each other: banks' AOCI and their income statement are not affected if a security is completely hedged against a certain risk.[13] These hedge positions therefore help us form a precise picture of a banks' exposure to price fluctuations of securities.

[11] Advanced approach banks have assets above $250 billion or foreign exposures above $10 billion. This rule change was phased in at 20% per year until 2018.

[12] That includes non-GSIB banks with at least $700 billion in assets or $75 billion in cross-jurisdictional activity, which implies that advanced approach banks with assets between $250 and $700 billion and foreign exposures below $75 billion were able to reinstate the AOCI filter.

[13] In practice, banks often prefer to use such qualified accounting hedges since valuation changes do not pass through the income statement, in contrast to hedges held in the derivatives book. A hedging arrangement may qualify for fair value hedge accounting treatment if the hedging instrument is judged as "highly effective" in offsetting fluctuations in the value of the security. The rules for hedge accounting are set forth in ASC 815: https://asc.fasb.org/815/tableOfContent.

3 Balance Sheet Dynamics

Given this regulatory setting, we illustrate the impact of security price changes on bank balance sheets in this section. To demonstrate how such mechanisms can work, Figure 3.1 considers a hypothetical balance sheet. Starting with the left-hand side, consider a bank that holds loans and AFS securities. For this example, we assume that the bank has accumulated a positive AOCI account from unrealized gains on its portfolio, but note that AOCI could be zero or negative depending on the past performance of the bank's assets. For an NC bank, AOCI is not included in regulatory capital, and the bank's regulatory capital is given by Capital^{NC}. In contrast, AC banks include AOCI in their regulatory capital which is therefore $\text{Capital}^{AC} = \text{Capital}^{NC} + \text{AOCI}$.

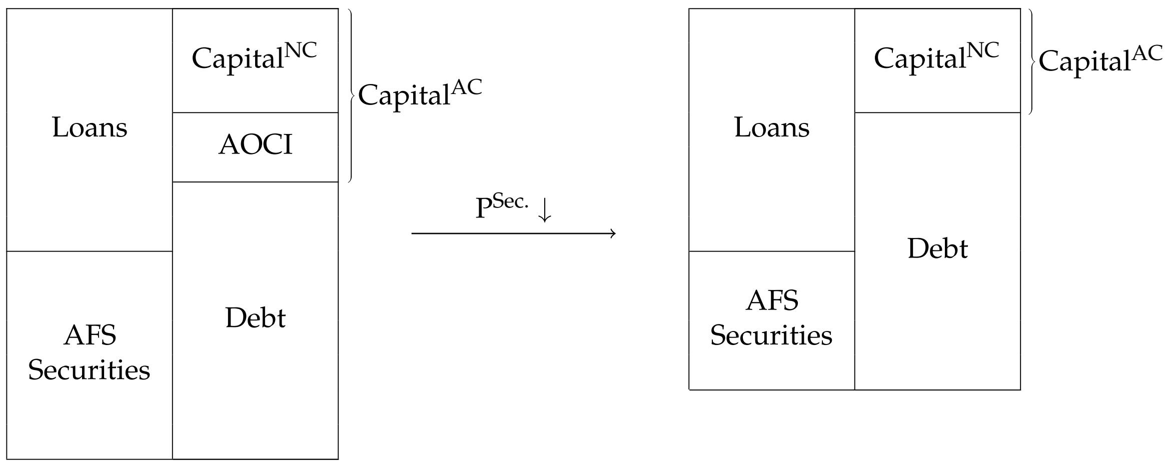
Next, holding all else constant, consider a fall in the price of securities, illustrated by the change from the left-hand side to the right-hand side in Figure 3.1. The balance sheet shrinks because AFS securities are marked to market. In this example, we assume for simplicity that the price decline wipes out the previous unrealized capital gains, so AOCI disappears. As before, this choice is made for illustration, as AOCI could alternatively shrink but remain positive, or turn negative. Following this price change, an AC bank would suffer a regulatory capital decline, while an NC bank would experience no change in regulatory capital.[14] This fall in measured regulatory capital could pressure banks to reduce their risk-weighted assets by cutting lending, particularly if they are less well capitalized. However, to measure the strength of this regulatory capital channel, we need to control for the presence of confounding channels unrelated to regulatory accounting that could lead securities values to affect bank lending.

Three alternative channels are likely relevant here. First, changes in securities values can operate through a net worth channel. Gains and losses on securities, all else equal, influence a bank's net worth (equity), which could affect lending in the presence of financial frictions. Second, changes in securities values could impact credit supply through their role as collateral. Because banks can pledge securities and borrow against them (e.g., in repo markets), a decline in the market value of their securities could reduce their borrowing capacity, potentially affecting their ability to lend.[15] Third, changes in securities values could operate via a liquidity stock channel. Banks hold securities in AFS because they expect to sell them at some future date, possibly supporting some short-term liquid-

[14] In this example, AC banks are actually better capitalized for a given amount of risk-weighted assets to begin with. In practice, banks would adjust their capital positions to remain relatively close to the required levels of capital. Thus, if AC and NC banks start with the same level of regulatory capital, AC banks would end up with less capital after the price decline.

[15] A similar collateral channel based on a bank's tangible common equity may also be present since certain financial market participants like Federal Home Loan Banks lend according to this ratio.

Figure 3.1: Accounting treatment for AFS Securities.



Notes: The figure shows changes in a hypothetical bank's balance sheet following a decline in security prices where securities are booked in AFS.

ity needs. A bank may therefore react by immediately reshuffling its portfolio away from loans to securities to rebuild its buffer stock of liquid securities.

To identify the independent effect of regulatory capital, our empirical analysis exploits that only a subset of securities at a subset of banks are marked to market in the computation of regulatory capital. This allows us to better isolate the effect of security values on lending via the regulatory channel by comparing "treated" securities whose values may pass through into regulatory capital against "control" securities whose values do not.

We first compare the effect of changes in the value of AFS securities, which are marked to market, against changes in the value of HTM, which are not (see Appendix Figure B.1). This comparison should net out the net worth and collateral channels, which are activated symmetrically by value changes of both types of securities, revealing the combined effect of the regulatory capital and liquidity channels. Similarly, because hedges offset all channels except for the collateral one, comparing the effect of changes of hedged vs. unhedged AFS securities should control for this channel (see Appendix Figure B.2).[16] Last, as the most direct test of the regulatory capital channel, we compare the change in AFS values at AC vs. NC banks. Since AFS value changes at NC banks should incorporate the net worth, collateral, and liquidity stock channels, this comparison isolates the role of the regulatory capital channel. Equipped with this institutional knowledge and these predictions, we next turn to the data and the empirical analysis.

[16]For a fully hedged security that falls in value, a bank gains since the value of the hedge increases. However, hedges are typically not used as collateral in financial markets and are therefore less pledgeable, reducing the value of the total collateral that the bank has available.

4 Data

We primarily base our analysis on the FR Y-14Q data (or Y14 for short). These data are collected at the bank holding company (BHC) level for institutions subject to the Dodd-Frank stress tests and are available at a quarterly frequency. We combine data from three different schedules to create a merged data set new to the literature. Of particular interest is the B.1 schedule, which covers the universe of security holdings in the investment portfolio. In this schedule, we observe the current market value of security holdings, the security price, the amortized cost, the accounting intent (AFS or HTM), and an asset class description (e.g., Agency MBS).[17] To measure effective duration, we add security level information from the Intercontinental Exchange Fixed Income & Data Services.

We match the security level data with their associated hedging relationships designated under Generally Accepted Accounting Principles (GAAP) from the B.2 schedule. From this schedule, we use information about the hedge type (fair value or cash flow hedge), the hedged risk, the hedge sidedness (offsets in one or multiple directions), and the hedge percentage.[18] For our main empirical analysis, we select only two-sided fair value hedges, which account for around 94 percent of all hedges.

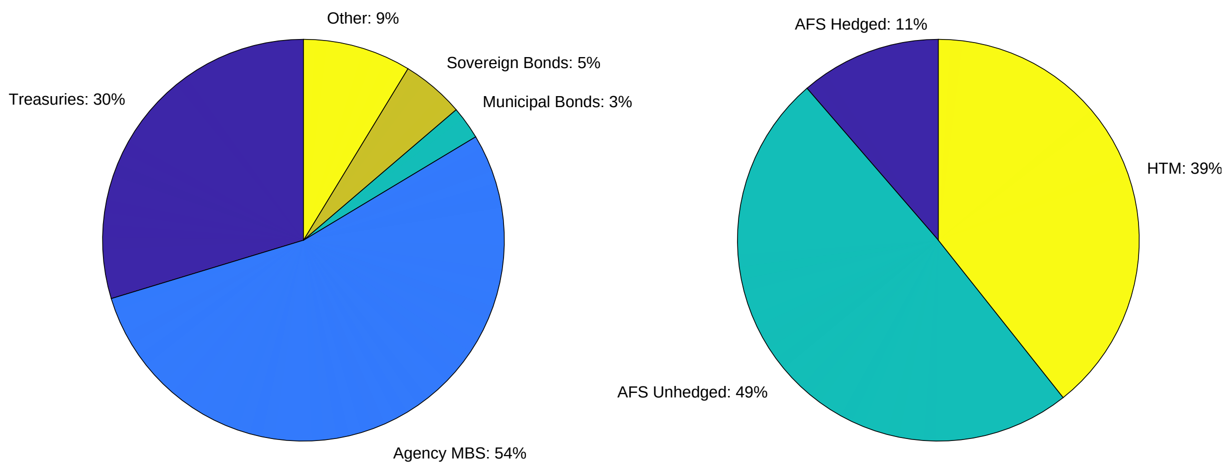
We obtain information on corporate credit relationships and firm financials from the Y14's H.1 schedule. This schedule provides data on all commercial loan facilities with over $1 million committed. In addition to the information on the loan facilities themselves, this schedule also includes detailed data on firm balance sheets and income statements collected by the banks. We refine this information in two ways. First, for publicly traded firms, we replace these fields with data from Standard & Poor's Compustat which is considered the most reliable source for firm financials. Second, when private firms have multiple loan facilities, and hence multiple reported observations for each financial variable at a given time, we use the median value across all observed BHC loan facilities in that period. This approach helps eliminate reporting errors and increases the number of dates for which we have observations on each firm's financial characteristics. Throughout, we exclude lending to financial and real estate firms.

Finally, we augment the data with BHC-level information from the FR Y-9C. Importantly, the variable BHCAP838 in these data identifies whether a BHC includes AOCI in its regulatory capital, making it an AC bank in our terminology. Appendix Table D.1 lists

[17] Amortized cost is defined as the purchase price of a debt security adjusted for amortization of premium or accretion of discount if the debt security was purchased at other than par or face value.

[18] The "hedge percentage" variable indicates how much of the securities holding is covered by the hedge. Accordingly, we consider a certain percentage of a security's price movement as hedged. Note that more than one hedge can be associated with a security, and we aggregate all the hedges to the security level.

Figure 5.1: Composition of Securities Portfolios.



Notes: Data from FR Y-14Q sampled in 2021:Q4. The charts show the allocation shares of aggregate securities portfolio by asset class (left panel) and by accounting designation (right panel). Shares are computed as percent of total market value.

the resulting classification of AC and NC banks in our data. For our main sample, there were 29 BHCs reporting data in the corporate loan portfolio consecutively, 10 of which are considered AC banks. Appendix Tables D.2-D.5 summarize all the variables we use from the Y14's B.1, B.2, and H.1 schedules, Compustat, and FR Y-9C, and Appendix E lists a number of sample restrictions and filtering steps that we apply.

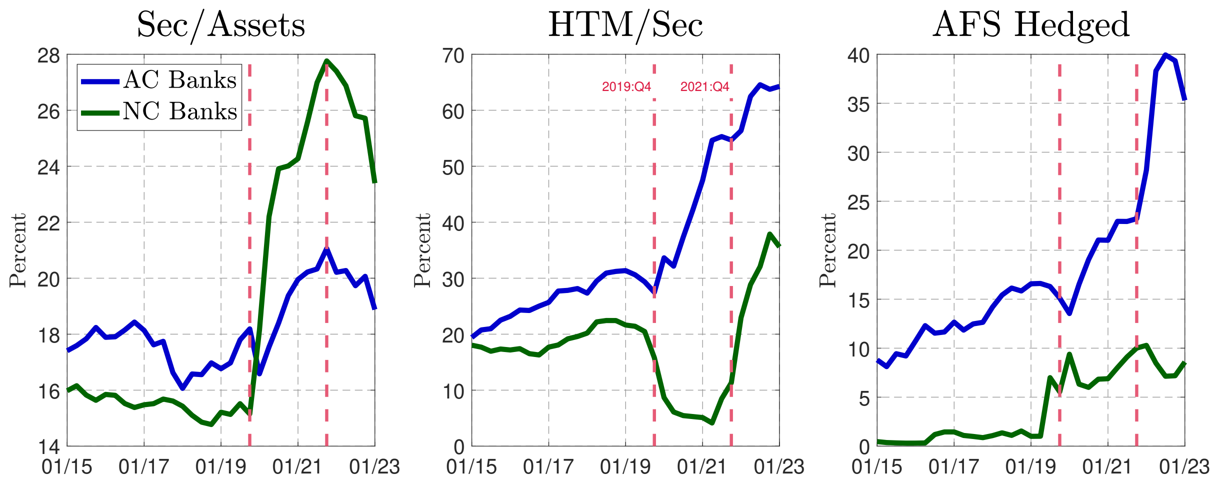
For our main empirical analysis, we focus on the monetary tightening cycle of 2022 and include data until the latest vintage that is available in 2023:Q1. To consider a pre-sample of similar length, we start our sample in 2021:Q1. A benefit of this starting point is that it excludes the period surrounding the COVID-19 outbreak in 2020, which exhibited an unusual pattern of bank-firm lending dominated by credit line draws from large firms (see, e.g., Greenwald, Krainer and Paul, 2023). However, we test the robustness of our findings on a longer sample in Section 6.1.

5 Stylized Facts

We next summarize key facts about the composition of bank securities portfolios and how these have varied by bank type and time.

Banks' investment securities portfolios are large, accounting for around 23 percent of aggregate bank assets in 2021:Q4. The left panel of Figure 5.1 displays the composition of security holdings by asset class. Bank securities are mostly composed of agency MBS

Figure 5.2: Evolution of Securities Portfolio.



Notes: Data from FR Y-14Q Schedules B.1 and B.2. The graph shows the evolution of the securities portfolio by bank type (AC versus NC banks). The left panel depicts securities as a percentage of total assets. The middle panel shows HTM holdings as a percentage of total securities. The right panel shows the share of AFS securities that are hedged. Vertical dashed lines indicate 2019:Q4 and 2021:Q4.

and Treasuries, which account for around 85 percent of the total portfolio at market value. Because these assets are almost exclusively from high-rated issuers or insured by the Government Sponsored Enterprises, credit risk on these portfolios is minimal. Instead, risk exposure on these bank portfolios is dominated by interest rate risk.

The right panel of Figure 5.1 breaks down these securities by their classification in 2021:Q4. Around 60 percent of all bank securities were held as AFS, with the rest as HTM, while 19 percent of the AFS portfolio was hedged using some form of accounting hedge. Appendix Figure F.1 provides additional information on the type of risks that the hedges cover, showing that banks primarily use hedges against interest rate risk (interest rate swaps), which account for 86 percent of all contracts.[19]

From this baseline, we next analyze changes in bank securities portfolios around our sample period. During the pandemic period, BHCs responded to large inflows of deposits and an environment of heightened uncertainty by dramatically increasing their security portfolios. This pattern is portrayed in the left panel of Figure 5.2 which shows the fraction of bank assets invested in securities. This surge in securities holdings was particularly pronounced for NC banks, which raised their securities holdings from 15

[19] Appendix Figures F.2 and F.3 decompose these patterns by AC and NC banks, showing that AC banks hold relatively more Treasuries than agency MBS compared with NC banks. Hedges effectively shorten the maturity of securities, which we illustrate in Appendix Figure F.4. While AC and NC banks have similar effective duration of AFS and HTM securities portfolios, AC banks hold AFS securities with substantially lower effective duration when taking into account hedges.

percent of total assets to a peak of 28 percent before partially reversing this increase during the tightening cycle. In contrast, AC banks raised their overall security holdings by substantially less during the period of low interest rates.[20]

The middle panel of Figure 5.2 shows that AC banks hold larger shares of their total securities book in HTM compared with NC banks throughout the sample period. This pattern is also documented in Fuster and Vickery (2018) and Kim, Kim and Ryan (2019) who analyze the years prior to the COVID-19 pandemic. The differences between AC and NC banks become particularly stark during the low interest rate environment in 2020 and 2021, with the HTM share of AC bank securities nearly doubling, while the HTM share for NC banks falls by more than half.[21]

Finally, focusing on fair-value hedges against interest rate risk, the right panel of Figure 5.2 shows that AC banks generally hedge a larger share of their AFS securities compared with NC banks. This hedging gap grew during the period of low interest rates in 2020 and 2021 and accelerated even further when rates started to rise in 2022:Q1.

These trends are all consistent with a regulatory motive for AC banks to avoid exposure to losses on AFS securities that would pass through to their regulatory capital. However, despite these efforts to limit AFS exposure, AC banks experienced security losses over the 2022-2023 monetary tightening episode that sharply reduced their AOCI positions. Appendix Figure F.5 shows that AOCI at AC banks fell by around one percent of risk-weighted assets due to unrealized losses on AFS securities, directly reducing the regulatory capital positions at these banks by the same amount. At the same time, NC banks experienced an even larger decline of AOCI by around three percentage points of risk-weighted assets, but faced no resulting change in regulatory capital due to their differential treatment under the regulatory accounting framework.

6 Identifying Credit Supply Effects

In this section, we measure the effect of fluctuations in bank security values on credit supply to nonfinancial firms.

[20] The differential changes of security holdings may also be partially explained by a larger increase of deposits at NC banks between 2019:Q4 and 2021:Q4, which experienced a rise of their deposit-to-asset ratio of around 8pp, in comparison to an increase of around 4pp at AC banks. However, the ratio of securities to deposits grew substantially more at NC banks (around 14pp) relative to AC banks (around 3pp).

[21] Appendix Figure C.1 further shows incidences of reclassifying existing securities between AFS and HTM for the two sets of banks (see also Granja, 2023). Kim, Kim and Ryan (2023) focus on reclassifications by the banks that reinstated the AOCI filter with the tailoring rules in 2019 and show that such banks reclassified more securities from HTM to AFS.

6.1 Effects by Security Classification

To begin, we estimate the overall effect of changes in securities values on bank-firm lending, and decompose this effect by how securities are classified (as AFS or HTM) and whether they are hedged. A typical challenge with such an exercise is that the set of firms that borrow from banks with larger securities losses may differ systematically from other firms. In this case, differences in lending could reflect the differential credit demand of these firms, rather than the causal effect of changes in securities values.

To address this, our main regression specifications include firm-time fixed effects, following Khwaja and Mian (2008), which absorb variation in overall firm credit demand. We thus identify credit supply effects from the relative changes in borrowing across multiple lenders by the same firm. For firm i and bank j, we estimate the regression

$$\frac{L_{i,j,t+2} - L_{i,j,t}}{0.5 \cdot (L_{i,j,t+2} + L_{i,j,t})} = \alpha_{i,t} + \beta \cdot \frac{\Delta Value^{SEC}_{j,t+1}}{Assets_{j,t}} + \tau_{AC_j,t} + \gamma X_{j,t} + \kappa_j + u_{i,j,t} \,, \tag{6.1}$$

where $L_{i,j,t}$ is the aggregated amount of term lending between a firm and a bank at time t, and $\alpha_{i,t}$ is a firm-time fixed effect. We focus on term lending and exclude credit lines from our main analysis because the predetermined spreads and commitments on credit lines largely insulate them from shifts in credit supply (Greenwald, Krainer and Paul, 2023), but we show that our results are robust to lifting this restriction later on. The dependent variable is the symmetric growth rate in $L_{i,j,t}$ over the two quarters from t to $t+2$. Unlike standard growth rates, symmetric growth rates allow for possible zero observations and are bounded in the range $[-2, 2]$, reducing the potential influence of outliers.

The main regressor of interest is the change in the value of a bank's securities between t and $t+1$ relative to total bank assets, denoted by $\Delta Value^{SEC}_{j,t+1} / Assets_{j,t}$. Since we observe the market value $MV^k_{j,t}$ and the price $P^k_{j,t}$ of each bank security k, we compute a bank's aggregated security value change as

$$\Delta Value^{SEC}_{j,t+1} = \sum_k \left(\frac{P^k_{j,t+1} - P^k_{j,t}}{0.5 \cdot (P^k_{j,t+1} + P^k_{j,t})} \right) \cdot MV^k_{j,t}, \tag{6.2}$$

where we again use the symmetric growth rate to approximate a percentage change in the price. Importantly, our detailed security level data enable us to compute the total value change of a bank's *pre-existing* securities portfolio aggregated from the individual security value changes. In contrast, a regressor constructed from aggregated bank balance sheet data would confound gains and losses on pre-existing securities with new purchases and sales. Thus, we take a bank's choice of security holdings as given and study how subsequent changes in the value of those securities affect bank credit supply.

The associated coefficient β captures credit supply effects. A positive β would indicate that a bank that experiences a fall in the value of its securities relative to another bank extends less credit to the same firm. Based on the discussions in Sections 3 and 5, a potential concern may be that AC banks have higher true values of β due to their regulatory exposure, but a less negative $\Delta Value^{SEC}_{j,t+1} / Assets_{j,t}$ over our sample period because of their lower securities holdings.[22] If so, this correlation between exposure and response would bias β downward. We therefore include an AC bank-time fixed effect $\tau_{AC_j,t}$, where AC_j is an indicator that is equal to one if bank j is an AC bank and zero otherwise.[23] This allows us to consider the variation within the set of AC or NC banks at a particular time. Last, to account for possible correlations of our main regressor with bank characteristics, we include a standard set of bank-specific controls $X_{j,t}$ and a bank fixed effect κ_j. Appendix Table G.1 shows summary statistics for the main regressors in (6.1).

The estimation results for regression (6.1) are reported in Table 6.1. Column (i) shows the response to a change in the total value of a bank's securities portfolio. We estimate a positive β, implying that banks experiencing more negative security value changes extend relatively less credit, and we can reject the absence of an effect at the 5 percent level.

Next, we test whether changes in AFS and HTM values, which are subject to different regulatory treatment, have distinct effects on bank credit supply. Column (ii) reestimates our regression focusing on AFS value changes and excluding changes in HTM values. We find that our estimated coefficient β doubles in size and increases in statistical significance. Column (iii) separately estimates the responses of AFS and HTM, finding a coefficient on AFS value changes close to that of Column (ii), but a coefficient on HTM value changes that is more than three times smaller and cannot be distinguished from zero at standard confidence levels.

A potential identification concern is that banks may specialize in certain types of lending. If the response of firm credit demand differs by loan type in a way correlated with our regressors of interest, then firm-time fixed effects may not be sufficient to control for this variation (Paravisini, Rappoport and Schnabl, 2023). To address this, Column (iv) repeats the analysis using a finer set of firm-time-loan purpose fixed effects and finds even larger differences between our estimated responses to AFS and HTM value changes.[24]

[22] Specifically, the quarterly average of $\Delta Value^{SEC}_{j,t+1} / Assets_{j,t}$ for AC banks is around -0.35% over our sample, whereas NC banks experienced a more negative decline of -0.49%.

