Macro-Banking Stability, Sovereign Debt and the Inflation Channel

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JEL Codes: G21, H63, E31

Keywords: Banks; Inflation; Financial Stability

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Abstract

We investigate the impact of inflation on banking stability. Using granular U.S. data from 1997 to 2014, we show that higher inflation induces a significant deterioration of banks' capital position because of the maturity mismatch of banks' assets and liabilities. Quantitative analysis reveals that the elasticity of banking capital to long-term inflation expectations is high, as a 1% increase to long-term inflation expectations leads to a 15% decrease in banks' Tier 1 capital. The analysis suggests that the use of inflation to reduce sovereigns' real debt burden could aggravate the sovereign-bank loop during debt crises.

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1 Introduction

The major inflationary episodes that occurred in advanced economies in recent years have elicited an intense debate on the mechanisms whereby inflation can affect macroeconomic stability. In this paper, we investigate a potentially important but overlooked channel of influence of inflation: its impact on the health and stability of the banking sector. In drawing policy implications, we argue that, through this channel, the use of inflation to reduce sovereigns' real debt burden could aggravate the sovereign-bank loop observed during debt crises.

Since the duration of banks' nominal assets is often far greater than that of banks' liabilities, changes in long-term nominal interest rates wrought through changes in inflation expectations can generate significant deteriorations in bank equity capital and, by extension, financial stability.[1]

[1] An increase in interest rates may also affect the capacity of banks to refund themselves in the money market. We do not focus on this channel in this paper.

Moreover, since adverse valuation effects influence all banks' nominal fixed-income holdings, the potential damage to a banking sector induced by inflation is related to banks' exposure to various markets (e.g., the sovereign debt market and the mortgage market). A vivid example is the recent failure of Silicon Valley Bank (SVB) in March 2023, marking the second-largest bank failure in U.S. history. The immediate cause of the failure was a run on SVB, triggered by the announcement of significant losses resulting from the sale of its securities. These losses were prompted by an increase in interest rates, as a response by the Federal Reserve to rising inflation.[2]

In this paper, we use bank balance sheet maturity data to quantify the elasticity of banking capital to changes in inflation expectations. The U.S. banking sector provides an ideal setting for our analysis, as it affords us rich maturity information on banks' fixed income positions. After using this maturity data to construct banks' sequence of future fixed income payment streams, we compute the valuation changes to such streams driven by counterfactual changes to inflation expectations. We find that the value of bank fixed income positions is economically sensitive to changes in inflation expectations: a 1% increase in long-term inflation expectations generates a decrease in Tier 1 capital of approximately 10-15%. These results are robust to controlling for bank size, systemically-important indicator status, and interest rate derivatives holdings.

The results can yield policy insights for various scenarios, including sovereign debt crises. Such crises are typically resolved through use of two policy levers: reduction of the sovereign's debt burden through default; or reduction of its real debt burden through inflation. Since the European sovereign debt crisis of the 2010s, an emerging literature has explored the linkages between the fiscal health of the sovereign and the stability of the banking sector (the sovereign-bank nexus). This literature often focuses on mechanisms linked to use of the first policy lever - and for good reason, as banks often have substantial exposure to domestic sovereign debt. Our analysis shows that, due to maturity mismatch in banks' balance sheets, there is a second, subtler exposure of banks to sovereign debt crises linked to use of the second policy lever (inflation).

Our work speaks to the broad literature that examines the interaction between inflation/monetary policy and financial stability (Smets, 2014; English et al., 2018; Gomez et al., 2021). It can also offer insights to the work on the sovereign-bank "doom loop" that has emerged in recent years

[2] While most of the interest rate increase in this period was due to monetary policy, concerns about the federal budget deficit and the government's commitment to address it also contributed. This sentiment became apparent during the October 2023 bond market sell-off, pushing the yield on the 10-year U.S. Treasury note to 5%.

(Brunnermeier et al., 2016; Dell'Ariccia et al., 2018; Farhi and Tirole, 2018; Gennaioli et al., 2014).[3]

The paper unfolds as follows: section 2 discusses the data on banks' nominal positions and maturity mismatch; section 3 presents the conceptual framework and describes the procedures to construct streams of future payments; section 4 presents the main results; section 5 concludes.

2 Data

2.1 Banks' fixed income portfolios and balance sheet maturity

We use the commercial banks' quarterly Call Reports (FFIEC 031 and 041) between 1997 Q2 - 2014 Q2 for information on the composition and maturity structure of banks' balance sheets. The choice of this sample period is dictated by data availability for the variables used in the analysis. To account for the possibility that common ownership ties foster risk-sharing across bank subsidiaries, we aggregate bank-level Call Report data at the bank holding company (BHC) level. We exclude from our sample any banks whose median asset value after 2006 Q1 is smaller than $500 million, and focus only on relatively large banks.[4] As we use recursive methods to construct synthetic payment streams from bank balance sheets, we drop a few banks whose observations are not continuous in the sample. Finally, to account for the M&A activity among banks and BHCs during this period, we use data on bank M&A activity from the Federal Reserve Bank of Chicago to identify affected banks. If institution A is acquired by institution B in date t, we add A's balance sheet positions to B and treat them as one institution prior to t.

The Call Report information on bank maturity information for this period is surprisingly rich, covering approximately 70% of banks' assets and liabilities.

2.2 Maturity mismatch

The first two panels of Figure 1 plot the average maturity/repricing period of the key items on banks' balance sheets.[5] On the asset side, pass-through mortgage-backed securities have the longest

[3]In re-emphasizing the inflation channel, we draw on a separate literature going back to Calvo (1988) which recognizes inflation and default as strategic substitutes of a sovereign facing an unsustainable debt burden (Aguiar et al., 2013; Hurtado et al., 2023; Sunder-Plassman, 2020).

[4]$500 million is the threshold above which a BHC needs to file regulatory report FR Y-9C (after March 2006).

[5]We set the average maturity/repricing period within each bucket to the midpoint of that buckets' range. Claims with over 15 years to maturity or the next repricing date are assumed to have a maturity/repricing period of 20 years; those with over three years are assumed to have a period of five years.

maturities, increasing from ten years at the beginning of the sample to 15 years at the end of it. Treasury and agency securities have maturities of around 5 years. Loans and leases, as well as structured MBS, have shorter maturities of three to four years. On the liability side, time deposits and other borrowed money have very short maturity of one to two years. By construction, savings and demand deposits have zero maturity.[6] These maturities remain relatively stable over time.

To gauge the degree of maturity mismatch, we define maturity gap as the difference between the weighted-average maturity/repricing period of bank assets and liabilities, as in English et al. (2018). We plot cross-sectional asset-weighted mean and median maturity gap in the third panel of Figure 1. Both measures of maturity gap fluctuate around three to five years over the period.

3 Quantitative framework

We provide a simple asset pricing framework to show how inflationary episodes can affect bank balance sheets. We first discuss the pricing of zero coupon bonds, noting that a more general fixed-income claim with coupon payments can be viewed as a portfolio of zero-coupon bonds with different maturities.

3.1 A simple asset-pricing model

We assume that the exogenous fundamentals of the economy at time t are functions of the state s_t. The history of the states from period 0 to t are denoted as the sequence $s^t = (s_0, ..., s_t)$. We posit that bonds represent pools on many independent borrowers whose repayment status at time t is determined by the history s^t. Given the borrower pool still making payments at the start of t ("remaining borrowers"), we denote the fraction of remaining borrowers that default in t by $h(s^t)$. We denote the gross inflation rate between periods t and $t+1$ in the continuation history s^{t+1} as $\pi_{t+1}(s^{t+1})$ and the real discount factor in history s^t for a payoff in s^{t+1} as $m_{t,t+1}(s^{t+1})$.

For tractability, we assume that the credit risk, characterized by the state-contingent haircut $h(s^t)$, and the real stochastic discount factor $m_{t,t+1}(s^{t+1})$ are both unaffected by changes in inflation expectations. Thus, we essentially restrict our attention to the partial equilibrium effect of inflation.

[6]Interest rates on transaction deposits are de facto very sticky (Hannan and Berger, 1991); as such, their effective maturities may be considerably longer than their contractual maturity. Nevertheless, we follow the literature and treat their effective maturity as zero.