[23] AC_j is time-invariant since banks do not switch types over our sample.

[24] Specifically, we consider the categories "Mergers and Acquisition," "Working Capital (permanent or short-term)," "Real estate investment or acquisition," and "All other purposes" as separate types (see also Appendix Table D.2).

Table 6.1: Credit Supply Effects.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value SEC	3.16**					
	(1.33)					
Δ Value AFS		6.08***	6.15***	7.37***		
		(1.85)	(1.78)	(1.89)		
Δ Value HTM			1.93	1.31	1.85	0.71
			(1.47)	(1.23)	(1.38)	(1.44)
Δ Value AFS Unhedged					8.13***	8.68***
					(2.67)	(2.73)
Δ Value AFS Hedged					2.86	3.46
					(4.94)	(5.24)
Fixed Effects						
Firm × Time	✓	✓	✓		✓	
Firm × Time × Purpose				✓		✓
Bank & AC × Time	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Derivatives					✓	✓
R-squared	0.57	0.57	0.57	0.55	0.57	0.55
Observations	13,038	13,038	13,038	11,093	13,027	11,093
Number of Firms	1,289	1,289	1,289	1,105	1,288	1,105
Number of Banks	27	27	27	26	26	26

Notes: Estimation results for regression (6.1). All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (iv) and (vi). Columns (ii)-(iv) distinguish security value changes into AFS and HTM value changes. Columns (v) and (vi) further distinguish AFS value changes into hedged and unhedged value changes. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. Columns (v) and (vi) include controls for derivative contracts from the trading and derivative book (see footnote 25 for details). All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Last, we split changes in AFS security values by whether the security is hedged or unhedged. In our data, banks report the fraction of a security that is hedged against a certain risk. Consistent with our focus on interest rate transmission, we consider fair-value hedges against interest rate risk, which account for 86 percent of all hedges in our sample. We further only include Treasuries in the hedged component since their values fluctuate only because of interest rate risk, while values of other securities may change due to a number of alternative risk factors (e.g., credit risk, prepayment risk, foreign exchange risk, etc.). To be conservative, we therefore consider value changes of other securities as unhedged since we cannot assume that those are purely resulting from interest rate risk, even if a bank reports that a security is fully hedged against that risk.[25]

Columns (v) and (vi) of Table 6.1 repeat our analysis, splitting the change in AFS security values into a hedged component and an unhedged component. As in Columns (iii) and (iv), we estimate these responses alongside the response to changes in HTM values, and separately consider regressions using firm-time and firm-time-loan purpose fixed effects. In both cases, we find that changes in the value of unhedged AFS securities have a strong and highly significant effect on bank credit supply that is even larger than the unconditional coefficients on changes in AFS values in Columns (iii) and (iv). In contrast, the effect of changes in the value of hedged AFS securities is less than half the size and cannot be statistically distinguished from zero.

Overall, our results indicate a strong pass-through from changes in the value of AFS securities to bank-firm lending, particularly for unhedged AFS securities, but a weaker or zero spillover from changes in the value of HTM and hedged AFS securities. These results suggest that the regulatory capital channel, which can explain these relative responses, is quantitatively important, confirming a prediction from Section 3. The weak responses to changes in HTM and hedged AFS values further suggest that the net worth and collateral channels were not particularly important during our sample period.

To measure economic significance, we conduct a back-of-the-envelope calculation. Given the average ratio of term lending to bank assets observed, our estimates imply a lending cut of around 20 cents for each $1 decline in the value of bank AFS portfolios.[26] Moreover, we note that the regulatory capital channel provides incentives to reduce all risk-weighted assets, and is therefore not restricted to firm lending or term loans. As a result, while these measured spillover effects are already substantial, we consider them a lower bound on the total crowding out effect, which likely extends to other forms of credit not present in our sample such as small business, consumer, and real estate credit.

These estimates are also sizable from a different perspective. In regression (6.1), we consider all value changes of securities. That is motivated by the stylized fact in Section 5 that the vast majority of securities is interest rate-sensitive but carries little credit risk, so that most price changes are due to ex-post movements in interest rates. Nonetheless, some value changes may be expected ex-ante. The fact that we still find a spillover effect into banks' loan portfolios shows that an important fraction is unexpected, such that banks

[25] To account for other hedges than the ones we observe, we add information about bank derivatives from their trading and their derivative books as controls. Specifically, based on the Y-9C filings, we add derivatives with a positive or negative fair value from the trading book (BHCM3543, BHCK3547), as well as notional and fair values for interest rate contracts from the derivative book (BHCKA126, BHCK8733, BHCK8737), all scaled by total assets, see Appendix Table D.5 for details.

[26] This is computed by multiplying the typical ratio of term lending to bank assets across the Y14 banks over our sample (around 3 percent) with the midpoint of the estimates for β in Table 6.1.

feel the need to adjust their credit supply schedule.

We perform extensive robustness tests and explore extensions of our baseline results in Columns (ii)-(iv), which are collected in Appendix G. First, we consider alternative regression specifications that (i) replace the firm-time fixed effects by variations of location-, size-, and industry-time fixed effects, (ii) extend the firm-time fixed effects by other contract terms to consider loans of similar types (Ivashina, Laeven and Moral-Benito, 2022), (iii) include credit lines, and (iv) exclude the episode of financial turmoil in 2023:Q1. By and large, our results remain much the same across the various robustness tests.

Second, we extend the sample backwards to include episodes of monetary easings and explore the possibility of asymmetric effects by separating positive and negative AFS value changes. Both extensions yield consistent findings: we obtain smaller effects for positive AFS value changes and samples that cover periods of falling interest rates.

Third, we consider alternative dependent variables in (6.1). We estimate the responses of creation and termination of credit relationships (the extensive margin), finding quantitatively stronger responses compared to our results above. To study dynamic adjustments, we reestimate our regressions at various horizons to form impulse responses. We find that the credit supply effects already show up in the same quarter as the change in security prices, continue to build over time, and peak after three quarters. We also estimate the effect on interest rates, and obtain estimates that are consistent but quantitatively weaker compared with the results for credit quantities. Finally, we test for a pretrend, but find no such evidence based on a placebo regression.

6.2 Effects by Bank Type

In the previous section, we compared responses to changes in the value of securities with different classifications or hedging status, finding these credit supply effects were mainly driven by unhedged AFS securities. However, the regulatory treatment of AFS securities is not uniform across banks. Critically, AC banks must pass through changes in AFS values to their regulatory capital, while NC banks do not. For a more direct test of the regulatory capital channel, we estimate differences in the response to AFS gains and losses between AC and NC banks. Formally, we estimate the interacted regression

$$\frac{L_{i,j,t+2} - L_{i,j,t}}{0.5 \cdot (L_{i,j,t+2} + L_{i,j,t})} = \beta_1 \cdot \frac{\Delta Value^{AFS}_{j,t+1}}{Assets_{j,t}} + \beta_2 \cdot \frac{\Delta Value^{AFS}_{j,t+1}}{Assets_{j,t}} \cdot AC_j + \gamma X_{j,t} + \kappa_j + u_{i,j,t} \,. \tag{6.3}$$

Since the new interaction term directly captures differences in the responses of AC and NC banks, we omit the AC-bank-time fixed effect $\tau_{AC_j,t}$ that was present in (6.1).

Table 6.2: Credit Supply Effects, AC vs. NC Banks.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS	4.83**	5.65**	2.45	2.09	-2.08	-2.53
	(2.14)	(2.37)	(2.48)	(2.59)	(4.81)	(4.92)
Δ Value AFS × AC	7.55**	9.26***	10.86*	14.03**	12.95*	15.18**
	(3.50)	(3.14)	(5.81)	(5.23)	(6.94)	(6.39)
Δ Value AFS × Size			-2.11	-3.08*	-3.99	-4.71
			(1.87)	(1.78)	(3.45)	(3.54)
Fixed Effects						
Firm × Time	✓		✓		✓	
Firm × Time × Purpose		✓		✓		✓
Bank	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Bank Controls × Δ Value AFS					✓	✓
R-squared	0.57	0.55	0.57	0.55	0.57	0.55
Observations	13,038	11,093	13,038	11,093	13,038	11,093
Number of Firms	1,289	1,105	1,289	1,105	1,289	1,105
Number of Banks	27	26	27	26	27	26

Notes: Estimation results for regression (6.3). All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii), (iv), and (vi). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. Columns (v) and (vi) include interaction terms between the various demeaned bank controls and $\Delta Value^{AFS}_{j,t} / Assets_{j,t}$. All specifications include bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 6.2 reports our estimates for regression (6.3). As discussed in Section 6.1 above, we address concerns about bank specialization across loan types by reporting our regression results in pairs, with one specification using firm-time fixed effects, and the other using firm-time-loan purpose fixed effects.

Columns (i) and (ii) present our baseline results. We estimate large and significant coefficients β_2, alongside positive estimates for β_1. As before, both coefficients are slightly larger when controlling for the finer firm-time-loan purpose fixed effects. To interpret these estimates, note that the estimated response of an NC bank to a given change in AFS values is β_1, while the estimated response of an AC bank is $\beta_1 + \beta_2$. As a result, our estimates imply that the response of AC banks is more than 2.5 times larger than that of NC banks, while the statistical significance of the interaction term means that we can reject the hypothesis that AC and NC banks react symmetrically.[27]

[27] These patterns are also visible from bank-holding company data. Appendix Figures F.6 and F.7 show

An important caveat to these initial results is that assignment of banks to the AC or NC category is not random, but is instead primarily determined by bank size, with the larger banks falling in the AC category. To the extent that large banks react differently to changes in securities values, we could be falsely attributing these differences to variation in regulatory treatment. To address this, we therefore augment our regressions (6.2) to include an interaction between the change in AFS values and bank size, measured as the (demeaned) logarithm of assets. Columns (iii) and (iv) display our estimates from the augmented regression. In both specifications, we find that the interaction between changes in AFS values and bank size carries a negative coefficient, implying that larger banks react less to changes in securities values, holding all else equal. Since AC banks are larger, controlling for this trend by size increases our coefficient for β_2. At the same time, our estimated response of NC banks (β_1) is roughly cut in half, and we can no longer reject that the response of an NC bank of average size is zero.

Last, to avoid similar confounding issues with other covariates, Columns (v) and (vi) further extend this regression by interacting the change in AFS values with additional demeaned bank controls.[28] As before, these additional controls absorb smooth variation in the responsiveness of banks to AFS gains and losses by characteristic, so that our main coefficient of interest β_2 more narrowly focuses on variation around the AC classification cutoff. As with our size interaction, allowing for these extra interacted controls increases the interaction coefficients β_2 and decreases the base coefficients β_1.[29]

Combined, these results provide evidence that firm credit supply at AC banks reacts more strongly than at NC banks to the same change in AFS values. This is consistent with our prediction in Section 3, since AFS gains and losses pass through to regulatory capital at AC banks but not NC banks.[30] Our results therefore provide strong evidence that the regulatory capital channel, only present for AC banks, is the primary mechanism of

that unrealized losses on AFS securities and C&I lending growth are positively related for NC banks, whereas they are negatively related for AC banks.

[28]Appendix Table G.1 shows summary statistics of various bank controls for the two type of banks separately, indicating some differences with respect to loan shares, deposit shares, and credit line commitments.

[29]The additional interaction terms are also meaningful in the sense of Oster (2019). Comparing R-squared measures of the baseline regressions in columns (i) and (ii), the ones with the additional interactions in columns (v) and (vi), and regressions that include bank-time fixed effects which give the maximum achievable R-squared measures from including bank level controls, shows that the additional interaction terms close between 6 and 68 percent of the gap in R-squared measures between the baseline regressions and the maximum R-squared measures.

[30]Appendix Table H.4 shows that these results are not explained by a firm switching between AC and NC banks when borrowing from both, but largely remain and even somewhat intensify when we extend the firm-time fixed effects by the AC-bank indicator AC_j, thus considering samples when a firm only borrows from one type of bank. The pass-through to total firm debt in Section 6.3 provides further evidence against the importance of such a switching effect in our data.

transmission from interest rates into bank-firm lending, while alternative channels such as the net worth, collateral, or liquidity stock channels present for both AC and NC banks were much weaker or nonexistent for our sample banks and period.

We supplement these findings with additional specifications and robustness checks in Appendix H. First, as in Section 6.1, we rerun regression (6.3), splitting changes in AFS values into hedged and unhedged components. Our estimates show that the effect for AC banks is stronger for changes in unhedged AFS values, though the estimates are less precise for this extended regression. Second, we explore heterogeneity in bank's responses by their capital positions. We find that less-capitalized banks show stronger spillover effects, as predicted in Section 3.

Third, we provide further evidence that our baseline findings are explained by banks' exposure to interest rate risk that leads to fluctuations in the value of their securities portfolios. To this end, we employ an instrumental variable regression, using the interaction between the yield change of the one-year Treasury security and a bank's preexisting AFS portfolio as an instrument for our main regressor. If anything, our results strengthen in magnitude for this alternative specification.

Fourth, we augment our regression to include deposit flows, net income changes, liquid asset holdings, and changes in the quality of loan portfolios at each bank. Incorporating these variables allows us to control for alternative mechanisms centered around liquidity or loan quality following changes in interest rates, such as those highlighted by Drechsler, Savov and Schnabl (2017), Gomez et al. (2021), and Kashyap and Stein (2000). We obtain estimates for the response of credit supply to changes in AFS security values that are similar to and slightly stronger than our baseline results, indicating that our findings are independent from these existing mechanisms.

6.3 Effects at the Firm Level

We conclude our empirical analysis at the firm level, testing if and how changes in bank securities values transmit into firm balance sheets and investment. We follow an approach similar to Khwaja and Mian (2008), computing each firm's overall exposure to changes in bank AFS values as a weighted average of these changes at each bank lending to that firm, weighted by the share of firm debt obtained from that bank.[31] Formally, we

[31] Consistent with the previous regressions, we restrict the sample to term loans only. Since we do not cover all firm debt positions, we control for the ratio of observed credit to total firm debt.

define the exposure of firm i to changes in bank AFS values from time t to $t+1$ as

$$\Delta \widetilde{Value}^{AFS}_{i,t+1} = \sum_j \left(\frac{\Delta Value^{AFS}_{j,t+1}}{Assets_{j,t}} \right) \cdot \left(\frac{L_{i,j,t}}{Debt_{i,t}} \right). \tag{6.4}$$

Using this definition, we estimate the regression

$$\frac{y_{i,t+4} - y_{i,t}}{0.5 \cdot (y_{i,t+4} + y_{i,t})} = \alpha_i + \kappa_t + \beta \cdot \Delta \widetilde{Value}^{AFS}_{i,t+1} + \gamma X_{i,t} + u_{i,t} \,, \tag{6.5}$$

where the dependent variable $y_{i,t}$ is either total liabilities, fixed assets (a proxy for investment), or cash and marketable securities.[32] We again use the symmetric growth rate for the dependent variable to approximate percentage changes, but this time consider a four-quarter-horizon since firm financials are updated annually for most private firms.

Because we have one observation per firm in each period, we can no longer include firm-time fixed effects. Instead, we rely on our results in Table G.2 showing that our findings are not dependent on the inclusion of a firm-time fixed effect. Instead, we include firm fixed effects (α_i) and time fixed effects (κ_t). We also include a vector of controls $X_{i,t}$ containing both firm-level variables, as well as bank-level variables that are aggregated to the firm level based on the firms' debt shares, as in (6.4). This latter group includes the contemporaneous deposit and net income changes at a firm's lender banks, as in Table H.3, to account for alternative channels highlighted by the existing literature.

The estimation results are reported in Table 6.3. Columns (i), (iii), and (v) show the estimates for total liabilities, fixed assets, and cash holdings. In each case, we find a positive coefficient, implying that all three variables decline at firms whose lender banks experience losses on their AFS securities, and we can reject that each effect is zero at the 5 percent level. To compare these results to our earlier findings, note that the ratio of our point estimate for total liabilities in Column (i) of Table 6.3 to our point estimates for bank lending in Columns (iii) and (iv) of Table 6.1 is 0.67 and 0.56, respectively. Because the ratio of debt to total liabilities is 0.57 at the average firm in our sample, these results are consistent with complete pass-through, meaning a change in total liabilities (in dollars) that is equal to the change in bank debt from the Y14 banks. These estimates therefore indicate that firms facing contractions of credit supply due to bank securities losses are generally unable to substitute to credit from other banks or nonbank lenders.

Columns (iii) and (v) show that firm adjustments of investment and cash holdings

[32] We consider total liabilities as opposed to total debt since firms may adjust other non-debt liabilities such as accounts payable in response to a credit supply shock.

Table 6.3: Firm Level Effects.

	Δ Liabilities		Investment		Δ Cash	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS	4.14**		5.30**		10.45**	
	(2.07)		(2.67)		(4.48)	
Δ Value AFS × Small		4.13**		5.35**		10.47**
		(2.07)		(2.67)		(4.49)
Δ Value AFS × Large		5.42		-4.33		7.64
		(6.70)		(9.31)		(18.39)
Fixed Effects						
Firm	✓	✓	✓	✓	✓	✓
Time	✓	✓	✓	✓	✓	✓
Firm Controls	✓	✓	✓	✓	✓	✓
R-squared	0.78	0.78	0.72	0.72	0.66	0.66
Observations	83,663	83,663	82,473	82,473	81,901	81,901
Number of Firms	22,499	22,499	22,162	22,162	22,116	22,116
Number of Banks	30	30	30	30	30	30

Notes: Estimation results for regression (6.5) where $y_{i,t}$ is either total liabilities in columns (i) and (ii), fixed assets in columns (iii) and (iv), or cash holdings in columns (v) and (vi). All specifications include firm fixed effects and the firm controls: cash holdings, fixed assets, liabilities, net income, sales (all scaled by total assets), firm size (natural logarithm of total assets), the ratio of observed debt to total debt, as well as the set of all bank controls used in previous regressions and deposit and net income changes from Column (iv) of Table H.3 aggregated to the firm level using debt shares across lenders. Standard errors in parentheses are clustered by firm. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

are also highly economically significant. Since firms in our sample have average ratios of fixed assets to total liabilities of 0.26, and cash to total liabilities of 0.13, these coefficients imply that each dollar of debt crowded out by bank securities losses leads firms to contract investment in fixed assets and cash holdings each by around 33 cents. Thus, the inability of firms to substitute into other forms of debt has real economic consequences by reducing investment and shrinking firms' precautionary cash buffers.

Finally, to explore heterogeneity in transmission, we separately estimate the response of firms by size. We hypothesize that larger firms should be less affected by a contraction of bank credit supply since they have better access to nonbank sources of financing. Columns (ii), (iv), and (vi) repeat the regressions of Columns (i), (iii), and (v), respectively, but use an indicator to split the sample into large firms in the top 10% of our firm size distribution, and small firms in the bottom 90% of our firm size distribution. Our estimates show coefficients on small firms that are significant and highly similar to our overall results. In contrast, our estimates for large firms are imprecise and cannot be statistically distinguished from zero. These findings motivate our construction of the model, which features two types of firms that differ in their access to financing.[33]

7 Model

To study the effects of changes in security values and their regulatory treatment on interest rate transmission in general equilibrium, we present a structural model building on Greenwald, Krainer and Paul (2023). We briefly summarize the key ingredients of the model, present the detailed structure, calibrate the model, and describe our findings.

7.1 Model Overview

Our model is designed to capture the pathway of transmission from interest rates, through securities values and bank capital requirements, into bank-firm lending and real activity. Banks in our model hold long term securities, which are priced according to long-term interest rate forecasts. Banks must also hold capital against their loan portfolio, which may be influenced by gains and losses on their securities, depending on the regulatory regime. Under a mark-to-market regime, where gains and losses are included in regulatory capital, an increase in securities prices allows banks to lend more without raising capital, expanding credit supply, while a decline in securities prices has the opposite effect.

Because Table 6.3 only finds strong evidence of credit supply effects at small firms, we introduce heterogeneity in firms by size. We assume that large "unconstrained" firms obtain credit by issuing bonds, insulating them from banking sector conditions.[34] In contrast, smaller "constrained" firms can only borrow using bank term loans, exposing them to changes in bank credit supply. These assumptions ensure that only small firms are directly affected by our regulatory capital mechanism in the model, and are conservative in that allowing similar effects at large firms would only amplify our results.

We embed this structure into a general equilibrium framework featuring a rich set of quantitatively realistic adjustment frictions, and calibrate the model to directly match our firm-level regressions in Table 6.3. We expose this model to a large increase in interest rates calibrated to match the rise in the data from 2021 to 2023, which causes securities

[33] Consistent with our model setup, where small firms only have access to term loans, Appendix Table I.1 shows that the results remain if we separate firms according to whether they have any unused credit line capacity in our data. Firms without credit line capacity show a similar pass-through as small firms.

[34] Greenwald, Krainer and Paul (2023) show that large firms also have substantially more undrawn credit line capacity, whose predetermined spreads would similarly insulate them from rising bank spreads.

prices to fall. If banks are required to include gains and losses on securities in their regulatory capital, this tightens capital requirements, contracting credit supply.

We evaluate the strength of this mechanism under three regulatory regimes: a "Baseline" regime corresponding to the existing economy, in which only a subset of securities are marked to market, a counterfactual "Book Value" regime in which no securities are marked to market, and a counterfactual "All Mark to Market" regime in which all securities are marked to market and all banks are AC banks. Comparing results across these regimes, we find large impacts of regulatory accounting policy on interest rate transmission, which is stronger when more securities are marked to market.

7.2 Model Structure

Demographics and Preferences. Our model features three types of household: constrained entrepreneurs (denoted C), unconstrained entrepreneurs (denoted U), and savers (denoted S). Each type of household is able to trade a complete set of contracts with other households of the same type, but not across types, leading to aggregation to a representative household for each type.

An entrepreneur of type j has exponential utility (constant absolute risk aversion) preferences over consumption $C_{j,t}$ defined by[35]

$$U_{j,t} = E_t \sum_{k=0}^{\infty} \beta_j^k \frac{(1 - \exp(-\zeta_D C_{j,t}))}{\zeta_D}. \tag{7.1}$$

Each entrepreneur owns a firm of the same type and consumes its dividends. As a result, using a concave utility function increases marginal utility when dividends are low, providing incentives for firms to smooth dividends.

For the saver type, we assume risk-neutral preferences over consumption $C_{S,t}$:

$$U_{S,t} = E_t \sum_{k=0}^{\infty} \left(\prod_{k=1}^{t} \beta_{S,k} \right) C_{S,t}. \tag{7.2}$$

This assumption simplifies our analysis by ensuring an exogenous risk-free rate that depends only on the discount factor and expected inflation. The $\beta_{S,k}$ terms represent time-

[35]Using exponential utility rather than power utility (constant relative risk aversion) preferences allows us to avoid taking a stand on whether entrepreneurs also receive consumption from other sources, and is able to accommodate zero or negative dividends (equity issuance), which can occur in practice.

varying discount factors for the saver, following the stochastic process

$$\log \beta_{S,t} = (1 - \rho_\beta) \log \bar{\beta}_S + \rho_\beta \log \beta_{S,t-1} + \varepsilon_{\beta,t}, \tag{7.3}$$

where $\varepsilon_{\beta,t}$ is a stochastic innovation we employ in Section 7.5 to shock real interest rates. Savers inelastically supply $\bar{N}$ units of labor each period.