Consider first the period-t price of a j-period zero-coupon bond issued in t that pays \$1 in $t+j$ in all possible continuation histories s^{t+j}:

$$w_j(s^t) = \sum_{s^{t+j}|s^t} \Pr(s^{t+j}|s^t) \prod_{k=0}^{j-1} \frac{\left(1 - h(s^{t+k+1})\right) m_{t+k,t+k+1}(s^{t+k+1})}{\pi_{t+k+1}(s^{t+k+1})} \equiv \frac{1}{(1+i_{t,t+j}(s^t))^j}. \tag{1}$$

The second equality is simply the definition of the j-period zero-coupon yield $i_{t,t+j}(s^t)$. It depends on expected inflation, default risk and the real stochastic discount factor. Given a history s^t, consider a surprise period-t policy announcement that permanently and immediately increases inflation expectations by $\Delta\pi$. When zero coupon yields $i_{t,t+j}(s^t)$ and the change in inflation rate $\Delta\pi$ are sufficiently small, we can approximate $\Delta w^j(s^t)$ by $\frac{1}{(1+i_{t,t+j}(s^t)+\Delta\pi)^j} - \frac{1}{(1+i_{t,t+j}(s^t))^j}$. Intuitively, changes to inflation expectations are priced into the nominal yield curves.[7]

Next, consider a more general financial claim which pays ν_j dollars in all states $s^{t+j}|s^t$ for $\forall j \geq 1$. By linearity, the decline in its value in a higher inflation scenario of $\Delta\pi$ is given as:

$$\Delta V(s^t) = \sum_j \left[\frac{1}{(1+i_{t,t+j}(s^t)+\Delta\pi)^j} - \frac{1}{(1+i_{t,t+j}(s^t))^j} \right] \nu_j. \tag{2}$$

In the rest of the paper, we compute $\Delta V(s^t)$ for bank portfolios, in a scenario of a one percentage point permanent increase in inflation expectations ($\Delta\pi = 0.01$).

3.2 Empirical framework

We want to compute inflation-induced valuation changes to banks' fixed income positions. This involves three steps. First, we construct banks' fixed income payment streams $\{\nu_j\}_{j\geq 1}$ using balance sheet information on fixed income position sizes and maturities. Second, we estimate zero-coupon yield curves $\{i_{t,t+j}\}_{j\geq 1}$ that allow us to re-price future payment streams for different types of claims held by banks. Third, we compute banks' gains and losses according to Equation (2).

We follow a procedure similar to Doepke and Schneider (2006) to create payment streams for various categories of fixed-income instruments on the bank balance sheet. Specifically, we employ a recursive method to construct payment streams from loans, leases, MBS, and time deposits,

[7] This condition can be found in other works investigating the wealth effects of inflation (e.g., Doepke and Schneider, 2006).

distinguishing between claims issued in earlier periods with high interest rates and those issued in later periods with low interest rates.

To price a given payment stream generated by banks' portfolio at each date, we need to know the relevant zero-coupon yield curve for each asset class. We use the approach of Svensson (1994) to parametrically estimate two yield curves: that of Treasury securities and that of swap contracts. The former is used to discount banks' holdings of safe assets and liabilities; the latter, to discount privately issued securities, such as loans and leases. The Svensson (1994) yield curve is the most commonly used parametric form in central banks (Reppa, 2008). It is flexible enough to produce curves with two extrema, one maximum and one minimum.

The Online Appendix provides details on the construction of payment streams and on the yield curve estimation.

4 Results

4.1 Inflation-induced capital losses

The benchmark results are shown in Figure 2. For each sample year (second quarter), we compute gains and losses as a percentage of Tier 1 capital for each bank in the sample, and report the asset-weighted average statistics in the figure. We find that a 1%-point increase in inflation expectations induce capital losses equivalent to a 10-15% reduction in banks' Tier 1 capital.[8] The effect size is remarkably stable throughout the sample period. As shown in Figure 2, fully 10%-points of capital losses are driven by write-downs of banks' loan and lease holdings, which represent 50-60% of banking assets on average. The longer durations of MBS make them the next largest source of capital losses ($\approx$ 3-5% of Tier 1 capital), despite only representing about 10% of bank assets. Treasury and agency securities cause an amount of capital loss which fluctuates around 1-2%-points. Simultaneously, the short maturities of banks' liabilities limit the capital gains from increases to inflation expectations to 5%-points.

The marked consistency of average inflation-induced capital losses over the sample period mask growing heterogeneity in the underlying capital loss distribution. The right panel of Figure 2 presents the cross-sectional distribution of capital losses at the beginning and the end of the sample period

[8] This value is comparable with estimates of Japanese banks provided by Bank of Japan (2013).

(1997Q2 and 2014Q2), showing increasing variation in the severity of capital losses. In 1997Q2, a 1%-point increase to inflation expectations would induce capital losses of greater than 20% for only 7.4% of banks; by 2014Q2, 39.3% of banks would bear a capital loss larger than 20%.