Productive Technology and Labor Demand. The production function is

$$Y_{j,t} = Z_t K_{j,t-1}^{\alpha} \bar{N}_j^{1-\alpha},$$

where $j \in \{C, U\}$ denotes the type of the firm, Z_t is exogenous aggregate productivity, $K_{j,t-1}$ is capital, and $\bar{N}_j$ is labor, which firms use in a fixed quantity at a fixed wage w.[36]

Firm Types. Firms take two types: constrained firms (denoted C) and unconstrained firms (denoted U). Each is owned by an entrepreneur of the corresponding type. Types differ in their ability to use financial instruments. While unconstrained firms can borrow using corporate bonds, constrained firms can only borrow using term loans from banks.

Firm Debt Contracts. We model both corporate bonds and term loans as floating rate contracts with fixed spreads, meaning that for each dollar of loan balance at time $t + j$ on a loan originally issued at time t, a firm must make an interest payment of $r_{t+j} + s_t$ dollars at time $t + 1$, where r_{t+j} is the contemporaneous risk-free rate, and s_t is the loan spread, which was fixed at origination (time t). In addition to interest, a fraction ν of debt matures and must be repaid each period, while fraction $1 - \nu$ of debt is carried into the following period, so that one-period debt corresponds to $\nu = 1$. This structure requires two debt-related state variables per firm: the total principal balance ($B_{j,t}$), and the total amount of promised spread payments in the following period ($S_{j,t}$). These evolve according to

$$\begin{aligned} B_{j,t} &= \underbrace{B_{j,t}^*}_{\text{new debt}} + \underbrace{(1-\nu)\pi_t^{-1} B_{j,t-1}}_{\text{existing debt}} \\ S_{j,t} &= \underbrace{s_{j,t} B_{j,t}^*}_{\text{new spread payments}} + \underbrace{(1-\nu)\pi_t^{-1} S_{j,t-1}}_{\text{existing spread payments}}, \end{aligned}$$

[36] Assuming labor demand and wages are fixed stands in for unmodeled frictions in the labor market that may prevent wage or hour adjustments at the relatively short time horizons we consider. Assuming that labor is a fixed factor also serves as a simple way to pin down the relative scales of the two types of firms without requiring us to take a stand on the elasticity of substitution the goods they produce.

where $B_{j,t}^{*}$ is newly issued debt, $s_{j,t}$ is the average spread per dollar of debt issued, and inflation (π_t) translates from nominal to real terms. The spread on new debt $s_{j,t}$ depends on each firm's funding structure: constrained firms borrow using bank loans at spread s_t^{loan}, while unconstrained firms borrow using corporate bonds at spread s_t^{bond}.

Firm Debt Covenants. Firm debt contracts contain debt-to-EBITDA covenants that penalize firms if their total debt exceeds a multiple of smoothed EBITDA $(X_{j,t})$, defined by

$$X_{j,t} = (1 - \rho_X) \underbrace{(Y_{j,t} - w\bar{N}_j)}_{\text{current EBITDA}} + \rho_X \pi_t^{-1} X_{j,t-1}, \tag{7.4}$$

where EBITDA represents output net of the wage bill, and the deflator term π_t^{-1} accounts for the fact that smoothed EBITDA is measured in nominal terms.

Because firms face uncertainty about their future EBITDA, they typically leave a precautionary buffer in their covenant ratios away from the violation threshold. To match this in our framework, we assume that a firm violates its covenant if

$$\pi_t^{-1} B_{j,t-1} > \omega_{i,t} \theta X_{j,t}, \tag{7.5}$$

where $\omega_{i,t}$ are i.i.d. shocks. These shocks induce uncertainty similar to that described above, leading to precautionary behavior. Because firms in our model are not exactly at the covenant violation threshold, they are not literally constrained, and can obtain an additional dollar of debt if they choose to. Instead, the increased probability of covenant violation from maintaining a smaller buffer, combined with the cost of credit, balances against the marginal benefit of debt to create an interior solution.

Rearranging (7.5), a firm of type j violates its covenant if and only if $\omega_{i,t} < \bar{\omega}_{j,t}$, for

$$\bar{\omega}_{j,t} = \frac{\pi_t^{-1} B_{j,t-1}}{\theta X_{j,t}}. \tag{7.6}$$

The probability of violation is $\Gamma_{\omega,j}(\bar{\omega}_{j,t})$, which is increasing in the firm's expected ratio of debt to smoothed EBITDA. We assume that firms that violate their covenants must pay a penalty equal to fraction κ_j of their start-of-period principal balance $\pi_t^{-1} B_{j,t-1}$.

Firm's Problem. The representative firm owned by entrepreneurs of type j chooses dividends $D_{j,t}$, cash holdings $A_{j,t}$, new debt issuance $B^*_{j,t}$, and new capital $K_{j,t}$ to maximize

$$V_{j,t} = D_{j,t} + \eta_{A,j} \frac{A_{j,t}^{1-\zeta_A}}{1-\zeta_A} + E_t\Big[\Lambda_{j,t+1} V_{j,t+1}\Big], \tag{7.7}$$

where term $\Lambda_{j,t+1}$ is the stochastic discount factor of the type j entrepreneur

$$\Lambda_{j,t+1} = \beta_j \exp\Big(-\zeta_D (C_{j,t+1} - C_{j,t})\Big), \tag{7.8}$$

which rewards dividend smoothing at equilibrium due to entrepreneurs' concave utility.

The value function (7.7) includes a utility term for holding cash. This stands in for the precautionary or liquidity motives that lead firms to hold cash in reality, allowing our model to reproduce this behavior in a deterministic setting. We allow the utility weight $\eta_{A,j}$ to vary by firm type j to match cash holdings by large and small firms.

The budget constraint for a firm of type j is

$$\begin{aligned} D_{j,t} = {} & \underbrace{(1-\tau)\,(Y_{j,t} - wN_j)}_{\text{after-tax profit}} + \underbrace{\Big(1-(1-\tau)\delta\Big)\bar{Q}_{j,t}K_{j,t-1}}_{\text{old capital}} + \underbrace{\pi_t^{-1}\Big(1+(1-\tau)r_{t-1}\Big)A_{j,t-1}}_{\text{old cash}} \\ & - \underbrace{\pi_t^{-1}\Big[\Big((1-\tau)r_{t-1} + \nu + \kappa_j \Gamma_{\omega,j}(\bar{\omega}_{j,t})\Big)B_{j,t-1} + (1-\tau)S_{j,t-1}\Big]}_{\text{payments on existing debt}} \\ & - \underbrace{Q_{j,t}K_{j,t}}_{\text{new capital}} - \underbrace{A_{j,t}}_{\text{new cash}} + \underbrace{B^*_{j,t}}_{\text{new debt}}, \end{aligned} \tag{7.9}$$

where $D_{j,t}$ is dividends paid to the type j entrepreneur, $Q_{j,t}$ is the price of new capital, $\bar{Q}_{j,t}$ is the resale price of old capital, $B^*_{j,t}$ is new debt issued by firm j, r_{t-1} is the risk-free interest rate, τ is the corporate tax rate, and δ is the depreciation rate. Both depreciation and interest payments on debt are tax-deductible. We assume that cash is held as a form of government debt and earns the risk-free rate, with its interest subject to corporate tax. The "payments on existing debt" term consists of base interest rate payments net of the tax shield $(1-\tau)r_{t-1}$, principal payments ν, and average violation costs $\kappa_j \Gamma_{\omega,j}(\bar{\omega}_{j,t})$, all per unit of principal balance, in addition to spread payments net of the tax shield $(1-\tau)S_{j,t-1}$.

Entrepeneurs' Problems. The unconstrained and constrained entrepreneurs choose consumption $C_{j,t}$ to maximize (7.1) subject to the budget constraint $C_{j,t} \leq D_{j,t}$.

Bank's Problem. We assume a homogeneous banking sector in which all gains and losses on AFS securities pass through to regulatory capital. Although only a subset of banks (the AC banks) receive this regulatory treatment in reality, we explain in Section 7.4 below how we calibrate this homogeneous-bank model to match the average effect of mark-to-market regulation across banks in our Y14 data.

The representative bank provides term loans to constrained firms. Since banks are owned by the saver and directly pass through their profits, we abstract from separately modeling a deposit structure, as in the absence of additional frictions the balance sheets of the bank and saver household are effectively combined.

Each bank is subject to a risk-based capital requirement of the form:

$$k_t + AOCI_t \geq \chi^{loan} B_t^{loan} + \chi^{other} \bar{B}^{other}. \tag{7.10}$$

This constraint requires that banks hold χ^{loan} dollars of capital for each dollar of term loans B_t^{loan} currently extended to firms, as well as a constant amount $\bar{B}^{other}$ of other bank assets, which carries a potentially different capital charge of χ^{other}. The term $AOCI_t$ represents unrealized gains and losses on securities, defined by

$$AOCI_t = (P_t - \bar{P}) \times b^{AFS}, \tag{7.11}$$

where P_t is the price of the long-term bond, $\bar{P}$ is its steady state value, and b^{AFS} is the number of long-term bonds held by the bank, assumed to be fixed and exogenous.

The representative bank chooses dividends d_t, bank capital k_t, and new loans to constrained firms $B_t^{loan,*}$ to maximize

$$v_t = \underbrace{d_t}_{\text{dividends}} - \underbrace{\left(\frac{\eta_k}{\bar{k}^{\zeta_L}}\right) \frac{k_t^{1+\zeta_L}}{1+\zeta_L}}_{\text{capital holding costs}} + E_t\Big[\Lambda_{S,t+1} v_{t+1}\Big]. \tag{7.12}$$

Capital requirements only matter for bank allocations if banks would otherwise prefer to hold less capital. To capture this, we include capital holding costs in bank utility, causing the capital requirement (7.10) to bind at equilibrium. As a result, changes in risk-weighted assets or AOCI influence bank behavior via the capital requirement. The capital holding cost has curvature ζ_L, which controls the strength of the credit supply mechanism and is the key parameter in our calibration. It also has a level parameter η_k that we scale by $\bar{k}^{\zeta_L}$, where $\bar{k}$ is steady state bank capital, to ensure numerical stability when ζ_L is large.

The bank maximizes (7.12) subject to (7.10) and the budget constraint

$$d_t \leq \underbrace{\bar{\pi}^{-1}\left[(r_{t-1}+\nu)\, B^{loan}_{C,t-1} + S^{loan}_{C,t-1}\right]}_{\text{payments on existing loans}} - \underbrace{B^{loan,*}_{C,t}}_{\text{new loans}} + \underbrace{\nu^{AFS}\bar{\pi}^{-1}(1-P_t)b^{AFS}}_{\text{LT securities}}, \tag{7.13}$$

which states that bank dividends equal total loan income net of newly issued debt plus net cash flows from long-term securities. The $1-P_t$ term in the long-term securities cash flows reflects that the bank receives \$1 for each security that matures, but replaces it with a new security at cost P_t to keep its face value of debt fixed at b^{AFS}.

Government Sector. The monetary authority has a time-varying inflation target π_t that it achieves perfectly. The stochastic process for this target (and hence for inflation) is

$$\log \pi_t = (1-\rho_\pi)\log\bar{\pi} + \rho_\pi \log \pi_{t-1} + \varepsilon_{\pi,t}, \tag{7.14}$$

where $\varepsilon_{\pi,t}$ represents a shock to inflation. The government provides risk-free one-period bonds (B^G_t) in zero net supply, short-term cash securities ($A_{j,t}$) in the quantity demanded by firms, and long-term securities in positive supply with fixed quantity b^{AFS}.[37] A fraction ν^{AFS} of these long-term securities matures each period, implying the cash flow structure ν^{AFS}, $(1-\nu^{AFS})\nu^{AFS}$, $(1-\nu^{AFS})^2\nu^{AFS}$, etc. The government budget constraint is:

$$\begin{aligned} 0 = \sum_j \underbrace{\tau\left[Y_{j,t} - wN_j + \pi_t^{-1}r_{t-1}\left(A_{j,t-1} - B_{j,t-1}\right) - \pi_t^{-1}S_{j,t-1}\right]}_{\text{corporate taxes}} \\ + \sum_j \underbrace{\left(A_{j,t} - \pi_t^{-1}(1+r_{t-1})A_{j,t-1}\right)}_{\text{cash securities}} - \underbrace{\nu^{AFS}\pi_t^{-1}(1-P_t)b^{AFS}}_{\text{LT debt}} + \underbrace{T_{S,t}}_{\text{lump sum tax}}. \end{aligned} \tag{7.15}$$

The right hand side is equal to corporate tax revenues plus net issuance of cash securities, minus the interest paid on long-term debt, plus a lump sum tax $T_{S,t}$ on the saver (subsidy if negative) that offsets any deficits or surpluses in the government budget.[38]

[37] While bonds B^G_t and short-term cash securities $A_{j,t}$ are effectively identical, we define them separately so that we can impose a zero net supply constraint on the bonds B^G_t, while the quantities of $A_{j,t}$ are determined by firm demand. This constraint is required because the linear preferences of savers imply that their demand for risk-free bonds is indeterminate at equilibrium. In practice, the exact allocation of bonds is arbitrary, since the government budget is balanced by lump sum taxes on savers. Instead, the one-period bonds exist solely to define the equilibrium risk-free rate.

[38] We omit the one-period government bonds B^G_t from the budget constraint as these are zero in equilibrium. Due to the linear (risk-neutral) preferences of the saver, it makes no difference whether resources are used for government spending or returned to the saver. We choose the latter simply for parsimony.

Saver's Problem. The saver chooses consumption $C_{S,t}$, new corporate bond issuance $B_t^{bond,*}$, and new government bonds B_t^G to maximize (7.2) subject to the budget constraint

$$C_{S,t} \leq \underbrace{wN}_{\text{labor income}} + \underbrace{d_t}_{\text{bank dividends}} + \underbrace{\bar{\pi}^{-1}\Big[(r_{t-1}+\nu)\,B_{t-1}^{bond} + (S_{t-1}^{bond} - q^{bond})\Big]}_{\text{existing corp. bonds}} - \underbrace{B_t^{bond,*}}_{\text{new corp. bonds}}$$
$$+ \underbrace{(1+r_{t-1})\bar{\pi}^{-1}B_{t-1}^G - B_t^G}_{\text{government bonds}} - \underbrace{T_{S,t}}_{\text{lump-sum taxes}},$$

where at equilibrium we must have $B_t^G = 0$ and $B_t^{bond,*} = B_{U,t}^*$, and where q^{bond} is an exogenous bond holding cost allowing for nonzero bond spreads at equilibrium.[39] Corporate bond principal balance and spread payments evolve according to

$$B_t^{bond} = B_t^{bond,*} + (1-\nu)\bar{\pi}^{-1}B_t^{bond} \tag{7.16}$$
$$S_t^{bond} = s_t^{bond}B_t^{bond,*} + (1-\nu)\bar{\pi}^{-1}S_t^{bond}. \tag{7.17}$$

Capital Producers. Capital is created for firm type j using technology

$$K_{j,t} = \lambda_t\Phi(i_{j,t})K_{j,t-1} + (1-\delta)K_{j,t-1},$$

where $i_{j,t} = I_{j,t}/K_{j,t-1}$ is the investment rate in sector j, and λ_t is a stochastic process generating time variation in the efficiency of investment, with law of motion

$$\log\lambda_t = \rho_\lambda \log\lambda_{t-1} + \varepsilon_{\lambda,t}, \tag{7.18}$$

Competitive capital producers buy existing capital at price $\bar{Q}_{j,t}$ and sell new capital at price $Q_{j,t}$, choosing the investment rate $i_{j,t}$ to maximize the static objective

$$Q_{j,t}\Big[\Phi(i_{j,t})K_{j,t-1} + (1-\delta)K_{j,t-1}\Big] - i_{j,t}K_{j,t-1} - \bar{Q}_{j,t}(1-\delta)K_{j,t-1}.$$

Equilibrium. Competitive equilibrium is the allocation that solves the optimization problems of the firms, entrepreneurs, saver, bank, and capital producer, and that clears the markets for output, capital goods, bank loans, corporate bonds, and government bonds. The model's complete set of equilibrium conditions can be found in Appendix A.1.

[39] In Appendix A.1, we show that at equilibrium $s_t^{bond} = q^{bond}$, allowing us to consider corporate bond spreads as fixed. This choice is motivated by the relatively stable Baa-Aaa bond spreads over the 2021:Q1 to 2023:Q1 period, which increase by only 20bp (from 78bp to 98bp), substantially less than the contemporaneous increase in long-term risk-free rates.

7.3 Replicating Our Empirical Regressions

To match our empirical estimates in Table 6.3, we need to compute the coefficients from an equivalent regression in the model. We first define our outcome variables as

$$\Delta \text{ Total Liabilities}_{C,t} = \frac{L_{C,t} - L_{C,t-4}}{0.5(L_{C,t} + L_{C,t-4})} \tag{7.19}$$

$$\Delta \text{ Fixed Assets}_{C,t} = \frac{K^{fixed}_{C,t} - K^{fixed}_{C,t-4}}{0.5(K^{fixed}_{C,t} + K^{fixed}_{C,t-4})} \tag{7.20}$$

$$\Delta \text{ Cash}_{C,t} = \frac{A_{C,t} - A_{C,t-4}}{0.5(A_{C,t} + A_{C,t-4})}, \tag{7.21}$$

where $L_{C,t}$ represents total liabilities of the firm and $K^{fixed}_{C,t}$ are firm fixed assets. Since we do not directly model non-debt liabilities, we assume that constrained firms have a constant amount of non-debt liabilities $\bar{L}^{other}_{C}$ so that $L_{C,t} = B_{C,t} + \bar{L}^{other}_{C}$, and calibrate $\bar{L}^{other}_{C}$ to match the ratio of debt to total liabilities among firms in our sample in steady state. Similarly, since we do not distinguish between fixed assets and other assets in the model, we define $K^{fixed}_{C,t} = K_{C,t} - \bar{K}^{other}_{C}$, where $\bar{K}^{other}_{C}$ is chosen to match the observed ratio of fixed to total assets among firms in our sample in steady state. This definition assumes that only a firm's fixed assets respond to the shift in credit supply and can be considered conservative in the sense that it yields the smallest possible response of total firm investment that is consistent with our regression evidence.

We next define the main independent variable from regression (6.5) as

$$\Delta \text{ Value AFS}_{t} = \frac{(P_{t-3} - P_{t-4})b^{AFS}}{B^{loan}_{t-4} + \bar{B}^{other}}, \tag{7.22}$$

where B^{loan}_{t-4} is total bank credit lagged four quarters. This lag structure reproduces the timing used in regression (6.5), where a 1Q change on the right-hand side (here from $t-4$ to $t-3$) drives a subsequent 4Q change on the left-hand side (here $t-4$ to t). Last, since banks in our model do not hold any assets besides term loans to constrained (small) firms, we account for other bank assets in our data using the constant $\bar{B}^{other}$.

To compute regression coefficients, we need variation in securities gains or losses across banks. To this end, we create new types of constrained firms and banks, which can be thought of as hypothetical or as actually existing with infinitesimal size. We assume that firms of type $C(-)$ borrow from banks of type $(-)$ that hold a slightly lower amount of securities $b^{AFS} - \epsilon$, while firms of type $C(+)$ borrow from banks of type $(+)$, that hold a slightly larger amount of securities $b^{AFS} + \epsilon$. This implies the AOCI values

$$AOCI_t(-) = (P_t - \bar{P})(b^{AFS} - \epsilon)$$
$$AOCI_t(+) = (P_t - \bar{P})(b^{AFS} + \epsilon),$$

where we use $\epsilon = 10^{-4}$ in our calculations. When P_t varies from its steady state value, this leads to differences in security gains and losses, and therefore credit supply adjustments, across these types of banks, providing variation we can use for our regression.

We next map our representative banking sector into the heterogeneous banks observed in the data. While our regressions in Table 6.3 already report the average effects over both AC and NC banks, they omit banks too small to be subject to the stress tests. Since these banks also do not pass through changes in AFS values to regulatory capital (like NC banks), we would overstate aggregate transmission if we assumed that the response to AFS value changes at these banks was the same as at an average Y14 bank.

Making the conservative assumption that non-Y14 banks do not react at all to changes in securities values, the effect of a change in aggregate AFS values on aggregate lending should be equal to the average effect within the sample of Y14 banks multiplied by the share of AFS securities held by Y14 banks. We can therefore recover coefficients corresponding to our regressions in Table 6.3 estimated on the Y14 sample by dividing our average effects for the full population by the share of AFS securities held by Y14 banks. Since banks in our Y14 sample hold 75% of all bank securities, we compute model equivalents to our Table 6.3 small firm coefficients in Columns (ii), (iv), and (vi) as[40]

$$\beta_{liabilities} = \frac{1}{0.75} \times \frac{\Delta \text{ Total Liabilities}_{C,t}(+) - \Delta \text{ Total Liabilities}_{C,t}(-)}{\Delta \text{ Value AFS}_t(+) - \Delta \text{ Value AFS}_t(-)} \tag{7.23}$$

$$\beta_{assets} = \frac{1}{0.75} \times \frac{\Delta \text{ Fixed Assets}_{C,t}(+) - \Delta \text{ Fixed Assets}_{C,t}(-)}{\Delta \text{ Value AFS}_t(+) - \Delta \text{ Value AFS}_t(-)} \tag{7.24}$$

$$\beta_{cash} = \frac{1}{0.75} \times \frac{\Delta \text{ Cash}_{C,t}(+) - \Delta \text{ Cash}_{C,t}(-)}{\Delta \text{ Value AFS}_t(+) - \Delta \text{ Value AFS}_t(-)}. \tag{7.25}$$

7.4 Calibration

We calibrate the model at quarterly frequency, with parameter values displayed in Table 7.1. For consistency with our empirical findings in Table 6.3, we match unconstrained moments to those for the top 10 percent of the firm size distribution and constrained firm moments to those for the bottom 90 percent of the size distribution. Unless otherwise

[40]Alternatively, the share of bank assets held by banks in our Y14 sample is 79%. Since a higher share of Y14 banks translates into stronger transmission, this would yield similar but slightly stronger results.

mentioned, our calibration is designed to match steady-state values to corresponding values in the data for the period from 2012:Q3 to 2019:Q4, the most recent extended "normal" period for which we have Y14 data.

Adjustment Frictions. The frictions on the various margins available to banks and firms are governed by the family of ζ parameters, differentiated by their subscripts. These correspond to the firms' margins for cash (ζ_A), dividends (ζ_D), investment (ζ_K), and to the bank's capital holding cost (ζ_L). Since these parameters are the most central to the model's dynamics, we calibrate them to directly match our estimates in Table 6.3.

Because it is the relative rather than the absolute degree of frictions that determine how heavily these margins are used following a shock, we need to first pin down one of the parameters externally, after which we can calibrate the remaining ζ parameters to match our regression evidence. Following our previous work (Greenwald, Krainer and Paul, 2023), we externally calibrate the investment friction to a standard value $\zeta_K = 0.250$, but show that our results are robust to alternative values in Appendix A.3.

With this parameter pinned down, we calibrate the remaining frictions to align our implied regression coefficients in equations (7.23) - (7.25) to match the regression results in Table 6.3. First, on the bank side, the curvature of the capital holding cost (ζ_L) determines how much changes in the value of securities pass through into spreads and ultimately borrowing by constrained firms. We set $\zeta_L = 1.390$ so that β_{debt} in our model, measured four quarters after a shock to interest rates, is exactly equal to our small firm coefficient in Column (ii) of Table 6.3. We similarly set the cash adjustment friction to $\zeta_A = 1.827$ and the dividend adjustment friction to $\zeta_D = 8.159$ so that β_{cash} and β_{asset} in our model match our small firm coefficients in columns (iv) and (vi) of Table 6.3, respectively.

Preferences. We set the saver discount factor to $\beta_S = 0.995$, implying a steady state real annualized interest rate of 2 percent. We set the entrepreneur discount factors to $\beta_C = \beta_U = 0.990$, which delivers a reasonable capital-output ratio of 2.2.

Bank Securities. For the long-term AFS securities held by banks, we set ν^{AFS} so that these securities have a cash flow duration of 4 years (16 quarters), which is typical in our data. Given the security's perpetuity structure, this requires choosing ν^{AFS} to satisfy

$$\frac{1+r}{r+\nu^{AFS}} = 16,$$

Table 7.1: Parameter Values: Baseline Calibration (Quarterly)

Parameter	Name	Value	Internal	Target/Source
		Adjustment Frictions		
Capital Adjustment (Curvature)	ζ_K	0.250	N	Standard
Cash Utility (Curvature)	ζ_A	1.827	Y	β_{asset}
Bank Capital Cost (Curvature)	ζ_L	1.390	Y	β_{debt}
Entrepreneur ARA	ζ_D	8.159	Y	β_{cash}
		Preferences		
Saver Discount Factor	β_S	0.995	N	Standard
Entrepreneur Discount Factor (U)	β_U	0.990	N	Standard
Entrepreneur Discount Factor (C)	β_C	0.990	N	Standard
		Long-Term Securities		
Frac. AFS Securities Maturing	ν^{AFS}	0.012	N	4Y Duration
Face Value of Securities	b^{AFS}	2.181	Y	Securities-loans ratio
		Debt Contracts		
Frac. Debt Maturing	ν	1.000	N	1Q Maturity
Bond Holding Cost	q^{bond}	0.625%	N	250bp Spread (Ann.)
Debt-to-EBITDA Limit	θ	15.000	N	Dealscan
Covenant Smoothing	ρ_X	0.750	N	4Q smoothing
Covenant Violation Fee (U)	κ_U	0.00362	N	Leverage, violation rate
Covenant Violation Fee (C)	κ_C	0.00396	N	Leverage, violation rate
Idio. EBITDA Vol. (U)	$\sigma_{\omega,U}$	0.715	N	Leverage, violation rate
Idio. EBITDA Vol. (C)	$\sigma_{\omega,C}$	0.794	N	Leverage, violation rate
		Financial		
Cash Utility (Level, C)	$\eta_{A,C}$	0.00523	Y	$\bar{A}/\bar{K} = 7.4\%$
Cash Utility (Level, U)	$\eta_{A,U}$	0.00326	Y	$\bar{A}/\bar{K} = 9.6\%$
Bank Capital Cost (Level)	η_B	0.00619	Y	250bp Spread (Ann.)
Non-Debt Liabilities	$\bar{L}_C^{other}$	0.261	Y	Total liabilities to debt
Non-Fixed Assets	$\bar{K}_C^{other}$	1.005	Y	Debt to fixed assets
Other Bank Assets	$\bar{B}^{other}$	15.454	Y	Bank assets to small firm loans
Loan Risk Weight	χ^{loan}	0.080	N	Basel risk weight
Other Risk Weight	χ^{other}	0.050	Y	Constrained firm loans to RWA
		Technology and Government		
Capital Share	α	0.330	N	Standard
Unconstrained Labor Demand	N_U	0.860	N	Asset shares
Productivity	$\log \bar{Z}$	-0.719	Y	$Y = 1$
Corporate Tax Rate	τ	0.210	N	Standard
Inflation Rate	$\bar{\pi}$	1.005	N	2% inflation

which implies $\nu^{AFS} = 0.012$. For the face value of AFS securities held by banks, we set $b^{AFS} = 2.181$ so that the steady state value of AFS securities ($\bar{P} \times b^{AFS}$) is equal to 5.30 times the steady state face value of bank loans to constrained firms (B^{loan}), consistent with the average in our Y14 sample over the 2021:Q1-2023:Q1 period.

Debt Contracts. We assume a one-period maturity ($\nu = 1$), but show in Appendix A.3 that we would obtain nearly identical results with longer-term debt ($\nu = 0.25$).[41]

We set the (constant) spread on corporate bonds to $\bar{s}^{bond} = 0.625$, so that all debt has the same spread in steady state. Following the evidence in Greenwald (2019), we choose a debt-to-EBITDA limit of $\theta = 15.000$, which corresponds to an annual debt-to-EBITDA limit of 3.75. For the smoothing parameter, we choose $\rho_L = 0.750$, which approximates the typical practice of averaging EBITDA over four quarters when evaluating covenant compliance. We parameterize the $\omega_{i,t}$ distribution as lognormal, with

$$\log \omega_{j,t} \sim N\left(-\frac{1}{2}\sigma^2_{\omega,j}, \sigma^2_{\omega,j}\right).$$

We choose the violation costs κ_C and κ_U and the volatilities $\sigma_{\omega,C}$ and $\sigma_{\omega,U}$ to jointly match four targets: the ratio of debt to capital (leverage) for $j \in \{C, U\}$, equal to 28 percent and 32 percent respectively, and the rate at which firms exceed the model debt-to-EBITDA threshold for $j \in \{C, U\}$, equal to 32 percent and 34 percent, respectively.

Financial. We choose scale parameters for the utility of cash at each type of firm ($\eta_{A,C}$ and $\eta_{A,U}$) to match the ratios of cash to assets of 9.6% at small (constrained) firms and 7.4% at large (unconstrained) firms, respectively, measured in our Y14 data.

For the bank capital constraint, we set the risk weight on bank loans to $\chi^{loan} = 0.080$. We set the risk weight on other bank assets to $\chi^{other} = 0.050$ to match a ratio of loans to constrained (small) firms to total bank risk-weighted assets of 3.5%. We pick the capital holding cost scale to be $\eta_k = 0.00619$ to ensure a steady state annual term loan spread of 250bp, equal to that on corporate bonds, consistent with the evidence by Schwert (2020).

We set the amount of non-debt liabilities to $\bar{L}^{other}_C = 0.261$ to reproduce a ratio of debt to total liabilities of 0.57, while the amount of non-fixed assets is $\bar{K}^{other}_C = 1.005$ to match

[41] Our results are invariant to this choice because of the robustness of our calibration procedure. Although lengthening the maturity of debt would weaken our mechanism holding parameters constant, it would also cause our implied regression coefficients to understate their empirical counterparts. Recalibration leads the model to strengthen our key frictions, particularly the capital holding cost friction parameter ζ_L, which effectively restores our results.

a ratio of debt to fixed assets of 1.5.[42] The value of other bank assets is calibrated to $\bar{B}^{other} = 15.454$ so that term loans to small (constrained) firms comprise 2.2% of total bank assets, equal to the average share over the 2021:Q1-2023:Q1 period for banks in our Y14 sample.

Technology and Government. For the capital share, we use a standard value of $\alpha = 0.330$. We set $\log \bar{Z} = -0.719$ so that $\bar{Y} = 1$ in steady state. For the investment adjustment cost, we choose the functional form

$$\Phi(i_{j,t}) = \phi_0 + \phi_1 \frac{i_{j,t}^{1-\zeta_K}}{1-\zeta_K}.$$

We calibrate $\zeta_K = 0.250$, as discussed above, and choose values of ϕ_0 and ϕ_1 so that $\Phi(i) = i$ and $\Phi'(i) = 1$ in steady state. For the labor supply quantities, we normalize $\bar{N} = 1$, and set $\bar{N}_U = 0.860$ and $\bar{N}_C = \bar{N} - \bar{N}_U$ to target a steady state share of capital held by unconstrained firms of 0.860, which is the share of assets held by firms in the top 10% of the size distribution in the Y14 data. Turning to the government sector, we calibrate the corporate tax rate to $\tau = 0.210$ to match its typical value in the U.S., and set the average level of inflation to $\bar{\pi} = 1.005$ to match an annual inflation rate of 2 percent.

7.5 Results: Shock to Interest Rates

The Experiment. Our empirical analysis uses a sample that covers the tightening cycle from 2021:Q1 to 2023:Q1. We correspondingly assume that the model begins in steady state in 2020:Q4, and then experiences shocks to both the real rate and inflation that affect the value of fixed-income securities. Over this period, five-year treasury yields rose by 3.43pp, accounted for by a rise in real (TIPS) five-year yields of 2.77pp, and a rise in five-year breakeven inflation of 0.66pp (source: St. Louis Fed's FRED database).

To implement this event in our model, we apply a set of unexpected exogenous shocks. We assume a common persistence for all exogenous processes of $\rho_\beta = \rho_\pi = \rho_\lambda = 0.990$.[43] Since the model would counterfactually predict a decline in investment following this

[42] We choose this ratio as the ratio of debt to fixed assets translates our regression coefficients into a marginal propensity to invest. However, because we are also matching the steady state ratio of debt to total assets, this can also be thought of as matching the steady state ratio of total assets to fixed assets.

[43] The exact value of this persistence is not very important since we target the change in long-term yields directly, rather than the change in the short rate. For example, if we understated the persistence of the change in rates, we would need to impose a larger rise in short-term rates to match the same change in long-term rates. This would affect the prices of long-term securities and regulatory capital in the same way.

increase in real interest rates, we apply an additional shock to the marginal efficiency of investment ($\varepsilon_{\lambda,1} = 0.2064$) so that investment is unchanged on impact.[44]

We compute responses using perfect foresight paths, assuming that households apply zero probability of these (or any) shocks arriving, either before or after their realizations. Following the shocks, we trace out the nonlinear path back to steady state.

To emphasize the impact of bank regulatory policy, we compare a "Baseline" economy, corresponding to the model described above, against two counterfactual economies: (i) a "Book Value" economy, in which bank regulatory capital is computed using book value ($P_t = \bar{P}$), so that $AOCI_t = 0$ in the bank regulatory capital equation (7.10); and (ii) an "All Mark to Market" economy, in which all securities are marked to market by regulators at all banks, equivalent to classifying all banks as AC banks and all securities as AFS.

For this second counterfactual, we account for the possibility that banks would endogenously change their securities holdings in response to a change in the regulatory framework. We develop a simple static model in Appendix A.2 that solves for optimal bank securities holdings. Our calibration of this model exploits the fact that AC banks are currently required to mark AFS securities to market in their regulatory capital, while NC banks are not. Comparing the securities holdings of the two types of banks can therefore pin down the cost to banks of having all their securities marked to market by regulators, and thus how their securities holdings would change under alternative regulation.

We find that if all securities were marked to market by regulators, banks would hold a ratio of securities to assets of 0.127, much lower than the average ratios of 0.241 and 0.206 held by NC and AC banks over our sample, and only slightly higher than the ratio of AFS securities to assets at AC banks of 0.116. Nonetheless, expanding the mark-to-market policy to all banks rather than AC banks has a quantitatively large effect because AC banks account for only 31% of the market over our sample. Combined, these changes imply that the quantity of marked-to-market securities increases by a factor of 3.55 in the All Mark to Market economy, which we impose by scaling b_{AFS} upwards by this factor.

Aggregate Results. Figure 7.1 displays aggregate responses to our experiment in our baseline and the two counterfactual economies. To build intuition, we first briefly describe the impact of this shock in the Book Value economy—a world where banks do not mark their securities to market when computing regulatory capital. However, we note that our main results relate to the *comparison* between the two economies, rather than the baseline effect of this combination of shocks in this relatively simple framework.

[44]This adjustment generates a more realistic path of aggregate investment, but is inconsequential for our main results on the relative differences across regulatory policies.

In the Book Value economy, a rise in both inflation and real rates raises the nominal risk-free rate and decreases the value of long-term bonds held by banks. Under Book Value regulation, these losses have no impact on required regulatory capital, as with NC banks in the data. In the absence of such changes, the spreads charged by banks remain effectively constant. Turning to the bottom row, we see that the volume of bank lending increases in the Book Value economy. This reflects the increased value of the tax shield under high interest rates, which makes borrowing appealing in the absence of high spreads. The additional debt is used to temporarily increase investment, and persistently increase cash holdings and payouts.

We next move to our Baseline economy in which gains and losses on securities pass through to regulatory capital, calibrated to match our empirical estimates in Table 6.3. Differences between the Baseline and Book Value economies therefore isolate the impact of mark-to-market regulatory accounting on interest rate transmission, and form our main results. Returning to the top row, we observe the exact same changes in risk-free rates and security prices in the Baseline economy. However, unlike in the Book Value economy, in the Baseline economy this large fall in security values decreases $AOCI_t$ in the regulatory capital equation (7.10), requiring banks to raise capital (k_t).

To lower the need for costly additional capital, banks contract lending and increase spreads on term loans. These high spreads depress bank lending, which falls by 2.5pp at the 4Q horizon in the Baseline economy, compared to rising by 5.3pp in the Book Value economy. With less resources obtained from bank credit, firms reduce investment, cash holdings, and dividends. In particular, investment is 1.4pp lower on impact in the Baseline economy than in the Book Value economy due to this regulatory capital channel.

Last, the All Mark to Market economy displays results from our counterfactual economy in which all securities are marked to market. Although banks respond by holding fewer securities, following our simple static model in Appendix A.2, extending the mark-to-market policy to all securities at a much wider set of banks implies that the quantity of marked-to-market securities is still more than three times as large. At equilibrium, this leads to a correspondingly larger increase in required bank capital and term loan spreads, causing bank lending to fall by as much as 18.7pp at the 4Q horizon, while investment is 4.5pp lower than in the Book Value economy on impact. Overall, these results point to a substantial amplification of interest rate transmission and the strength of monetary policy under regulation that marks all securities to market.

Results by Firm Type. Having analyzed the aggregate responses, we now turn to the responses by firm type. Figure 7.2 displays responses for unconstrained firms in the top

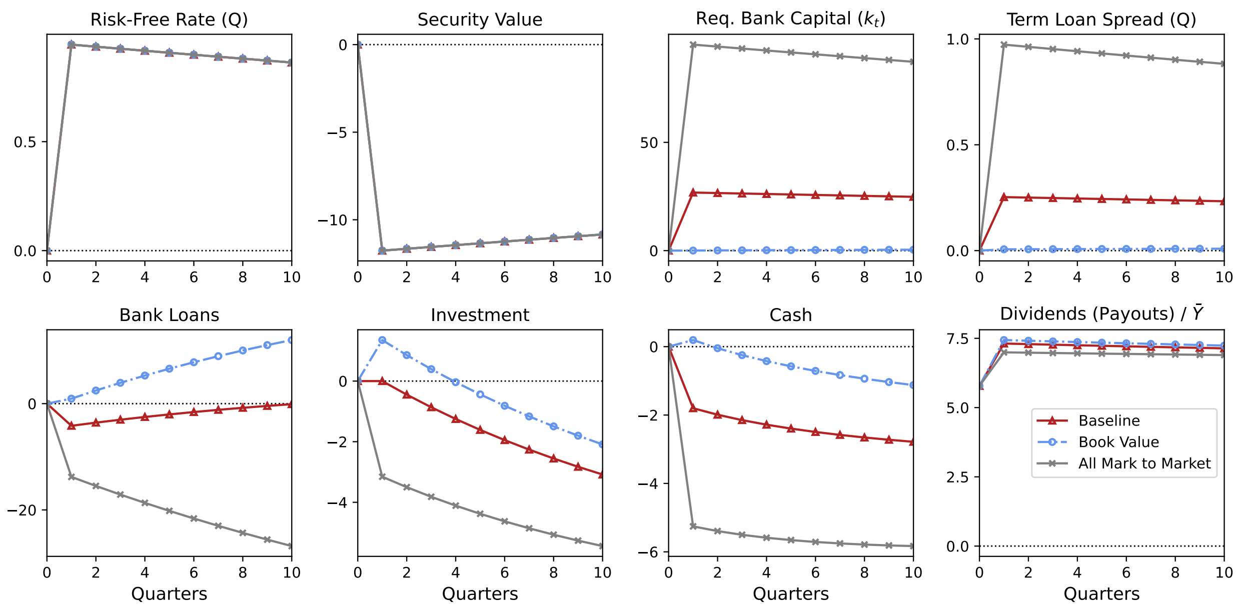


Figure 7.1: Aggregate Model Responses

Notes: This figure plots the economy's response to the combined set of shocks $(\varepsilon_{\beta,1}, \varepsilon_{\pi,1}, \varepsilon_{\lambda,1})$ described above. Variable definitions are as follows: Risk-Free Rate (R_t, the one-period risk-free rate), Security Value (P_t), Required Bank Capital (k_t), Output (Y_t), Bank Loans (B_t^{loan}), Investment (I_t), Cash (A_t), Dividends (Payouts) / $\bar{Y}$ ($D_t/\bar{Y}$). Aggregate variables (firm variables without a type subscript) are computed as sums over constrained and unconstrained firms. All variables are displayed in percent changes from steady state with the exception of Dividends / $\bar{Y}$, which displays levels in percent.

row and constrained firms in the bottom row. Beginning with the top row, we see that unconstrained firms are completely unaffected by the difference in regulatory policy, with identical allocations in both economies. Unconstrained firms in this experiment borrow using corporate bonds, which are obtained outside the banking sector, and whose spreads are not determined by bank regulation. As a result, the contraction in bank credit supply and resulting increase in spreads does not affect unconstrained firm borrowing at all. With unconstrained firm financial conditions unchanged across the three economies, we observe identical allocations of investment, cash, and dividends at these firms.

In contrast, constrained firms are completely dependent on term lending from banks. As a result, contractions in bank credit supply in the Baseline and All Mark to Market economies have large depressing effects on constrained firm debt. Constrained firms respond by sharply reducing their investment, cash holdings, and payouts. In particular, investment at constrained firms falls by an additional 9.7pp on impact in the Baseline economy relative to the Book Value economy, and by an additional 32.2pp on impact in the All Mark to Market economy relative to the Book Value economy.

Given these results by firm type, our aggregate results in Figure 7.1 can be viewed as

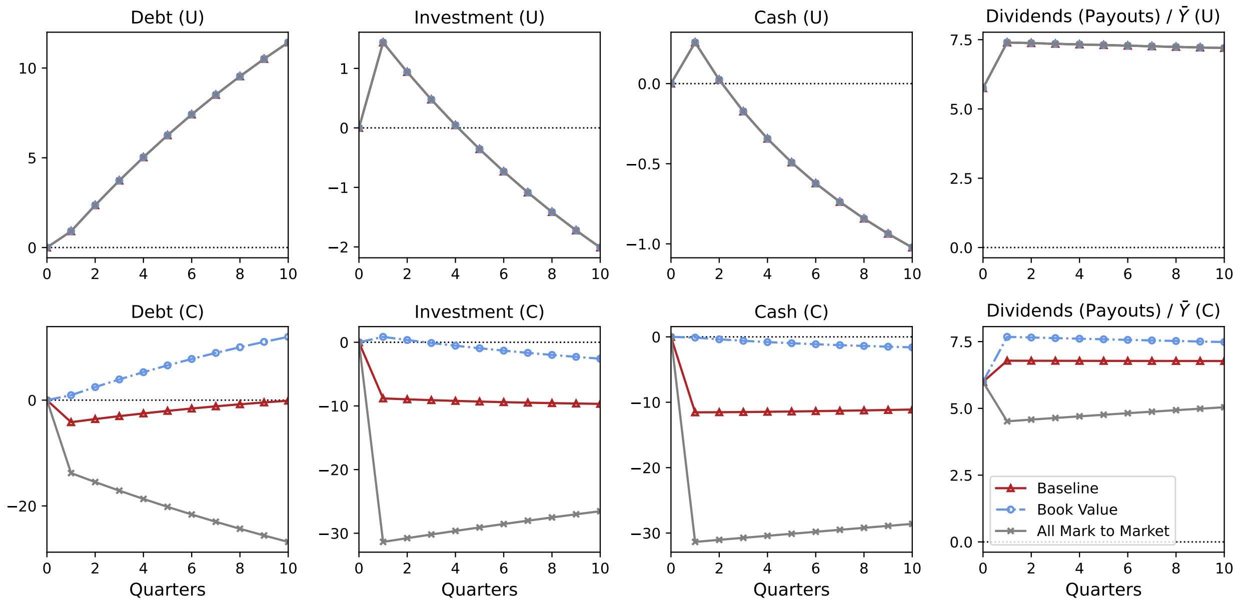


Figure 7.2: Model Responses by Firm Type

Notes: This figure plots the economy's response to the combined set of shocks $(\varepsilon_{\beta,1}, \varepsilon_{\pi,1}, \varepsilon_{\lambda,1})$ described above. Variable definitions are as follows: Debt ($B_{j,t}$), Investment ($I_{j,t}$), Cash ($A_{j,t}$), Dividends (Payouts) / $\bar{Y}$ ($D_{j,t}/\bar{Y}_j$). Variables followed by (U) denote values for the unconstrained firms, while variables followed by (C) denote values for the constrained firms. All variables are displayed in percent changes from steady state with the exceptions of Dividends (Payouts) / $\bar{Y}$, which is displayed in percent.

a composition of a null response by large, unconstrained firms, combined with a massive response by smaller, constrained firms. Because smaller firms account for only a minority of output and investment, the aggregate economy displays substantial yet more modest differences. At the same time, we note that constrained firms map to 90 percent of the firms in the economy. To the extent that the real world contains nonlinearities due to distress, layoffs, or bankruptcies, these disproportionate impacts at small firms could have even larger distributional and aggregate implications.

In summary, our model shows that transmission from securities prices into measured bank regulatory capital via AOCI is an important channel by which interest rates influence firm borrowing and real activity.

8 Conclusion

Bank regulation and monetary policy are often considered separately. In this paper, we provide evidence that the two are inherently linked. By changing interest rates, monetary policy affects market prices of debt securities that account for close to one quarter of bank assets. We show that such value changes lead to adjustments of banks' credit supply to nonfinancial firms and translate to changes of real firm outcomes like investment.

The strength of this monetary transmission channel through bank balance sheets is determined by the regulatory treatment of securities. In the United States, larger banks must adapt their regulatory capital when the value of their securities that are marked to market changes. Our empirical evidence shows that this regulatory capital channel is the primary factor driving the response of bank lending to securities values in our sample.

We study the quantitative importance of this transmission channel within a general equilibrium model that is tightly calibrated to our cross-sectional regression evidence. Based on counterfactual policy scenarios, we find that if all banks were required to pass unrealized gains and losses on all securities through to their regulatory capital, monetary policy would become more potent—both in speed and in magnitude—as this spillover channel through fast-moving securities prices strengthens.