4.2 The role of bank size and bank risk edging

One could expect that factors that influence banks' management of maturity mismatch also influence their counterfactual capital losses in higher inflation equilibria. For instance, if larger banks are better at managing the risks of maturity mismatch, their capital losses could be less severe. In Figure 3, we re-present the results of the same inflation experiment according to the three size-classes of banks referenced earlier. Overall, the sizes of losses are robust across the three groups of banks, which are around 10-15% percent of Tier 1 capital. If anything, banks with assets larger than $50 billion bear slightly larger losses than medium and small-sized banks during 2003-2009. Thus, inflation causes a substantial loss to big banks which bear more systemic importance.

Figure 4 breaks down the results by bank interest rate derivative exposure. Even at the end of our sample window, about half of the banks do not hold any interest rate derivatives. While the gross capital loss profiles of banks with no or limited interest rate derivative positions are roughly similar and consistent with the story of a 10-15% capital loss, banks with derivative positions greater than 20% of total assets experience larger gross capital losses, which are particularly acute in the lead-up to the Great Recession. These results support the findings of Begenau et al. (2015) that banks incur similar exposures to interest rate risk through derivatives and other business activities.

5 Conclusion

This paper argued that banks' large fixed income positions and maturity mismatch can be the source of a relevant channel whereby inflation can erode macrofinancial stability.

To investigate the quantitative implications of this channel, we generate synthetic payment streams for U.S. banks from 1997 Q2 - 2014 Q2 using maturity characteristics from the balance sheet for the purpose of computing portfolio values under counterfactual inflation expectations regimes. When we increase permanent inflation expectations by 1 percentage point, we find that the resultant net valuation losses to banks' balance sheets represent a 10-15% reduction in their Tier

1 capital. In light of the fact that Manasse and Roubini (2009) use the inflation threshold of 10.5% to separate low- and high-inflation sovereign debt crises, the results suggest that the bandwidth of the inflation channel to transmit instability to banks is considerable and worthy of further research.

References

Aguiar, M., Amador, M., Farhi, E., and Gopinath, G. (2013). Crisis and commitment: Inflation credibility and the vulnerability to sovereign debt crises. *NBER Working Paper Series, 19516*.

Bank of Japan (2013). Financial system report. *Bank of Japan Reports and Research Papers, 2013*.

Begenau, J., Piazzesi, M., and Schneider, M. (2015). Banks' risk exposures. *NBER Working Paper Series, 21334*.

Brunnermeier, M., Garicano, L., Lane, P., Pagano, M., Reis, R., Santos, T., Thesmar, D., Van Nieuwerburgh, S., and Vayanos, D. (2016). The sovereign-bank diabolic loop and esbies. *American Economic Review: Papers & Proceedings*, 106(5):508–512.

Calvo, G. (1988). Servicing the public debt: The role of expectations. *American Economic Review*, 78(2):647–661.

Dell'Ariccia, G., Ferreira, C., Jenkison, N., Laeven, L., Martin, A., Minoiu, C., and Popov, A. (2018). Managing the sovereign-bank nexus. *European Centeral Bank Working Paper No 2177*.

Doepke, M. and Schneider, M. (2006). Inflation and the redistribution of nominal wealth. *Journal of Political Economy*, 114(6):1069–1097.

English, W. B., Van den Heuvel, S. J., and Zakrajšek, E. (2018). Interest rate risk and bank equity valuations. *Journal of Monetary Economics*, 98:80–97.

Farhi, E. and Tirole, J. (2018). Deadly embrance. *Review of Economic Studies*, 85(3):1781–1823.

Gennaioli, N., Martin, A., and Rossi, S. (2014). Sovereign default, domestics banks, and financial institutions. *Journal of Finance*, 66(2):819–861.

Gomez, M., Landier, A., Sraer, D., and Thesmar, D. (2021). Banks' exposure to interest rate risk and the transmission of monetary policy. *Journal of Monetary Economics*, 117:1781–1823.

Hannan, T. H. and Berger, A. N. (1991). The rigidity of prices: Evidence from the banking industry. *The American Economic Review*, 81(4):938–945.

Hurtado, S., Nuño, G., and Thomas, C. (2023). Monetary policy and sovereign debt sustainability. *Journal of the European Economic Association*, 21(1):293–325.

Manasse, P. and Roubini, N. (2009). Rules of thumb for sovereign debt crises. *Journal of International Economics*, 78:192–205.

Reppa, Z. (2008). Estimating yield curves from swap, BUBOR and FRA data. Technical report, MNB Occasional Papers 73.