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Internet Appendix

A Model Appendix

A.1 Model Optimality Conditions

This section derives the optimality conditions that must hold at equilibrium.

Firms. Define expected violation costs per dollar of debt to be

$$\xi_{j,t} = \kappa_j \Gamma_{\omega,j}(\bar{\omega}_{j,t}),$$

which is equal to the product of the cost and probability of violation. The optimality condition for capital for a firm of type j is

$$Q_{j,t} = E_t \left\{ \Lambda_{j,t+1} \left[(1-\tau) \underbrace{\frac{\partial Y_{j,t+1}}{\partial K_{j,t}}}_{\text{MPK}} + \underbrace{\Big(1 - (1-\tau)\delta\Big) \bar{Q}_{j,t+1}}_{\text{remaining capital}} + \underbrace{\Psi_{j,t} \frac{\partial X^*_{j,t+1}}{\partial K_{j,t}}}_{\text{violation costs}} \right] \right\},$$

which equates the cost of a new unit of capital to the discounted value of the marginal income it will provide next period, the marginal sale value of the remaining capital next period, and the effect of that capital on expected violation costs. To this end, the term $\Psi_{j,t}$ represents the marginal benefit of reducing the firm's violation costs by increasing smoothed EBITDA, both today and in the future, and is equal to

$$\Psi_{j,t} = -\bar{\pi}^{-1} \frac{\partial \xi_{j,t}}{\partial X_{j,t}} B_{j,t-1} + E_t \left\{ \Lambda_{j,t+1} \Psi_{j,t+1} \frac{\partial X^*_{j,t+1}}{\partial X_{j,t}} \right\}.$$

The optimality condition for debt is

$$1 = \Omega^B_{j,t} + \Omega^S_{j,t} s_{j,t},$$

which sets the benefit of debt (\$1 today) against the marginal cost of carrying an additional \$1 of debt into the next period and promising an additional $s_{j,t}$ in spread payments.

The marginal continuation costs of principal balances $\Omega^B_{j,t}$ and spread payments $\Omega^S_{j,t}$ are

$$\Omega^B_{j,t} = E_t\left\{\Lambda_{j,t+1}\bar{\pi}^{-1}\left[\left((1-\tau)r_t + \nu + \xi_{j,t+1}\right) + \frac{\partial \xi_{j,t+1}}{\partial B_t} + (1-\nu)\Omega^B_{j,t+1}\right]\right\}$$
$$\Omega^S_{j,t} = E_t\left\{\Lambda_{j,t+1}\bar{\pi}^{-1}\left[(1-\tau) + (1-\nu)\Omega^S_{j,t+1}\right]\right\}.$$

The optimality condition for cash is

$$1 = \exp(\tilde{a}_t)\eta_{A,j}A_{j,t}^{-\zeta_A} + \bar{\pi}^{-1}(1+r_t)E_t\left[\Lambda_{j,t+1}\right],$$

which sets the cost of acquiring \$1 of cash equal to the utility benefit to the firm from the liquidity services as well as the continuation value of \$1 of cash next period, net of discounting and inflation. Last, the derivative terms used above can be evaluated as

$$\frac{\partial Y_{j,t+1}}{\partial K_{j,t}} = \alpha\frac{Y_{j,t+1}}{K_{j,t}} \qquad \frac{\partial X^*_{j,t+1}}{\partial K_{j,t}} = (1-\rho_X)\frac{\partial Y_{j,t+1}}{\partial K_{j,t}} \qquad \frac{\partial X^*_{j,t+1}}{\partial X_{j,t}} = \rho_X\bar{\pi}^{-1}$$

$$\frac{\partial \xi_{j,t}}{\partial X_{j,t}} = -\kappa_j f_{\omega,j}(\bar{\omega}_{j,t})\frac{\bar{\omega}_{j,t}}{X_{j,t}} \qquad \frac{\partial \xi_{j,t+1}}{\partial B_{j,t}} = \kappa_j f_{\omega,j}(\bar{\omega}_{j,t+1})\frac{\bar{\omega}_{j,t+1}}{B_{j,t}}.$$

Saver. The saver's optimality condition for risk-free government debt is

$$1 = (1+r_t)\bar{\pi}^{-1}E_t\left[\Lambda_{S,t+1}\right].$$

Under the baseline assumption that the saver is risk-neutral we have $\Lambda_{S,t+1} = \beta$ and so

$$1 + r_t = \bar{\pi}\beta_S^{-1}.$$

The saver's optimality condition for corporate bonds is

$$1 = \Omega^B_{S,t} + \Omega^S_{S,t}(s_t^{bond} - q^{bond}), \tag{A.1}$$

which sets the cost of buying \$1 of corporate bonds today equal to the marginal benefit of \$1 of corporate bond balances and the marginal benefit of an extra s_t^{bond} of corporate bond spread payments going forward, net of the holding cost q^{bond}. These marginal continuation values are equal to

$$\Omega^B_{S,t} = E_t \left\{ \Lambda_{S,t+1} \bar{\pi}^{-1} \Big[r_t + \nu + (1-\nu)\Omega^B_{S,t+1} \Big] \right\} \tag{A.2}$$

$$\Omega^S_{S,t} = E_t \left\{ \Lambda_{S,t+1} \bar{\pi}^{-1} \Big[1 + (1-\nu)\Omega^S_{S,t+1} \Big] \right\}. \tag{A.3}$$

Under our benchmark assumption that savers have risk-neutral preferences, so that $\Lambda_{S,t+1} = \beta_S$ and $1 + r_t = \bar{\pi}\beta_S^{-1}$, we can guess and verify that these quantities are both equal to constants:

$$\Omega^B_{S,t} = 1 \qquad\qquad \Omega^S_{S,t} = \frac{1}{r+\nu}.$$

Substituting into the optimality condition, we obtain

$$s_t^{bond} = q^{bond},$$

so that the corporate bond spread is effectively fixed.

Bank. The optimality conditions for the representative bank with respect to capital is

$$\mu_t = \hat{\eta}_k k_t^{\zeta_B}, \tag{A.4}$$

where μ_t is the multiplier on the capital requirement, and $\hat{\eta}_k = \eta_k / \bar{k}^{\zeta_L}$. The optimality condition for constrained debt issuance $B^*_{C,t}$ is

$$0 = -1 - \Xi_t + \Omega_{B,t} + s^{loan}_{C,t}\Omega_{S,t},$$

where $\Omega_{B,t}$ and $\Omega_{S,t}$ are defined as in (A.2) and (A.3), and Ξ_t represents the present and future cost of tightening the capital requirement. Intuitively, the $\Omega_{B,t}$ and $\Omega_{S,t}$ expressions are re-used because the saver's marginal value of an additional dollar of principal balance or additional dollar of promised spread payments is the same across both products, although the amount of spread payments promised per dollar of bank loan and corporate bond may differ.

The marginal holding cost term Ξ, after applying (A.4) above, is equal to

$$\Xi_t = \chi^B \hat{\eta}_k k_t^{\zeta_B} + E_t \Big[\Lambda_{S,t+1} \bar{\pi}^{-1} (1-\nu) \Xi_{t+1} \Big].$$

Substituting for this term and applying (A.2) and (A.3) now yields

$$s_{C,t}^{loan} = \Omega_{S,t}^{-1}\Big(1 + \Xi_t - \Omega_{B,t}\Big) = (r + \nu)\Xi_t.$$

In the case $\nu = 1$ (short-term debt), this becomes

$$s_{C,t}^{loan} = (1 + r)\chi^B \hat{\eta}_k k_t^{\zeta_B}.$$

Capital Producer. The optimality condition for a capital producer of type j is

$$\begin{aligned} Q_{j,t} &= \Phi'(i_{j,t})^{-1} \\ \bar{Q}_{j,t} &= Q_{j,t} + \frac{Q_{j,t}\Phi(i_{j,t}) - i_{j,t}}{1 - \delta} \end{aligned}$$

where $i_{j,t} \equiv I_{j,t}/K_{j,t-1}$. The difference between $Q_{j,t}$ and $\bar{Q}_{j,t}$ is second order and would disappear in a linearized solution.

A.2 Endogenizing Bank Securities Holdings

Let b denote total bank securities holdings scaled by bank assets, and let A denote bank AFS securities holdings scaled by bank assets. To provide a motive for banks to hold securities, we assume that banks have an optimal quantity of securities holdings $\bar{b}$, and face a quadratic cost from deviating from this

$$c(b) = \frac{\gamma}{2}(b - \bar{b})^2, \tag{A.5}$$

where without loss of generality we can set $\gamma = 1$. We assume that an exogenous fraction w of securities must be held as AFS securities, so that $b^{AFS} = wb$.

Banks also face a cost of holding securities that are marked to market by the regulator. For AC banks in the baseline environment, this cost is $c^{AFS}(b^{AFS})$, while for NC banks in the baseline environment, this cost is $c^{AFS}(0)$. We can parameterize the cost function as

$$c^{AFS}(b^{AFS}) = \frac{\phi}{2}(b^{AFS})^2, \tag{A.6}$$

where the choice of a quadratic cost is consistent with experiencing disutility proportional to the variance of the value of AFS securities.

In this setting, an AC bank minimizes

$$c(b_{AC}) - c^{AFS}(w_{AC}b_{AC}), \tag{A.7}$$

while an NC bank maximizes

$$c(b_{NC}) - c^{AFS}(0). \tag{A.8}$$

The first order conditions are

$$0 = c'(b_{AC}) + c'(w_{AC}b_{AC})w_{AC} \tag{A.9}$$

$$0 = c'(b_{NC}). \tag{A.10}$$

Substituting in the parametric forms of these functions and rearranging yields

$$\bar{b} - b_{AC} = \phi(w_{AC}b_{AC})w_{AC} \tag{A.11}$$

$$\bar{b} - b_{NC} = 0. \tag{A.12}$$

In this setting, an AC bank chooses b_{AC} to minimize

$$\frac{1}{2}(b_{AC} - \bar{b})^2 + \frac{\phi}{2}(wb_{AC})^2, \tag{A.13}$$

while an NC bank maximizes

$$\frac{1}{2}(b_{AC} - \bar{b})^2. \tag{A.14}$$

The first order conditions are

$$0 = b_{AC} - \bar{b} + \phi w^2 b_{AC}$$

$$0 = b_{NC} - \bar{b}.$$

which can be rearranged to yield

$$b_{AC} = \frac{\bar{b}}{1 + \phi w^2} \tag{A.15}$$

$$b_{NC} = \bar{b}. \tag{A.16}$$

Equation (A.16) implies that we can use the NC banks, who are unaffected by the constraint, to pin down the optimal (unconstrained) level of bank security holdings. Computing the average ratio of securities to assets among NC banks over the period 2021:Q1 to 2023:Q1, we obtain a value of $b_{NC} = 0.241$.

Given our value for $\bar{b}$, we can now recover the parameter ϕ from (A.15). Averaging the ratios of securities to assets and AFS securities to total securities for AC banks over the period 2021:Q1 - 2023:Q1, we obtain values $w = 0.433$ and $b_{AC} = 0.206$. Substituting and solving for ϕ now yields

$$\phi = \frac{1}{w^2}\left(\frac{b_{AC}}{\bar{b}} - 1\right) = \frac{1}{0.433^2}\left(\frac{0.206}{0.241} - 1\right) = 0.899. \tag{A.17}$$

Intuitively, the greater the disutility from being exposed to volatility in regulatory capital, the less securities an AC bank will hold, holding the AFS share w fixed. This allows us to use the lower securities holdings of AC banks to infer the disutility of regulatory risk *phi*.

Given this estimate, we can now solve for optimal bank securities holdings in a counterfactual economy in which all securities are marked to market. This can be modeled in our simple framework by setting $w = 1$. In this case, banks would choose counterfactual securities holdings $\hat{b}$ to minimize

$$\frac{1}{2}(\hat{b} - \bar{b})^2 + \frac{\phi}{2}\hat{b}^2, \tag{A.18}$$

yielding the optimality condition

$$0 = \hat{b} - \bar{b} + \phi\hat{b}. \tag{A.19}$$

Solving for $\hat{b}$ we obtain

$$\hat{b} = \frac{\bar{b}}{1+\phi} = \frac{0.241}{1+0.899} = 0.127. \tag{A.20}$$

This calculation implies that in a world where all securities are marked to market, we would observe a ratio of securities to assets of 0.127. This dramatic decline compared to bank securities holdings in the current equilibrium for both AC and NC banks shows the importance of allowing banks to endogenously choose their portfolios.

Last, we can compute the change in the effect of securities values on regulatory capital between the Baseline and the All Mark to Market economies. To do this, we compute the ratio of marked-to-market securities between the two economies as

$$\frac{1.0}{0.44 \times 0.70} \times \frac{0.127}{0.116} = 3.55. \tag{A.21}$$

The first term on the left hand side of (A.21) adjusts for the share of banks that have their securities marked to marked by regulators. In All Mark to Market economy, this is all banks, represented by the 1.0 term in the numerator. In the Baseline economy, this only reflects AC banks, who are responsible for 44% of lending to firms in the Y14 sample, which itself represents 70% of the overall banking market. The second term accounts for differences in the amount of marked-to-market securities at each affected bank. According to (A.20) above, each bank holds securities equal to 0.127 of assets in the All Mark to Market counterfactual, compared to an average ratio of marked-to-market (AFS) securities to assets at Y14 banks in our 2021:Q1 - 2023:Q1 sample. Multiplying the two, we see that the aggregate quantity of marked-to-market securities would increase by 3.55 when moving from the Baseline to the All Mark to Market economy.

A.3 Model Robustness

In this section we evaluate the model's robustness to various assumptions.

Investment Elasticity. As explained in Section 7.4, because our regressions pin down the relative frictions across margins, we first calibrate the absolute friction for one firm margin (the investment friction ζ_K), and then calibrate the remaining friction (ζ) parameters to match our regression coefficients. To study the influence of our choice of ζ_K on our results, Figures A.1 and A.2 display versions of our main model results in Figures 7.1 and 7.2 that vary this parameter. In particular, Figure A.1 imposes a value of $\zeta_K = 0.125$ that is half that of our baseline calibration, while Figure A.2 imposes a value of $\zeta_K = 0.5$ that is twice that of our baseline calibration. In each case, we recalibrate the remaining parameters, including recalibrating the other ζ parameters to match our empirical regressions.

Comparing Figures A.1 and A.2 to Figures 7.1 and 7.2 in the main text, we observe that the strength of the investment friction is, perhaps unsurprisingly, most important for aggregate investment, which falls by more in the economy with low investment frictions, and by less in the economy with high investment frictions. However, for our main results on the *relative* investment response across policy regimes, the results are similar. While our benchmark calibration found that investment is 1.4pp lower on impact in the Baseline economy relative to the Book Value economy, the corresponding difference is 1.5pp for the economy with low investment frictions, and 1.2pp for the economy with high investment frictions. Thus, we conclude that our main results on the impact of regulatory accounting standards on interest rate transmission are robust to the calibration of the investment elasticity.

Long-Term Debt. In our baseline model, we assume that debt is one-quarter debt ($\nu = 1$). In practice, most debt to firms has substantially longer maturity than a single quarter, potentially making it more difficult to crowd out new lending to small firms. To show that our results are robust to the maturity of debt, Figure A.3 displays results after recalibrating our model under an average debt maturity of four quarters ($\nu = 0.25$). As before, we then compute the response to our tightening cycle experiment under the same set of regulatory accounting policies (Baseline, Book Value, All Mark to Market).

Perhaps surprisingly, extending the maturity of debt barely changes our results. While we previously found that investment is 1.4pp lower in the Baseline economy on impact than in the Book Value economy, the corresponding number in our long-term debt extension is also 1.4pp. Similarly, while we previously found that investment is 4.5pp lower in the Baseline economy on impact than in the Book Value economy, this value is again essentially equal at 4.5pp in our long-term debt extension. Thus, our quantitative results are highly robust to extending the maturity of debt.

The reason for this robustness is our calibration procedure. Holding all other parameters fixed, extending the maturity of debt would decrease the responsiveness of credit growth to a change in spreads, because only a fraction of that debt is turning over and therefore exposed to changing spreads, while spreads on non-maturity debt are unaffected by the change in spreads. All else equal, this would weaken the regulatory capital channel we have highlighted in this paper. However, holding other parameters fixed, this weaker response of debt to a change in bank securities values would also cause us to seriously understate the magnitude of firm credit responses, as measured by our implied regression coefficients. To restore the model's ability to match our estimated regression coefficients, the recalibration step will strengthen the curvature of the bank capital holding cost, leading to a larger change in spreads. This larger change in spreads in turn causes a larger proportional change in the issuance of *new* debt, until the proportional response of total debt is similar to that in the short-term debt model.

In summary, recalibrating our model causes it to offset this weakening effect of long-term debt on the mechanism with a strengthening of the quantitative pass-through from securities values to spreads, until we match our regression coefficients, yielding results extremely similar to our baseline results.

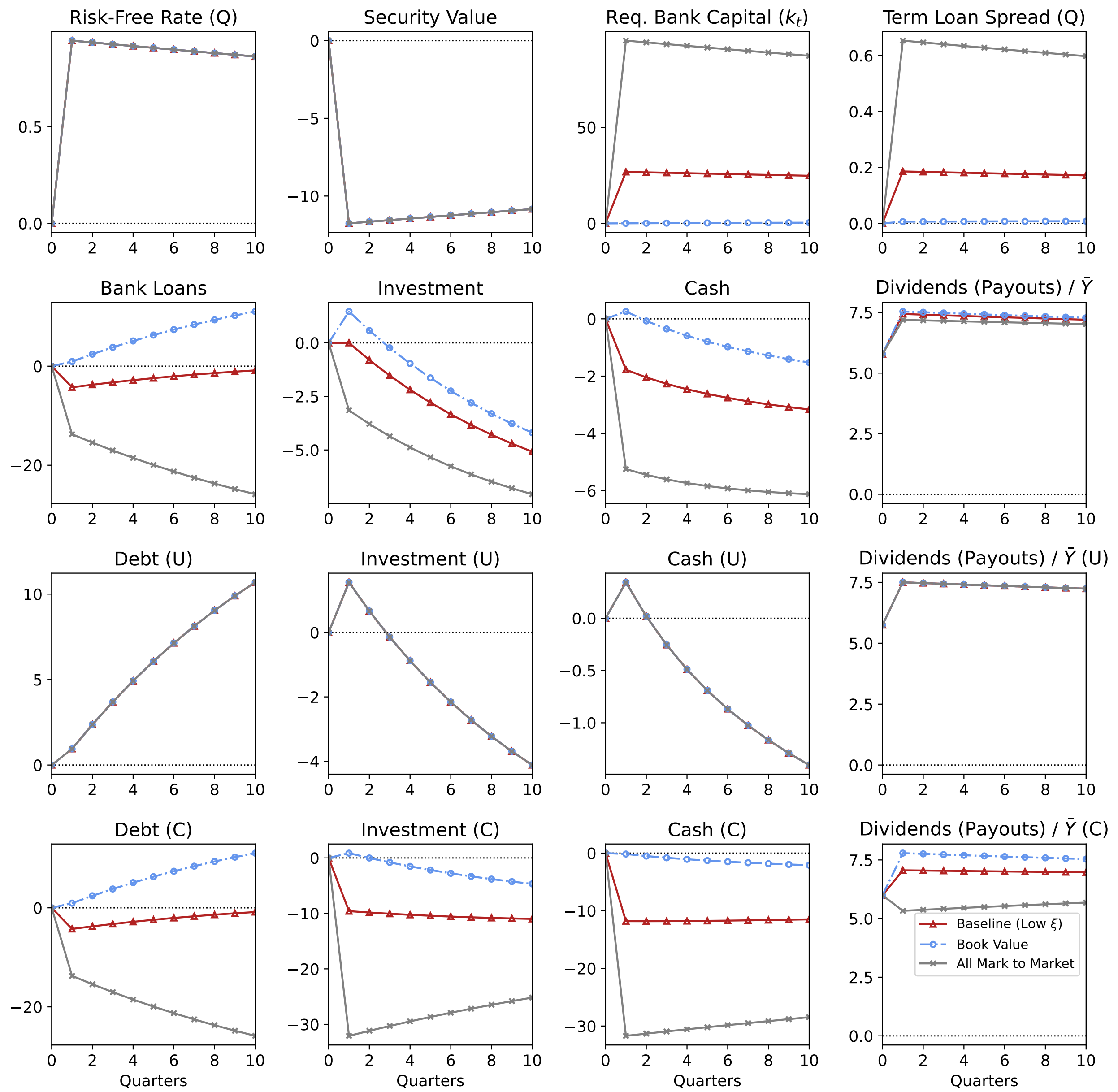


Figure A.1: Model Responses, Low Investment Frictions

Notes: This figure plots the economy's response to the combined set of shocks $(\varepsilon_{\beta,1}, \varepsilon_{\pi,1}, \varepsilon_{\lambda,1})$ described above. Variable definitions are as follows: Risk-Free Rate (R_t, the one-period risk-free rate), Security Value (P_t), Required Bank Capital (k_t), Output (Y_t), Bank Loans (B_t^{loan}), Investment (I_t), Cash (A_t), Dividends (Payouts) / $\bar{Y}$ ($D_t/\bar{Y}$). Aggregate variables (firm variables without a type subscript) are computed as sums over constrained and unconstrained firms. All variables are displayed in percent changes from steady state with the exception of Dividends / $\bar{Y}$, which displays levels in percent.

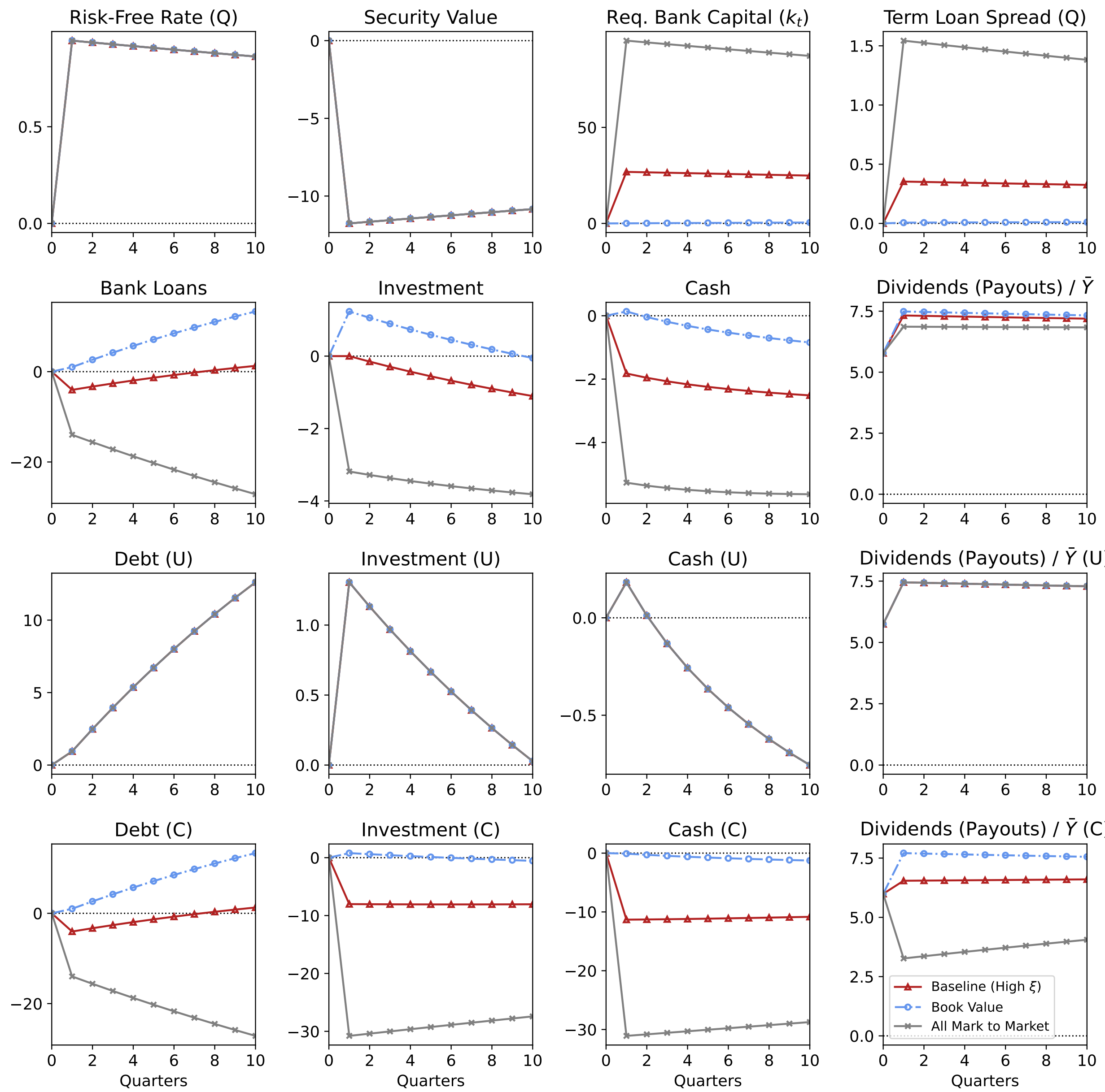


Figure A.2: Model Responses, High Investment Frictions

Notes: This figure plots the economy's response to the combined set of shocks $(\varepsilon_{\beta,1}, \varepsilon_{\pi,1}, \varepsilon_{\lambda,1})$ described above. Variable definitions are as follows: Risk-Free Rate (R_t, the one-period risk-free rate), Security Value (P_t), Required Bank Capital (k_t), Output (Y_t), Bank Loans (B_t^{loan}), Investment (I_t), Cash (A_t), Dividends (Payouts) / $\bar{Y}$ ($D_t/\bar{Y}$). Aggregate variables (firm variables without a type subscript) are computed as sums over constrained and unconstrained firms. All variables are displayed in percent changes from steady state with the exception of Dividends / $\bar{Y}$, which displays levels in percent.

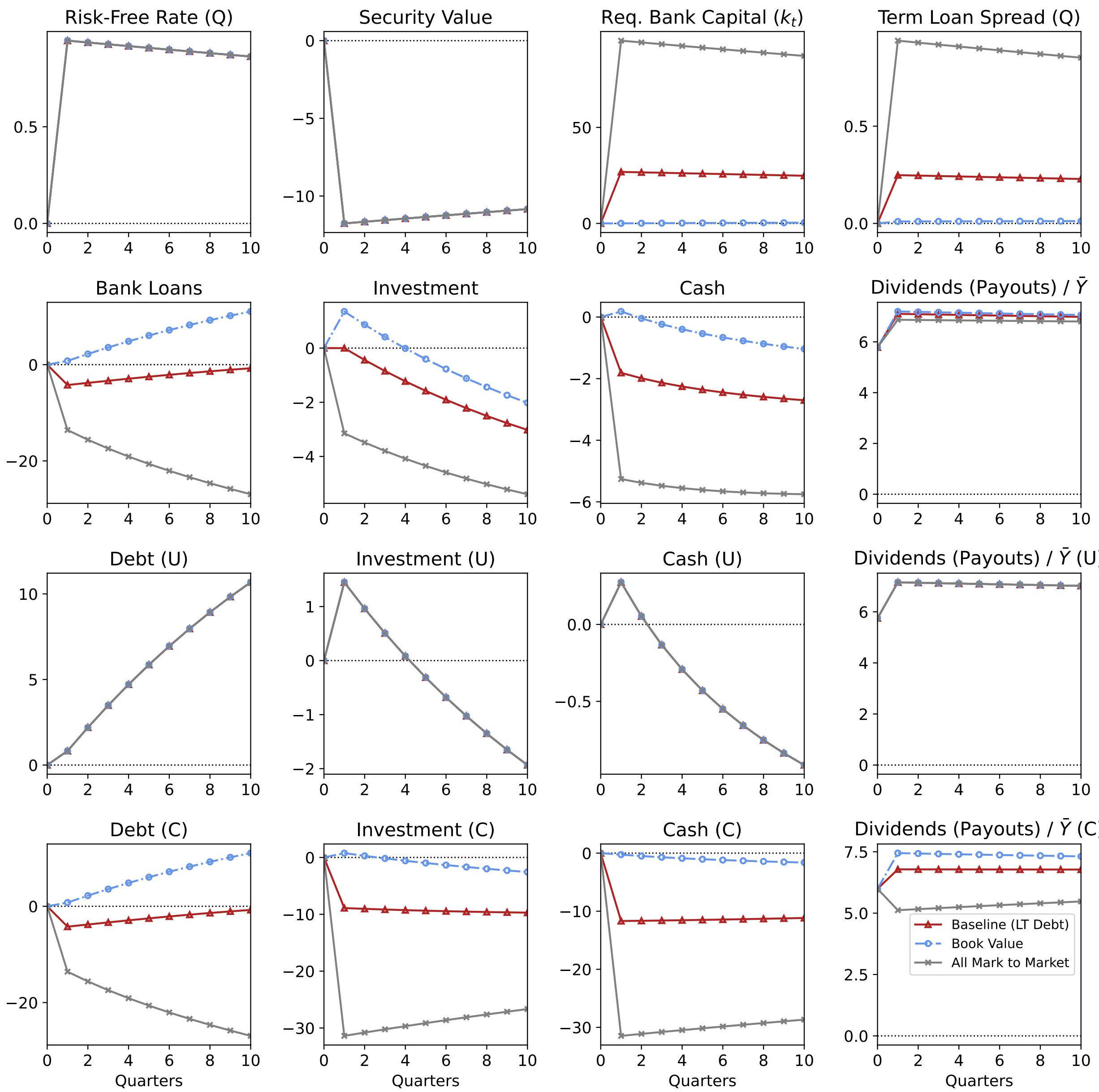
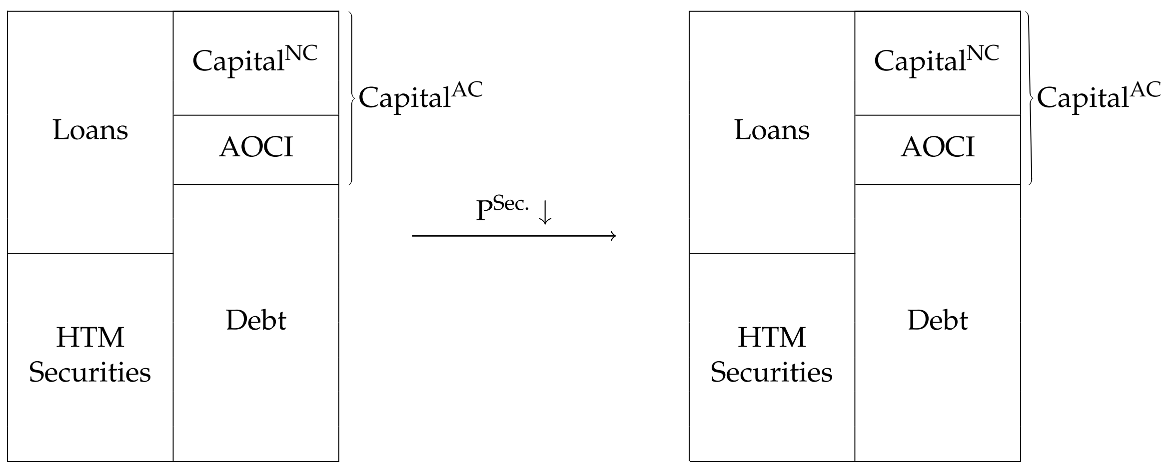


Figure A.3: Model Responses, Long-Term Debt

Notes: This figure plots the economy's response to the combined set of shocks $(\varepsilon_{\beta,1}, \varepsilon_{\pi,1}, \varepsilon_{\lambda,1})$ described above. Variable definitions are as follows: Risk-Free Rate (R_t, the one-period risk-free rate), Security Value (P_t), Required Bank Capital (k_t), Output (Y_t), Bank Loans (B_t^{loan}), Investment (I_t), Cash (A_t), Dividends (Payouts) / $\bar{Y}$ ($D_t/\bar{Y}$). Aggregate variables (firm variables without a type subscript) are computed as sums over constrained and unconstrained firms. All variables are displayed in percent changes from steady state with the exception of Dividends / $\bar{Y}$, which displays levels in percent.

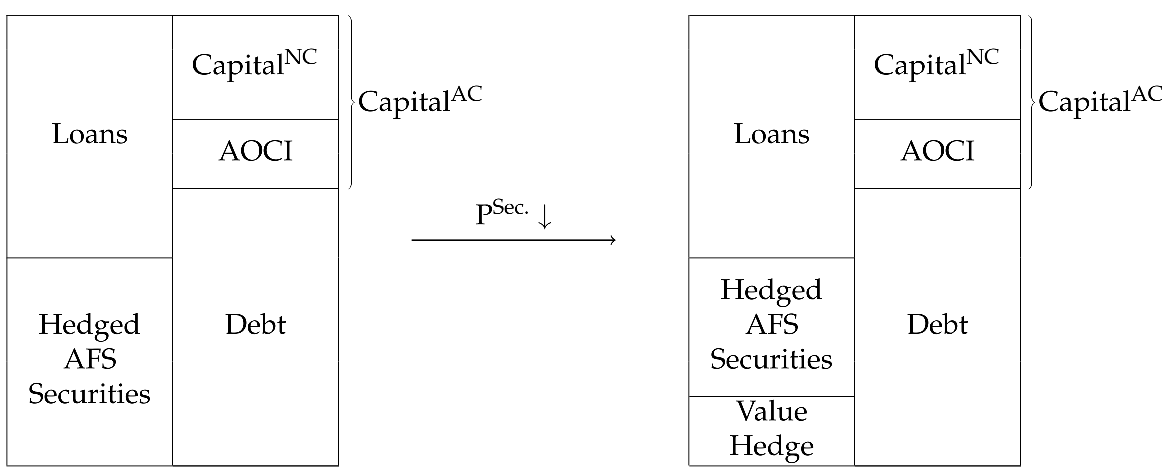
B Balance Sheet Dynamics

Figure B.1: Accounting treatment for HTM Securities.



Notes: The figure shows changes in a hypothetical bank's balance sheet following a decline in security prices where securities are booked in HTM.

Figure B.2: Accounting treatment for hedged AFS Securities.



Notes: The figure shows changes in a hypothetical bank's balance sheet following a decline in security prices where securities are booked in AFS and matched with a qualified fair value hedge.

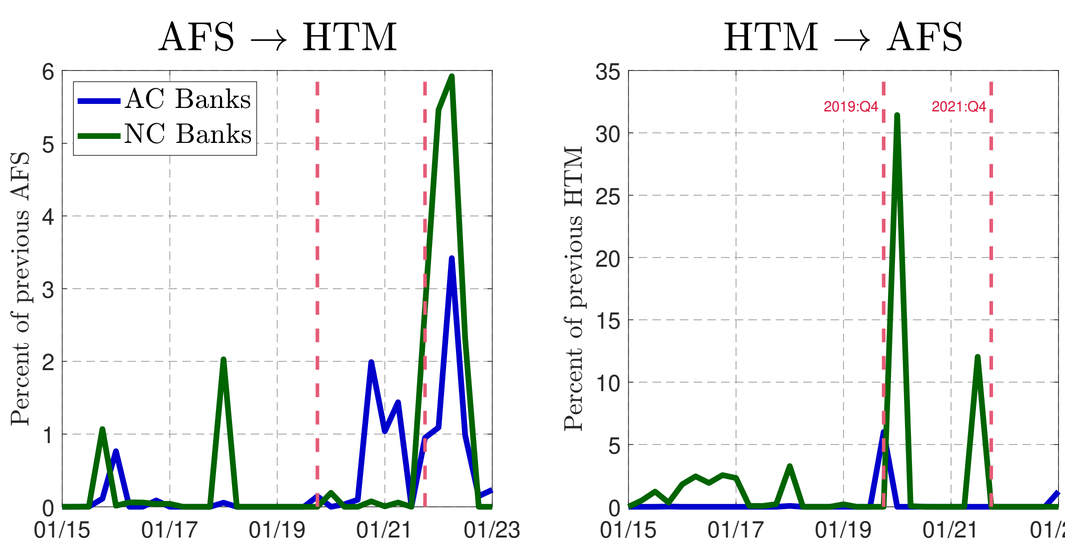
C Security Reclassifications

Accounting reclassifications are intended to be rare, but permissible under certain circumstances. Conditions under which a security holder can reclassify from HTM to AFS include (see ASC 320-10-25-6):

- Evidence of significant deterioration in security issuer's creditworthiness
- A change in tax law that eliminates or reduces the tax-exempt status of interest of the debt security
- A major business combination or major disposition that necessitates the sale or transfer of held-to-maturity securities to maintain the entity's interest rate risk position or credit risk policy
- A change in statutory or regulatory requirements significantly modifying either what constitutes a permissible investment or the maximum level of investments in certain kinds of securities, thereby causing an entity to dispose a held-to-maturity security
- A significant increase in the industry's capital requirements by the regulator that causes the entity to downsize by selling held-to-maturity securities
- A significant increase in the risk weights of debt securities used for regulatory risk-based capital purposes

Also relevant for security reclassifications is that holders are allowed a one-time election to sell and/or transfer debt securities classified as held-to-maturity that reference a rate expected to be discontinued (e.g., LIBOR), see ASC 848-10-35-1.

Figure C.1: Accounting designation changes



Notes: Data from FR Y-14 Schedule B.1. The chart shows the fraction of securities transferred between AFS and HTM accounting designations relative to total AFS or HTM securities in the previous quarter. Vertical dashed lines indicate 2019:Q4 and 2021:Q4.

D Data

Table D.1: AC and NC Banks.

AC BHCs	NC BHCs
JPMORGAN CHASE & CO	CHARLES SCHWAB CORP
BANK OF AMER CORP	M&T BK CORP
STATE STREET CORP	KEYCORP
WELLS FARGO & CO	HUNTINGTON BSHRS
NORTHERN TR CORP	PNC FNCL SVC GROUP
CITIGROUP	FIFTH THIRD BC
MORGAN STANLEY	TRUIST FC
GOLDMAN SACHS GROUP THE	U.S. BANCORP
DB USA CORP	CITIZENS FNCL GRP
BANK OF NY MELLON CORP	BMO FNCL CORP
	MUFG AMERS HOLDS CORP
	ALLY FNCL
	CAPITAL ONE FC
	HSBC N AMER HOLDS
	REGIONS FC
	TD GRP US HOLDS LLC
	SANTANDER HOLDS USA
	UBS AMERS HOLD LLC
	RBC US GRP HOLDS LLC

Notes: This table lists the AC and NC banks in our data for our main sample 2021:Q1-2023:Q1. Banks are identified to be one of the two categories according to the variable BHCAP838 from the Y-9C filings.

Table D.2: FR Y-14Q H.1 Variable Definitions.

Variable Name	Description / Use in main analysis	Field No.
Zip code	Zip code of headquarters	7
Industry	Derived 2-Digit NAICS Code	8
TIN	Taxpayer Identification Number	11
Internal Credit Facility ID	Used together with BHC and previous facility ID to construct loan histories	15
Previous Internal Credit Facility ID	Used together with BHC and facility ID to construct loan histories	16
Term Loan	Loan facility type reported as Term Loan, includes Term Loan A-C, Bridge Loans, Asset-Based, and Debtor in Possession.	20
Credit Line	Loan facility type reported as revolving or non-revolving line of credit, standby letter of credit, fronting exposure, or commitment to commit.	20
Purpose	Credit facility purpose	22
Committed Credit	Committed credit exposure	24
Used Credit	Utilized credit exposure	25
Line Reported on Y-9C	Line number reported in HC-C schedule of FR Y-9C	26
Participation Flag	Used to determine whether a loan is syndicated	34
Variable Rate	Interest rate variability reported as “Floating” or “Mixed”	37
Interest Rate	Current interest rate	38
Date Financials	Financial statement date used to match firm financials to Y-14 date	52
Net Sales Current	Firm sales over trailing 12-month period	54
Net Income	Current net income for trailing 12-months used to construct return on assets	59, 60
Cash	Cash & Marketable Securities	61
Fixed Assets	Fixed assets	69
Total Assets	Total assets, current year and prior year	70
Short Term Debt	Used in calculating total debt	74
Long Term Debt	Used in calculating total debt	78
Total Liabilities	Firm Total Liabilities	80
Syndicated Loan	Syndicated loan flag	100

Notes: Nominal series are converted into real series using the consumer price index for all items taken from St. Louis Fed’s FRED database. The corresponding “Field No.” can be found in the data dictionary (Schedule H.1, pp. 162-217): https://www.federalreserve.gov/reportforms/forms/FR_Y-14Q20200331_i.pdf

Table D.3: FR Y-14Q B.1 & B.2 and Vendor Data Variable Definitions.

Variable Name	Description / Use	Schedule / Field No.
Unique Identifier	Unique ID used by BHC to identify each record over time	B.1/B.2
Identifier Value	ID, corresponds to a CUSIP, ISIN, or SEDOL identifier, if it exists	B.1
Security description	Reported asset class of security	B.1
Market value	Fair value of security holding in $USD	B.1
Price	Price of security in $USD.	B.1
Amortized cost	Purchase price of debt security in $USD adjusted for amortization/accretion of discounts/premia and adjusted for hedge gains and losses	B.1
Accounting intent	Available-for-sale, held-to-maturity.	B.1
Hedge type	Use only fair value hedges.	B.2/6
Hedged risk	Use only hedges linked to interest rate risk.	B.2/7
Hedge percentage	Portion of the asset holding being hedged, 0-100 percent.	B.2/9
Hedge sidedness	Use only two-sided hedges.	B.2/12
Security duration	Effective rate duration at security level.	ICE

Notes: Variables and further descriptions for FR Y-14Q schedules B.1 and B.2 may be found in data dictionary: https://www.federalreserve.gov/reportforms/forms/FR_Y-14Q20200331_i.pdf

Table D.4: Compustat Variable Definitions.

Variable Name	Description	Compustat Name
Total Assets	Total firm assets	atq
Employer Identification Number	Used to match to TIN in Y14	ein
Total Liabilities	Total firm liabilities	ltq
Net Income	Firm net income (converted to 12-month trailing series)	niq
Total Debt	Debt in current liabilities + long-term debt	dlcq + dlttq
Sales	Total firm sales	saleq
Fixed Assets	Net property, plant, and equipment	ppentq
Cash	Cash & Marketable securities	cheq

Notes: All data obtained from the Wharton Research Data Services. Nominal series deflated using the consumer price index for all items taken from St. Louis Fed's FRED database.

Table D.5: Variables from Y-9C filings.

Variable Code	Variable Label
BHCK2170	Total Assets
BHCK2948	Total Liabilities
BHCK4340	Net Income
BHCK3197	Earning assets that reprice or mature within one year
BHCK3296	Interest-bearing deposit liabilities that reprice or mature within one year
BHCK3298	Long-term debt that reprices within one year
BHCK3408	Variable-rate preferred stock
BHCK3409	Long-term debt that matures within one year
BHDM6631	Domestic offices: noninterest-bearing deposits
BHDM6636	Domestic offices: interest-bearing deposits
BHFN6631	Foreign offices: noninterest-bearing deposits
BHFN6636	Foreign offices: interest-bearing deposits
BHCAP793	CET 1 Capital Ratio
BHCA7206	Tier 1 Capital Ratio
BHCA7205	Total Capital Ratio
BHCKB529	Loans and Leases held for investment
BHCK5369	Loans and Leases held for sale
BHCM3543	Trading Assets: Derivatives positive fair value
BHCK3547	Trading Liabilities: Derivatives with a negative fair value
BHCKA126	Derivatives, Interest Rate Contracts: Total gross notional amount of derivative contracts held for trading
BHCK8733	Derivatives, Interest Rate Contracts: Contracts held for trading: Gross positive fair value
BHCK8737	Derivatives, Interest Rate Contracts: Contracts held for trading: Gross negative fair value
BHCAP838	AOCI opt-out election
BHCM3531, BHCM3532, BHCM3533	Trading book: Government securities
BHCKG379, BHCKG380, BHCKG381, BHCKK197, BHCKK198	Trading book: Mortgage-backed securities
BHCKHT62, BHCKG386	Trading book: Other debt securities
BHCKG210	Trading book: Short position for debt securities
BHCKJJ33	Provision for loan and lease losses
BHCAB530	AOCI
BHCAA223	Risk-weighted Assets

Notes: The table lists variables that are collected from the Consolidated Financial Statements or FR Y-9C filings for Bank-Holding Companies from the Board of Governors' National Information Center database. The one-year income gap is defined as $(\text{BHCK}\,3197 - (\text{BHCK}\,3296 + \text{BHCK}\,3298 + \text{BHCK}\,3408 + \text{BHCK}\,3409))\,/\text{BHCK}\,2170$. Total deposits are given by $(\text{BHDM}\,6631 + \text{BHDM}\,6636 + \text{BHFN}\,6631 + \text{BHFN}\,6636)$. Nominal series are deflated using the consumer price index for all items taken from St. Louis Fed's FRED database.

E Sample Restrictions and Filtering Steps

We apply the following filtering steps to the H.1 schedule:

1. We constrain the sample to loan facilities with line reported on the HC-C schedule in the FR Y9-C filings as commercial and industrial loans, "other" loans, "other" leases, and owner-occupied commercial real estate (corresponding to Field No. 26 in the H.1 schedule of the Y14 to be equal to 4, 8, 9, or 10; see Table D.2). In addition, we drop all observations with NAICS codes 52 and 53 (loans to financial firms and real estate firms).

2. Observations with negative or zero values for committed exposure, negative values for utilized exposure, with committed exposure less than utilized exposure, and gaps in their loan histories are excluded.

3. When aggregating loans at the firm level, we exclude observations for which the firm identifier "TIN" is missing. To preserve some of these missing values, we fill in missing TINs from a history where the non-missing TIN observations are all the same over a unique facility ID.

4. When using information on firms' financials in the analysis, we apply a set of filters to ensure that the reported information is sensible. We exclude observations (i) if total assets, total liabilities, short-term debt, long-term debt, cash assets, tangible assets, or interest expenses are negative, (ii) if tangible assets, cash assets, or total liabilities are greater than total assets, and (iii) if total debt (short term + long term) is greater than total liabilities.