Smets, F. (2014). Financial stability and monetary policy: How closely interlinked. *International Journal of Central Banking*, 10(2):263–300.

Sunder-Plassman, L. (2020). Inflation, default and sovereign debt: The role of denomination and ownership. *Journal of International Economics*, 127(2).

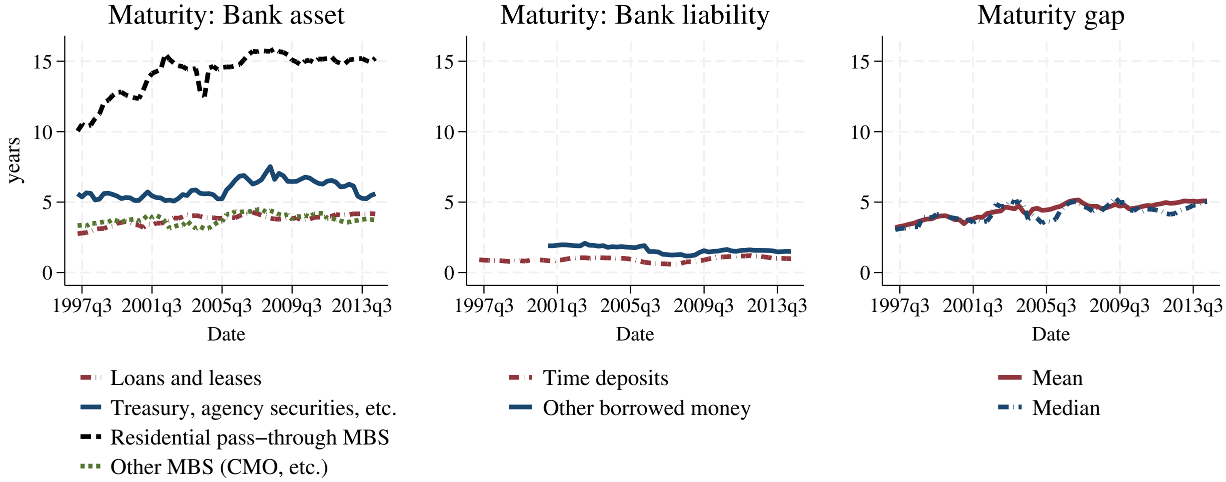
Svensson, L. E. (1994). Estimating and interpreting forward interest rates: Sweden 1992-1994. Technical report, National Bureau of Economic Research, Working Paper 4871s.

Table 1: Number of Bank Holding Companies

Year	Total	Large	Medium	Small
1997	812	25	47	740
1998	845	25	47	773
1999	883	26	50	807
2000	920	26	53	841
2001	955	28	56	871
2002	982	28	56	898
2003	1,004	28	57	919
2004	1,034	29	59	946
2005	1,064	29	61	974
2006	1,085	29	62	994
2007	1,087	28	60	999
2008	1,074	26	56	992
2009	1,060	28	52	980
2010	1,017	28	48	941
2011	994	27	48	919
2012	1,127	29	60	1,038
2013	1,110	29	59	1,022
2014	1,084	29	58	997

Note: Large banks have median assets after 2006 Q1 larger than $50 billion, medium banks have median assets after 2006 Q1 between $10-$50 billion, and small banks have median assets after 2006 Q1 less than $10 billion.

Figure 1: Maturity of bank assets and liabilities



Note: We compute statistics for each bank in the sample, and report the asset-weighted average statistics in the figure.

Figure 2: Inflation-induced capital losses

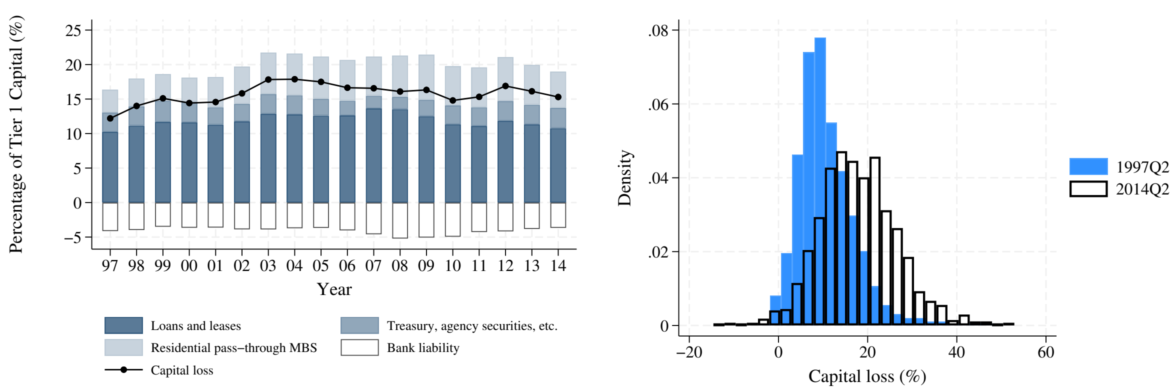
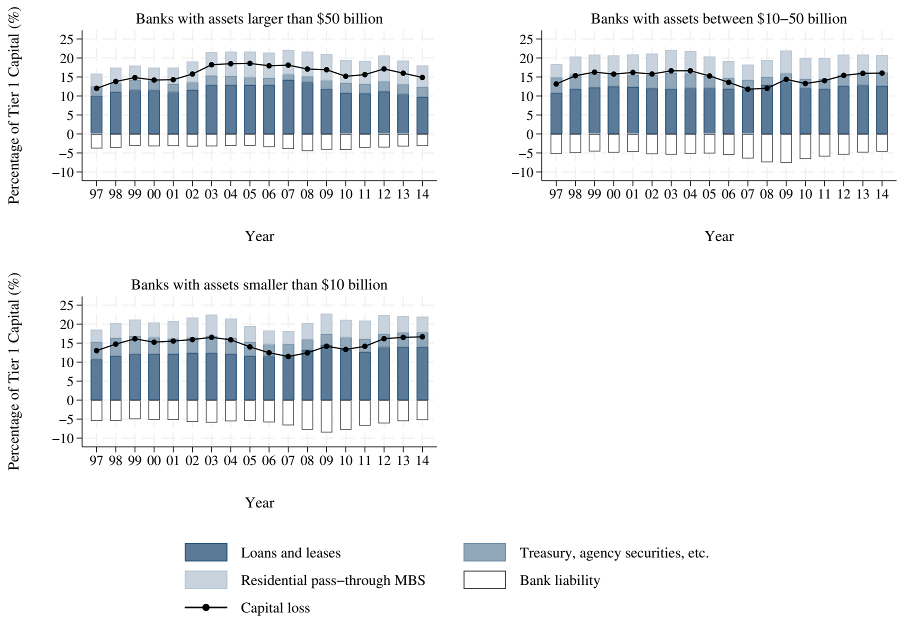
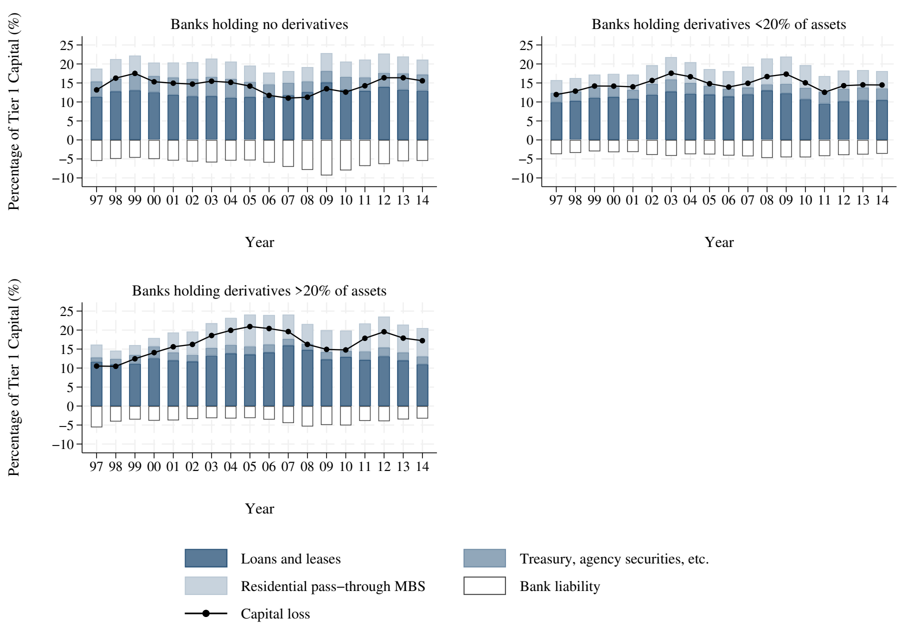


Figure 3: Gains and losses by bank size (total assets)



Note: We compute gains and losses for each bank in the sample, and report the asset-weighted average statistics in the figure.

Figure 4: Gains and losses by bank derivative holdings



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