5. When using the interest rate on loans in our calculations, we exclude observations with interest rates below 0.5 or above 50 percent to minimize the influence of data entry errors.

We apply the following filtering steps to the B.1 and B.2 schedules:

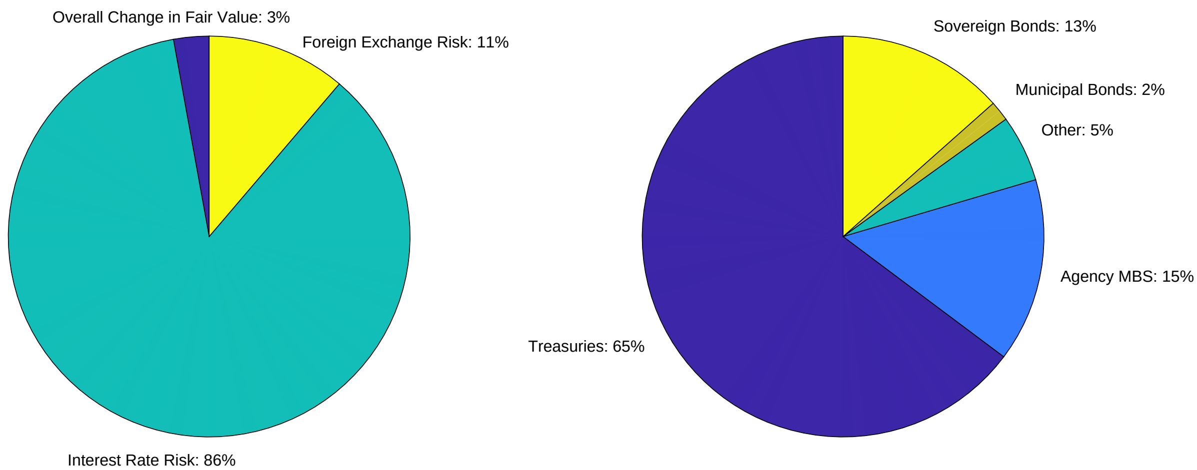
1. We exclude hedges with hedge horizons past the observation date.

2. We exclude observations with negative market values, amortized costs, or prices.

3. If the pricing date differs from the observation date, we refill the price variable one year backwards or forward, so that pricing date and observation date align.

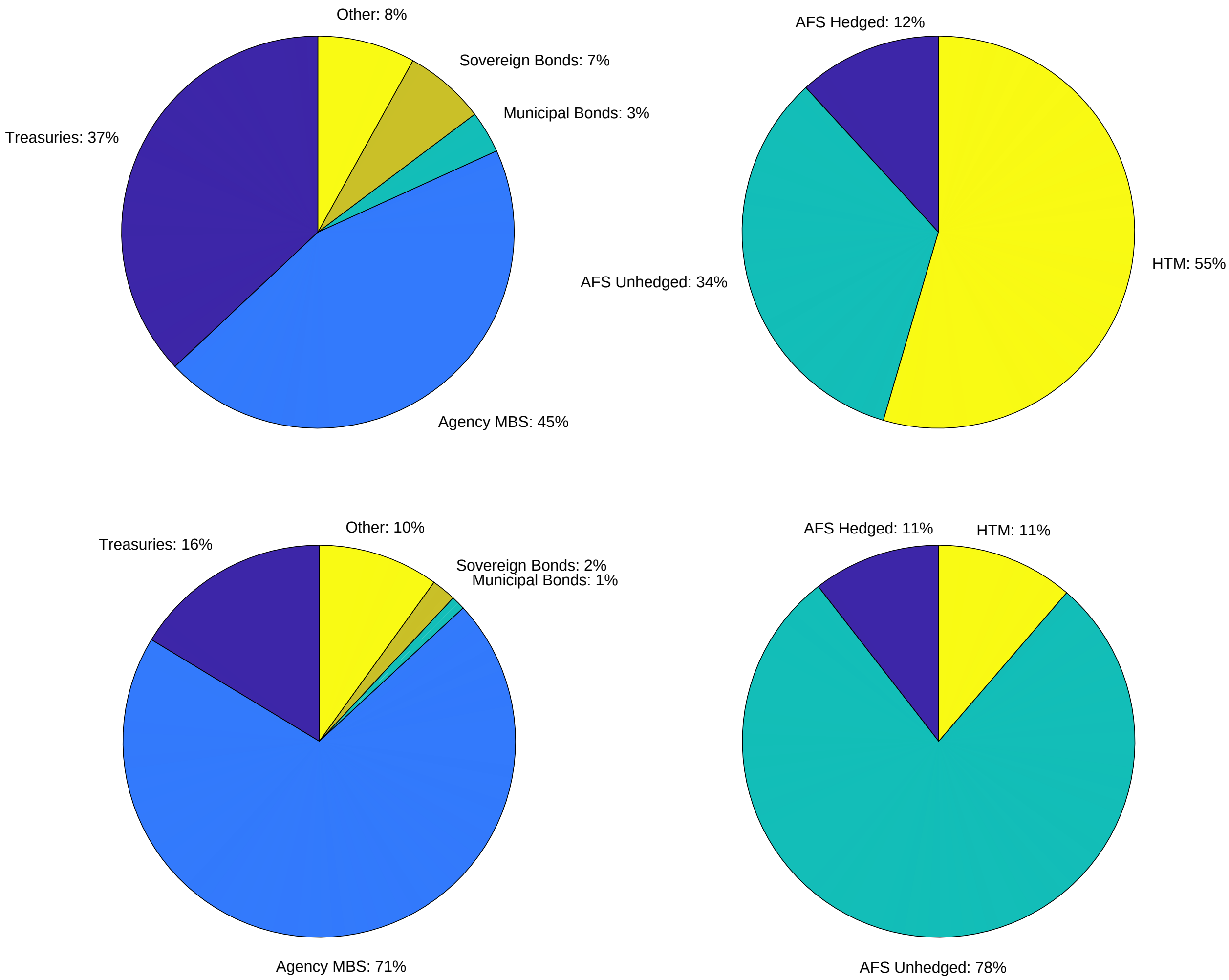
F Stylized Facts

Figure F.1: Composition of Accounting Hedges.



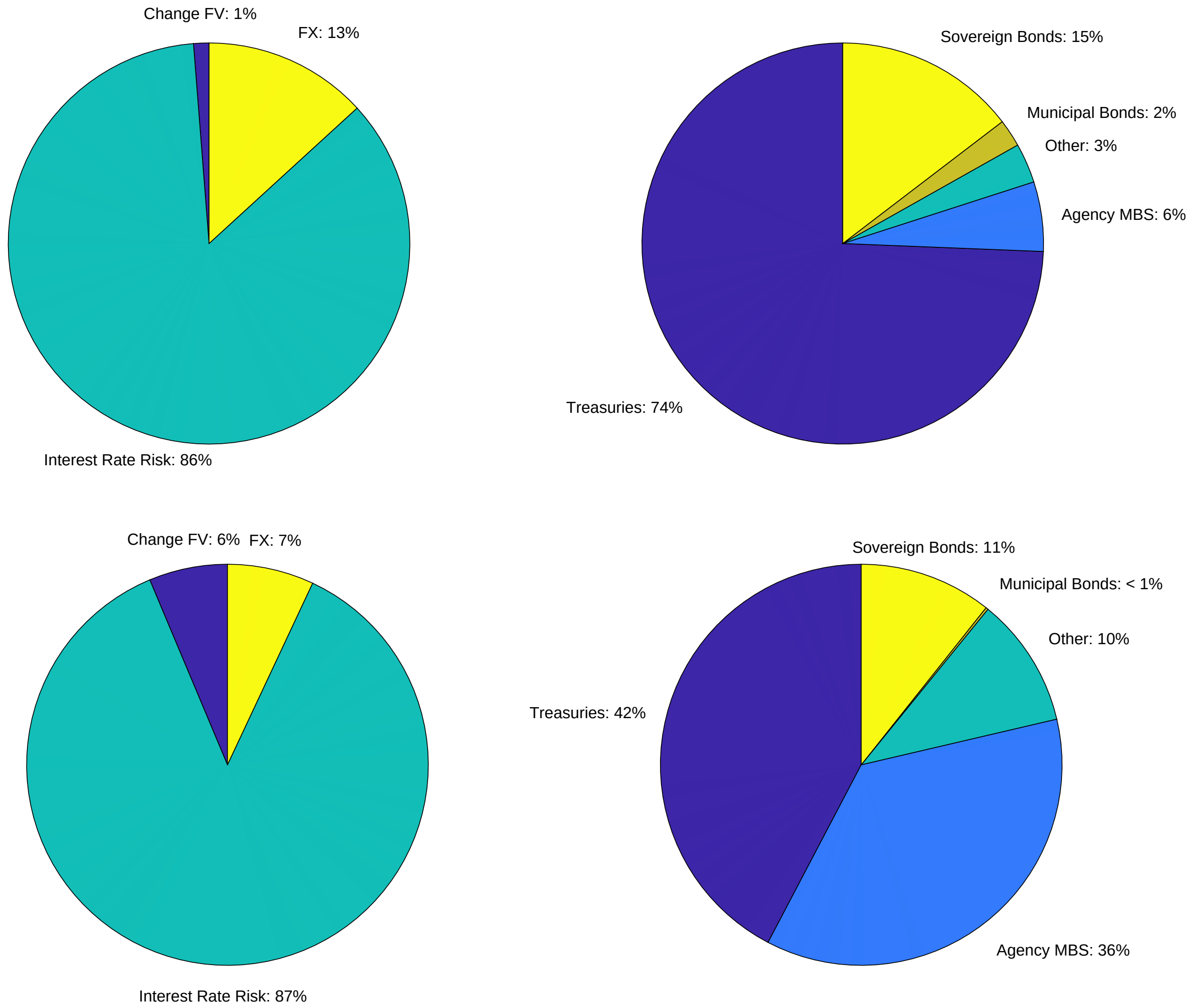
Notes: Data from FR Y-14Q sampled in 2021:Q4. The charts show the allocation shares of qualified accounting hedges by hedge type (left panel) and by hedged item or asset class (right panel). Shares are computed as percent of total market value hedged.

Figure F.2: Securities Portfolios for AC banks (top) and NC Banks (bottom).



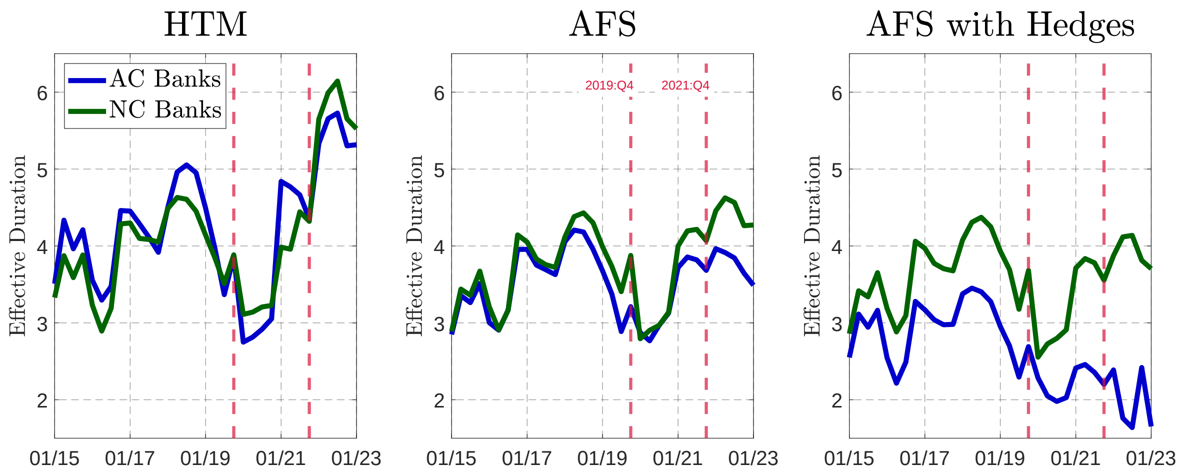
Notes: Data from FR Y-14Q sampled in 2021:Q4. The charts show the allocation shares of aggregate securities portfolio by asset class (left panels) and by accounting designation (right panels), separately for AC banks (top) and NC banks (bottom). Shares are computed as percent of total market value.

Figure F.3: Accounting Hedges for AC banks (top) and NC Banks (bottom).



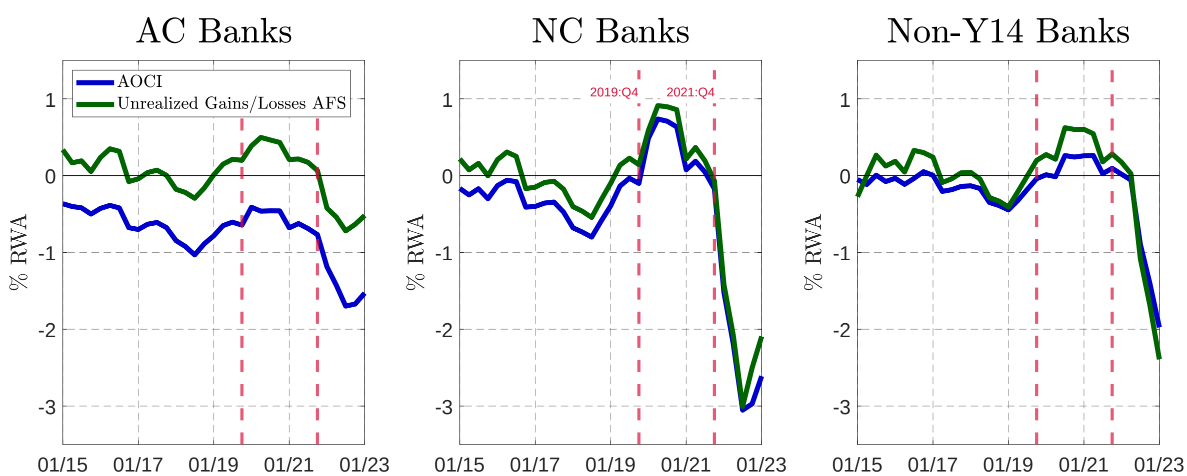
Notes: Data from FR Y-14Q sampled in 2021:Q4. The charts show the allocation shares of qualified accounting hedges by hedge type (left panels) and by hedged item or asset class (right panels), separately for AC banks (top) and NC banks (bottom). Shares are computed as percent of total market value hedged.

Figure F.4: Duration of Securities Portfolios.



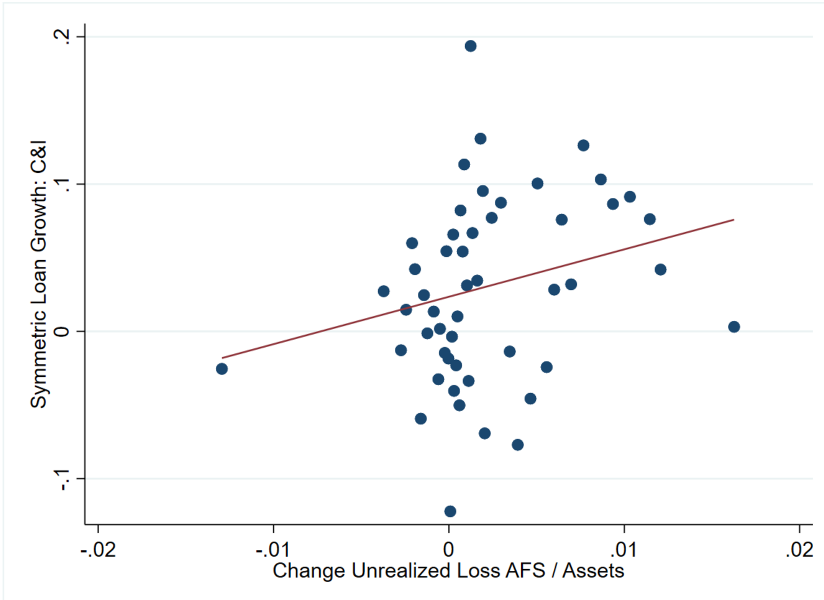
Notes: The graph shows the evolution of the effective duration of banks' HTM and AFS securities portfolios weighted by the market value of securities. The right panel takes into account that hedges shorten the maturity of AFS securities (i.e. a security that is fully hedged has a zero maturity).

Figure F.5: AOCI and Unrealized Gains/Losses AFS.



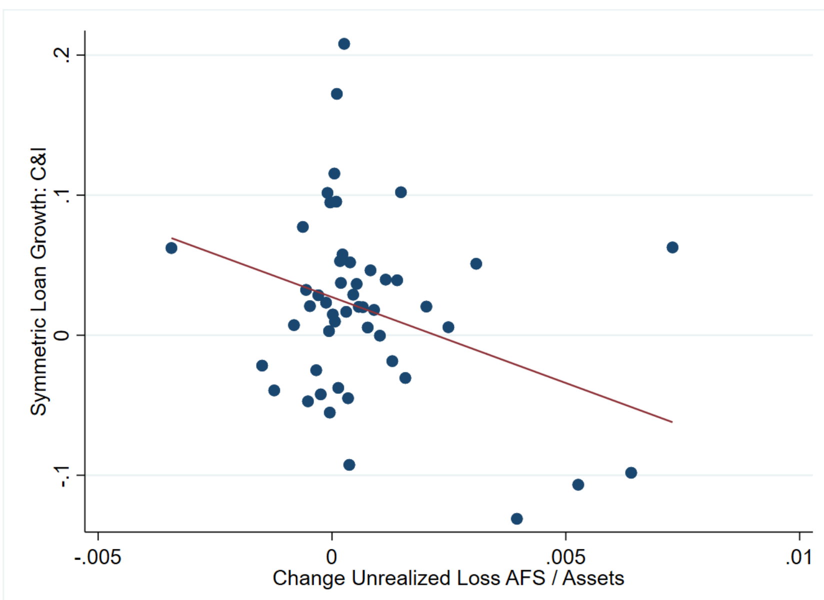
Notes: The graph shows the evolution of AOCI and unrealized gains/losses on AFS securities (both relative to risk-weighted assets) for AC banks (left panel), NC banks (middle), and non-Y14 banks (right). Source: Y-9C data.

Figure F.6: Unrealized Losses AFS and Lending Growth—NC Banks.



Notes: Data from FR Y-9C over 2021:Q1-2023:Q1 for NC banks that are part of the Y-14 sample. Binscatter plot of the change in unrealized losses on AFS securities between t and $t+1$ (relative to total assets at t) against the C&I lending growth between t and $t+2$ computed using the symmetric growth rate.

Figure F.7: Unrealized Losses AFS and Lending Growth—AC Banks.



Notes: Data from FR Y-9C over 2021:Q1-2023:Q1 for AC banks that are part of the Y-14 sample. Binscatter plot of the change in unrealized losses on AFS securities between t and $t+1$ (relative to total assets at t) against the C&I lending growth between t and $t+2$ computed using the symmetric growth rate.

G Credit Supply Effects

In this appendix, we explore extensions and test the robustness of our empirical findings in Section 6.

First, we consider alternative fixed effects specifications. Table G.2 omits the firm-time fixed effects and replaces those by variations of location-, size-, and industry-time fixed effects, which extends the sample to include firms that borrow from a single lender. Second, loans differ by contract terms such as maturity, whether they are adjustable- or fixed-rate loans, and whether a loan is syndicated. To ensure that we compare loans with similar contract terms, we extend the firm-time fixed effects with such characteristics. Table G.3 shows the updated estimation results. For both extensions, our results are similar to our baseline estimates.

Third, we extend the sample to include bank-firm observations that also cover credit lines. Columns (i) and (ii) of Table G.4 show that our results vanish when we consider used credit amounts. This finding can be explained by the fact that banks have less control over restricting the usage of credit lines which are strongly demand-driven. However, banks may adjust committed credit amounts. We therefore consider regressions with changes in committed credit as a dependent variable in columns (iii) and (iv) of Table G.4. Despite this change, we still find that our baseline results are substantially weaker, which may be explained by the fact that many firms have substantial room between their committed and used credit lines and adjusting the committed amounts may not change the used amounts substantially. However, once we restrict the unused amount to be below 10 percent of the total committed amount in columns (v) and (vi) of Table G.4, our initial results reappear. Thus, our findings are robust to including credit lines into the analysis if those do not have substantial unused credit.

Fourth, a potential concern may be that firms reduce their credit demand at banks with larger value losses of securities, as opposed to banks restricting credit supply, since firms might be worried about overall bank health. We view such a concern to be less applicable to the set of relatively large banks in our data over most of the sample when the stability of the U.S. financial system was not being questioned. However, in 2023:Q1, financial stability concerns may have played a role with the turmoil around SVB. We therefore rerun our regressions on a sample that ends in 2022:Q4. The results are shown in Table G.5. The findings for value changes of AFS securities remain the same for this new sample. We also find positive and marginally significant results for value changes of HTM securities. These results can be explained by the collateral channel or the net worth channel discussed in Section 3.

Fifth, we extend the sample backwards as far as possible to include periods of monetary easings. Table G.6 shows the updated results for the period 2016:Q4-2023:Q1. While our key findings remain, the coefficients reduce somewhat in magnitude. This comparison indicates that the effects are larger following a sharp unexpected monetary tightening as it occurred in 2022. To further explore the possibility of asymmetric effects, we separate positive and negative AFS value changes in Table G.7. We find larger and statistically significant effects for negative AFS value changes, though we cannot reject that the estimates are different from the ones of positive AFS value changes at standard confidence levels.

Sixth, in addition to the intensive margin responses, we further analyze extensive margin adjustments. That is, the dependent variable in our baseline regression (6.1) includes all bank-firm observations in t and $t+2$ that show an existing lending relationship for both periods and are non-zero in at least one of the periods. However, non-existing relationships in either t or $t+2$ are not part of the sample. We incorporate such new lending relationships or the end of old relationships by including zero-observations for $L_{i,j,t}$ or $L_{i,j,t+2}$ in such instances. The updated results are shown in Table G.8. The estimated coefficients β increase in magnitude and are even more precisely estimated, showing that such extensive margin adjustments further strengthen our findings.[45]

Seventh, we reestimate regression (6.1) for various horizons to portray the dynamic response of credit. Table G.9 shows the results. The crowding out effect is already sizable and significant within the same quarter during which securities change value. Hence, the transmission of monetary policy through bank securities portfolios operates at a high frequency since asset prices change instantly and lead to quick credit adjustments. The response builds up over time and becomes strongest at the three-quarter horizon.

Eighth, we test whether the identified supply effects apply not only to credit quantities but also to interest rates charged on loans. Table G.10 shows the results for regressions that use changes in interest rates as a dependent variable in (6.1), again portraying the dynamic response for various horizons. We find negative coefficients for β that indicate the identification of supply adjustments. At the three-quarter horizon, the responses are statistically different from zero at the 5 percent confidence level. However, compared with the credit responses, the statistical significance is weaker overall.[46]

[45]However, we do not measure the exact strength of the spillover effect in dollar terms based on these estimates, since the symmetric growth rate that we use as a dependent variable in regression (6.1) approximates all new relationships or the ending of old relationships as either -2 or 2.

[46]We note that although this evidence supports a rise in interest rates, it is not strictly necessary since our model mechanism ultimately works through quantities, as constrained firms adjust other margins such as investment to offset credit lost due to crowding out. While crowding out occurs via credit spread increases in our model, it could also occur via credit rationing as in e.g., Stiglitz and Weiss (1981), with a smaller increase or no increase in spreads, due to information frictions not present in our model.

And, finally, we test for a pretrend by running a placebo regression that uses $(L_{i,j,t} - L_{i,j,t-2})/(0.5 \cdot (L_{i,j,t} - L_{i,j,t-2}))$ as a dependent variable in (6.1). Table G.11 shows that our findings vanish for this alternative setup.

Table G.1: Summary Statistics.

Variable	**Obs.**	**Mean**	**Std.**	**P10**	**Median**	**P90**	**AC**	**NC**
Main Regressors								
Δ Value SEC/Assets	183	-.44	.61	1.26	.16	.10	-.35	-.49
Δ Value AFS/Assets	183	-.28	.39	-.91	-.11	.06	-0.13	-0.36
Δ Value HTM/Assets	183	-.16	.40	-.55	-.012	.02	-.22	-0.13
Bank Controls								
ROA	183	.62	.42	.22	.55	1.11	0.53	0.64
Income Gap	183	37.30	11.74	28.50	38.85	49.23	36.89	37.50
Leverage	183	90.23	1.81	87.93	90.40	92.47	91.60	89.50
Ln(Total Assets)	183	19.67	1.01	18.73	19.22	21.39	20.65	19.16
Deposit Share	183	69.50	16.06	50.79	75.23	84.51	68.75	74.03
Loan Share	183	42.40	17.27	15.41	45.25	63.85	24.79	51.63
Unused Credit/Assets	183	8.13	5.37	2.23	6.63	16.98	3.72	10.44

Notes: Summary statistics for the regressors in regression (6.1) at the bank level. All variables are multiplied by 100, except for Ln(Total Assets). Averages for AC and NC banks shown. Sample: 2021:Q1 - 2023:Q1.

Table G.2: Omitting Firm-Time Fixed Effects.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	4.59**	6.09**	3.47**	5.46**
	(1.91)	(2.31)	(1.51)	(2.33)
Δ Value HTM			-4.59**	-3.15
			(2.04)	(2.04)
Fixed Effects				
Location × Size × Time	✓		✓	
Location × Size × Time × Industry		✓		✓
Bank & AC × Time	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
R-squared	0.25	0.46	0.26	0.46
Observations	51,242	25,906	51,242	25,906
Number of Firms	12,544	7,719	12,544	7,719
Number of Banks	28	28	28	28

Notes: Estimation results for regression (6.1). Columns (i) and (iii) include location-size-time fixed effects based on U.S. states and percentiles of the total asset distribution and columns (ii) and (iv) include location-size-time-industry fixed effects, which additionally use 2-digit NAICS codes. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.3: Firm-Time Fixed Effects Extensions.

	(i)	(ii)	(iii)	(iv)	(v)
Δ Value AFS	6.08***	5.65***	5.49***	5.33***	5.63**
	(1.85)	(1.94)	(1.56)	(1.65)	(2.08)
Fixed Effects					
Firm × Time	✓				
Firm × Time × Syn.		✓			
Firm × Time × Mat.			✓		
Firm × Time × Float.				✓	
Firm × Time × All					✓
Bank & AC × Time	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓
R-squared	0.57	0.53	0.54	0.54	0.53
Observations	13,038	11,606	12,523	11,376	10,277
Number of Firms	1,289	1,165	1,242	1,142	1,035
Number of Banks	27	27	27	27	25

Notes: Estimation results for regression (6.1). Column (i) shows the baseline estimate using firm-time fixed effects, Column (ii) extends the fixed effects by whether the loan is syndicated, Column (iii) by the loan's maturity based on three bins (less than one quarter, less than one year, and more than one year), Column (iv) by whether the loan carries an adjustable or a floating rate, and Column (v) uses all three additional characteristics. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.4: Credit Lines.

	Used		Committed		Committed Res.	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS	3.07	2.46	1.32	2.10**	5.70**	7.00***
	(1.99)	(2.70)	(1.01)	(0.90)	(2.19)	(1.92)
Δ Value HTM	0.66	-0.30	0.93	0.60	2.93**	2.93*
	(1.06)	(0.94)	(0.88)	(0.76)	(1.33)	(1.48)
Fixed Effects						
Firm × Time	✓		✓		✓	
Firm × Time × Purpose		✓		✓		✓
Bank & AC × Time	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
R-squared	0.69	0.71	0.47	0.5	0.53	0.53
Observations	84,241	66,960	84,241	66,960	23,575	18,525
Number of Firms	5,622	4,581	5,622	4,581	2,371	1,899
Number of Banks	28	28	28	28	28	28

Notes: Estimation results for regression (6.1) which extends the sample to include bank-firm observations that also cover credit lines. Columns (i) and (ii) employ used credit for the dependent variable, while the remaining columns use committed credit instead. Columns (v) and (vi) restrict unused credit to be below 10 percent of total committed credit. All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii) and (iv). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.5: Excluding 2023:Q1.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	8.16***	9.95***	8.44***	10.26***
	(2.70)	(2.66)	(2.40)	(2.43)
Δ Value HTM			3.20*	2.52*
			(1.58)	(1.36)
Fixed Effects				
Firm × Time	✓		✓	
Firm × Time × Purpose		✓		✓
Bank & AC × Time	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
R-squared	0.59	0.56	0.59	0.56
Observations	11,020	9,365	11,020	9,365
Number of Firms	1,243	1,065	1,243	1,065
Number of Banks	27	26	27	26

Notes: Estimation results for regression (6.1). All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii) and (iv). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2022:Q4. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.6: Extended Sample.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	3.17**	4.87***	3.23**	4.91***
	(1.49)	(1.77)	(1.53)	(1.79)
Δ Value HTM			1.24	0.60
			(0.94)	(0.91)
Fixed Effects				
Firm × Time	✓		✓	
Firm × Time × Purpose		✓		✓
Bank & AC × Time	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
R-squared	0.56	0.55	0.56	0.55
Observations	41,541	33,269	41,541	33,269
Number of Firms	2,301	1,896	2,301	1,896
Number of Banks	34	34	34	34

Notes: Estimation results for regression (6.1). All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii) and (iv). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2016:Q4 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.7: Asymmetric Effects.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS (-)	3.38**	5.62***			3.24**	5.50***
	(1.49)	(1.63)			(1.48)	(1.60)
Δ Value AFS (+)			3.66	3.77	3.07	2.80
			(4.06)	(5.18)	(4.00)	(5.04)
Fixed Effects						
Firm × Time	✓		✓		✓	
Firm × Time × Purpose		✓		✓		✓
Bank & AC × Time	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
R-squared	0.56	0.55	0.56	0.55	0.56	0.55
Observations	41,561	33,290	41,561	33,290	41,561	33,290
Number of Firms	2,303	1,897	2,303	1,897	2,303	1,897
Number of Banks	35	35	35	35	35	35

Notes: Estimation results for regression (6.1), separating positive and negative AFS value changes. All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii), (iv), and (vi). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2016:Q4 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.8: Extensive Margin.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	48.38***	43.47***	47.48***	43.70***
	(14.23)	(11.57)	(13.48)	(11.26)
Δ Value HTM			-7.61	1.89
			(11.82)	(9.14)
Fixed Effects				
Firm × Time	✓		✓	
Firm × Time × Purpose		✓		✓
Bank & AC × Time	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
R-squared	0.69	0.71	0.69	0.71
Observations	23,200	19,744	23,200	19,744
Number of Firms	2,781	2,385	2,781	2,385
Number of Banks	30	28	30	28

Notes: Estimation results for regression (6.1) that incorporates new lending relationships and the ending of old relationships. All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii) and (iv). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.9: Dynamic Response.

	h=1	h=2	h=3	h=4	h=5
Δ Value AFS	6.82**	11.80***	12.56***	9.91*	6.03
	(3.18)	(3.80)	(4.11)	(5.17)	(4.04)
Fixed Effects					
Firm × Time	✓	✓	✓	✓	✓
Bank & AC × Time	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓
R-squared	0.59	0.57	0.57	0.57	0.58
Observations	5,087	5,087	5,087	5,087	5,087
Number of Firms	771	771	771	771	771
Number of Banks	27	27	27	27	27

Notes: Estimation results for regression (6.1) that uses $2 \cdot (L_{i,j,t+h} - L_{i,j,t})/(L_{i,j,t+h} + L_{i,j,t})$ as a dependent variable for $h = 1, 2, \ldots$. All specifications are estimated for a balanced sample, include firm-time fixed effects, as well as various bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.10: Interest Rates.

	h=1	h=2	h=3	h=4	h=5
Δ Value AFS	-0.02	-0.09	-0.16**	-0.13	-0.10
	(0.03)	(0.05)	(0.06)	(0.11)	(0.13)
Fixed Effects					
Firm × Time	✓	✓	✓	✓	✓
Bank & AC × Time	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓
R-squared	0.6	0.81	0.89	0.91	0.92
Observations	5,017	5,017	5,017	5,017	5,017
Number of Firms	765	765	765	765	765
Number of Banks	27	27	27	27	27

Notes: Estimation results for regression (6.1) that uses changes in interest rates $r_{i,j,t+h} - r_{i,j,t}$ as a dependent variable for $h = 1, 2, \ldots$. All specifications are estimated for a balanced sample, include firm-time fixed effects, as well as various bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table G.11: Placebo Regression.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	-0.33	-0.08	-0.26	-0.06
	(1.98)	(1.84)	(1.97)	(1.84)
Δ Value HTM			0.44	0.08
			(0.57)	(0.72)
Fixed Effects				
Firm × Time	✓		✓	
Firm × Time × Purpose		✓		✓
Bank & AC × Time	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
R-squared	0.58	0.56	0.58	0.56
Observations	16,570	14,082	16,570	14,082
Number of Firms	1,423	1,215	1,423	1,215
Number of Banks	29	28	29	28

Notes: Estimation results for regression (6.1) which uses $2 \cdot (L_{i,j,t} - L_{i,j,t-2})/(L_{i,j,t} + L_{i,j,t-2})$ as a dependent variable. All specifications include firm-time fixed effects that additionally vary by the loan purpose in columns (ii) and (iv). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include AC-banks-time fixed effects and bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

H Mechanism

In this section, we further explore the mechanisms explaining our results and contrast them with alternative channels.

AC Banks - Hedged vs. Unhedged Securities. We rerun regression (6.3) but additionally distinguish AFS value changes into hedged and unhedged ones. The results—reported in Table H.1—show that the coefficient related to unhedged security value changes interacted with the AC-banks indicator is statistically different from zero when we use the finer firm-time-loan purpose fixed effects. In contrast, we do not find such differential effects for hedged securities. These findings are consistent with the regulatory capital channel, which operates for unhedged securities at AC banks.

Bank Capital. We investigate differences across banks depending on their capital positions. To this end, we consider the regression

$$\frac{L_{i,j,t+2} - L_{i,j,t}}{0.5 \cdot (L_{i,j,t+2} + L_{i,j,t})} = \beta_1 \cdot \frac{\Delta Value^{AFS}_{j,t+1}}{Assets_{j,t}} + \beta_2 \cdot \frac{\Delta Value^{AFS}_{j,t+1}}{Assets_{j,t}} \cdot Cap_{j,t} + \gamma X_{j,t} + \kappa_j + u_{i,j,t} , \tag{H.1}$$

where $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$ is now interacted with a measure of bank capital $Cap_{j,t}$. For bank capital positions, we consider CET1, Tier 1, and total bank capital, and use the difference between the ratio and the requirement for each.

The estimation results for regressions (H.1) are reported in Table H.2. Across the various capital measures, β_2 is negative and statistically different from zero at standard confidence levels. That is, banks that are less capitalized show stronger spillover effects, confirming a prediction from Section 3. For the reported estimation results, we control for interaction terms between $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$ and various other bank controls, ensuring that we are not picking up an alternative channel based on correlations between bank observables.

Interest Rate Risk Channel. We provide further evidence that our baseline findings are explained by banks' exposure to interest rate risk that leads to fluctuations in the value of their securities portfolios, as opposed to other simultaneous reactions to changes in interest rates. To this end, we consider three extensions of regression (6.1) that are summarized in Table H.3 where Column (i) shows our baseline results.

First, Kashyap and Stein (2000) show that the effect of monetary policy on lending is stronger for banks with less liquid balance sheets, that is, with lower security holdings relative to assets. Intuitively, as monetary policy tightens, these banks have less liquid assets to sell and therefore need to contract lending. In contrast, we find that banks with larger value changes of securities relative to assets show a stronger lending response (which tend to be banks with more ex-ante securities relative to assets). To account for the channel by Kashyap and Stein (2000), we further control for banks' ex-ante AFS and HTM holdings, as well as their trading securities (distinguishing government, mortgage-backed, and other debt securities, as well as short positions for debt securities, see Appendix Table D.5 for details). The estimation results with these additional controls are shown in Column (ii) of Table H.3. If anything, our findings slightly strengthen in magnitude and statistical significance.

Second, we employ an instrumental variable regression. As discussed above, value changes of a bank's AFS portfolio can be the result of a number of risk factors and we aim to isolate the channel working through unexpected changes in interest rates. As an instrument for $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$, we therefore use the interaction between the yield change of the one-year treasury security from t to $t+1$, which captures changes in the stance of monetary policy, and a bank's AFS portfolio valued at market prices relative total assets at time t.

The first-stage regression yields a negative coefficient with respect to our instrument which is statistically different from zero at the 1 percent confidence level with an F-statistic of 45. Intuitively, an unexpected increase in interest rates leads to a more negative response of the value of a bank's AFS portfolio the larger the initial value of that portfolio. Table H.3 reports the second-stage results in Column (iii). The coefficient associated with $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$ remains positive and statistically significant at the 5 percent confidence level for the instrumental variable regression, providing additional evidence for the interest rate risk channel. The estimated coefficient is also larger than our baseline estimate, indicating that unexpected value changes of securities may yield even stronger spillover effects.

Third, we directly control for other simultaneous responses to interest rate movements. Specifically, changes in interest rates affect the interest rate gap between deposit rates and short-term market rates, resulting in deposit fluctuations (Drechsler, Savov and Schnabl, 2017). In turn, banks may alter their credit supply schedule to firms. Moreover, changes in the stance of monetary policy can affect banks differently depending on the maturity structure of their balance sheets. For example, banks that hold more adjustable-rate loans may obtain relatively more interest income in the short-run when monetary policy tightens (Gomez et al., 2021).

While our baseline controls—in particular banks' deposit shares and their income gap—partly account for such simultaneous deposit flows and cash flow effects, we directly control for them by including changes in bank deposits and net income from t to $t+1$ (both relative to total assets at time t) as separate regressors into our baseline regression (6.1).[47]

Moreover, a potential alternative explanation for our results is that banks with larger value losses of securities also experienced a stronger decline in the expected profitability of their legacy loans, leading to a contraction in lending that is not caused by the value losses of securities but by the poor performance of the loan portfolio. To address this concern, we directly control for the change in the quality of a bank's existing term loan portfolio using banks' reported probabilities of default and provision for loan losses from

[47] We use banks' net income change as opposed to changes in the net interest margin to account for other non-interest income changes. However, the results are unaffected by this choice. They equally hold when controlling for changes of net interest margins instead.

banks' income statements from t to $t+1$.[48]

Column (iv) of Table H.3 reports the new estimation results. While the coefficients on the added regressors are not statistically different from zero, the size and significance of the coefficient with respect to $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$ remain largely unchanged, providing further evidence that our initial results are not driven by such simultaneous developments but by responses to security price changes.

Table H.1: AC Banks - Hedged vs. Unhedged.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS Unhedged	-1.16	-1.41	-1.73	-1.62
	(4.77)	(5.29)	(4.98)	(4.94)
Δ Value AFS Unhedged × AC	6.85	14.44	14.70	24.21**
	(9.00)	(9.34)	(9.49)	(10.19)
Δ Value AFS Hedged			19.61	18.93
			(21.11)	(32.31)
Δ Value AFS Hedged × AC			-49.57	-49.16
			(40.62)	(57.78)
Fixed Effects				
Firm × Time	✓		✓	
Firm × Time × Purpose		✓		✓
Bank	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
Derivatives	✓	✓	✓	✓
Bank Controls × Δ Value AFS Unhedged	✓	✓	✓	✓
Bank Controls × Δ Value AFS Hedged			✓	✓
R-squared	0.57	0.55	0.57	0.55
Observations	13,027	11,093	13,027	11,093
Number of Firms	1,288	1,105	1,288	1,105
Number of Banks	26	26	26	26

Notes: Estimation results for regression (6.3). All specifications include firm-time and bank fixed effects. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. All specifications include controls for derivative contracts from the trading and derivative book (see footnote 25 for details) and $\Delta Value^{HTM}_{j,t+1} / Assets_{j,t}$. Interaction terms between the various demeaned bank controls and $\Delta Value^{AFS}_{j,t+1} / Assets_{j,t}$ are included for hedged securities in columns (iii) and (iv) and for unhedged securities in all specifications. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

[48]Specifically, we compute changes in banks' reported probabilities of default on their total term loan portfolio weighted by used credit amounts and omitting the observation associated with the dependent variable (leave-one-out). Provision for loan losses are measured using item BHCKJJ33 from the Y-9C filings (see Appendix Table D.5 for details).

Table H.2: Bank Capital Positions.

	(i)	(ii)	(iii)
Δ Value AFS	5.82	6.00	7.42
	(4.50)	(4.89)	(5.12)
Δ Value AFS × CET1	-1.06*		
	(0.57)		
Δ Value AFS × Tier1		-1.17*	
		(0.66)	
Δ Value AFS × Total			-1.50**
			(0.69)
Firm × Time FE; Bank FE	✓	✓	✓
Bank Controls	✓	✓	✓
Bank Controls × Δ Value AFS	✓	✓	✓
R-squared	0.57	0.57	0.57
Observations	13,038	13,038	13,038
Number of Firms	1,289	1,289	1,289
Number of Banks	27	27	27

Notes: Estimation results for regression (H.1). All specifications include firm-time and bank fixed effects. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, the ratio of unused credit lines to assets, and each respective capital buffer. All specifications include interaction terms between the various demeaned bank controls and $\Delta Value^{AFS}_{j,t+1}/Assets_{j,t}$, apart from bank leverage which is highly correlated with the other capital measures. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table H.3: Interest Rate Risk Channel.

	(i)	(ii)	(iii)	(iv)
Δ Value AFS	6.08***	7.71***	14.07**	6.58***
	(1.85)	(1.47)	(6.12)	(2.07)
Δ Net Income				0.64
				(2.83)
Δ Deposits				-0.06
				(0.20)
Δ Probability Default				31.79
				(45.21)
Δ Provision Losses				5.91
				(6.43)
Firm × Time FE	✓	✓	✓	✓
Bank FE; AC × Time FE	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓
Banking Book Securities		✓	✓	
Trading Book Securities		✓		
Estimator	OLS	OLS	IV	OLS
First Stage F-Stat.			45	
R-squared	0.57	0.57	0.57	0.57
Observations	13,038	13,027	13,038	13,038
Number of Firms	1,289	1,288	1,289	1,289
Number of Banks	27	26	27	27

Notes: Estimation results for regression (6.1). All specifications include firm-time fixed effects, AC-banks time fixed effects, and bank fixed effects. Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. Columns (ii) and (iii) include AFS securities at market value as well as HTM securities at book value, both relative to assets. Column (ii) includes banks' securities from the trading portfolio at time t: government, mortgage-backed, and other debt securities, as well as short positions on debt securities (all relative to assets). Column (iii) considers an instrumental variable regression using the interaction between the yield change of the one-year treasury security from t to $t+1$ and a bank's AFS portfolio valued at market prices relative total assets at time t as an instrument. Column (iv) includes changes in net income, deposits, probabilities of default of banks term loan portfolios (weighted by used credit amounts), and provision for loan losses from t to $t+1$ (all relative to assets). Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table H.4: AC Banks - Firm-time FE Extension.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS	4.11*	5.60*	2.11	1.79	-3.70	-6.45
	(2.21)	(3.22)	(4.22)	(5.51)	(6.76)	(7.68)
Δ Value AFS × AC	29.24	34.40*	30.96	37.66*	29.27	35.76**
	(18.23)	(16.92)	(19.59)	(19.05)	(17.59)	(17.16)
Δ Value AFS × Size			-2.09	-3.82	-2.74	-4.59
			(2.79)	(3.43)	(4.96)	(5.87)
Fixed Effects						
Firm × Time × AC	✓		✓		✓	
Firm × Time × AC × Purpose		✓		✓		✓
Bank	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Bank Controls × Δ Value AFS					✓	✓
R-squared	0.61	0.6	0.61	0.6	0.61	0.6
Observations	7,115	5,738	7,115	5,738	7,115	5,738
Number of Firms	758	628	758	628	758	628
Number of Banks	27	25	27	25	27	25

Notes: Estimation results for regression (6.3). All specifications include firm-time-AC-bank fixed effects that additionally vary by the loan purpose in columns (ii), (iv), and (vi). Bank controls: bank size (natural log of assets), return on assets (net income/assets), deposit share (total deposits/assets), loan share (loans/assets), leverage (liabilities/assets), banks' income gap, and the ratio of unused credit lines to assets. Columns (v) and (vi) include interaction terms between the various demeaned bank controls and $\Delta Value^{AFS}_{j,t+1}/Assets_{j,t}$. All specifications include bank fixed effects. Standard errors in parentheses are clustered by bank. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

I Effects at the Firm Level

Table I.1: Firm Level Effects - Credit Line Access.

	Δ Liabilities		Investment		Δ Cash	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Δ Value AFS	4.14**		5.30**		10.45**	
	(2.07)		(2.67)		(4.48)	
Δ Value AFS × No CL		5.23**		6.68**		10.84**
		(2.05)		(2.65)		(4.54)
Δ Value AFS × CL		-13.06**		-16.50**		4.39
		(6.16)		(7.23)		(10.41)
Fixed Effects						
Firm	✓	✓	✓	✓	✓	✓
Time	✓	✓	✓	✓	✓	✓
Firm Controls	✓	✓	✓	✓	✓	✓
R-squared	0.78	0.78	0.72	0.72	0.66	0.66
Observations	83,663	83,663	82,473	82,473	81,901	81,901
Number of Firms	22,499	22,499	22,162	22,162	22,116	22,116
Number of Banks	29	29	29	29	29	29

Notes: Estimation results for regression (6.5) where $y_{i,t}$ is either total liabilities in columns (i) and (ii), fixed assets in columns (iii) and (iv), or cash holdings in columns (v) and (vi). All specifications include firm fixed effects and the firm controls: cash holdings, fixed assets, liabilities, net income, sales (all scaled by total assets), firm size (natural logarithm of total assets), the ratio of observed debt to total debt, as well as the set of all bank controls used in previous regressions and deposit and net income changes from Column (iv) of Table H.3 aggregated to the firm level using debt shares across lenders. Columns (ii), (iv), and (vi) separate firms as to whether they have any unused credit line capacity in our data ("CL") or not ("No CL"). Standard errors in parentheses are clustered by firm. Sample: 2021:Q1 - 2023:Q1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.