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RISK MANAGEMENT IN FINANCIAL INSTITUTIONS

Abstract

We study risk management in financial institutions using data on hedging of interest rate and foreign exchange risk. We find strong evidence that institutions with higher net worth hedge more, controlling for risk exposures, both across institutions and within institutions over time. For identification, we exploit net worth shocks resulting from loan losses due to drops in house prices. Institutions that sustain such shocks reduce hedging significantly relative to otherwise similar institutions. The reduction in hedging is differentially larger among institutions with high real estate exposure. The evidence is consistent with the theory that financial constraints impede both financing and hedging.

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Risk Management in Financial Institutions*

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May 2019

Abstract

We study risk management in financial institutions using data on hedging of interest rate and foreign exchange risk. We find strong evidence that institutions with higher net worth hedge more, controlling for risk exposures, both across institutions and within institutions over time. For identification, we exploit net worth shocks resulting from loan losses due to drops in house prices. Institutions that sustain such shocks reduce hedging significantly relative to otherwise similar institutions. The reduction in hedging is differentially larger among institutions with high real estate exposure. The evidence is consistent with the theory that financial constraints impede both financing and hedging.

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1 Introduction

Despite much debate about bank risk management and its purported failure during the financial crisis, the basic patterns of risk management in financial institutions are not known and its main determinants are not well understood. Since financial institutions play a key role in the macroeconomy and the transmission of monetary policy, understanding their exposure to shocks is essential for monetary and macro-prudential policy.[1] Financial institutions can manage the risk exposures arising from lending and deposit-taking activities using financial derivatives; indeed, financial institutions are the largest users of derivatives, measured in terms of gross notional exposures. We study risk management in U.S. financial institutions using panel data on interest rate and foreign exchange rate derivatives positions which represent on average 94% and 5% of the notional value of all derivatives used for hedging, that is, almost all the derivatives financial institutions use for hedging purposes.[2]

We show that the net worth of financial institutions is a principal determinant of their risk management both across institutions and within institutions over time: institutions with higher net worth hedge more and institutions whose net worth declines reduce hedging. To study the causal effect of net worth on hedging, we propose a novel identification strategy using net worth shocks resulting from loan losses which are in turn due to house price drops. Using difference-in-differences specifications, we find that institutions which sustain such shocks reduce hedging of both interest rate and foreign exchange risk substantially relative to otherwise similar institutions. Using triple differences specifications to control for differences in lending opportunities, we show that the reduction in both types of hedging is differentially larger for institutions with higher real estate exposure, which sustain larger shocks to their net worth. We conclude that the financing needs associated with hedging are a major barrier to risk management.

[1] Following Bernanke and Gertler (1989), the effects of the net worth of financial institutions on the availability of intermediated finance and real activity are analyzed by Holmström and Tirole (1997), Gertler and Kiyotaki (2010), Brunnermeier and Sannikov (2014), and Rampini and Viswanathan (2019), among others. Empirically, the effects of bank net worth on lending and real activity are documented by Peek and Rosengren (1997, 2000), and its effects on employment are studied by Chodorow-Reich (2014). Financial institutions' central role in the transmission of monetary policy is examined by Gertler and Gilchrist (1994), Bernanke and Gertler (1995), Kashyap and Stein (2000), and Jiménez, Ongena, Peydró, and Saurina (2012).

[2] According to the BIS' *Derivative Statistics* (December 2014), financial institutions account for more than 97% of all gross derivatives exposures. Financial institutions' derivatives positions for hedging include, in addition to interest rate and foreign exchange derivatives, equity derivatives (0.7%) and commodity derivatives (0.1%). Not included in these calculations are credit derivatives, as no breakdown between uses for hedging and trading is available.

We use theory to inform our measurement. A leading theory of risk management argues that firms subject to financial constraints are effectively risk averse, giving them an incentive to hedge (see Froot, Scharfstein, and Stein (1993)). Given this rationale, Rampini and Viswanathan (2010, 2013) show that when financing and risk management are subject to the same financial constraints, that is, promises to both financiers and hedging counterparties need to be collateralized, both require net worth and thus risk management has an opportunity cost which is higher for more constrained firms. The same risk management concerns arise in the context of financial institutions (see Froot and Stein (1998) and Rampini and Viswanathan (2019)). Financial institutions face a trade-off between lending and risk management: financially constrained institutions must allocate their limited net worth between the two. Hedging has an opportunity cost in terms of forgone lending. The main prediction is that more financially constrained financial institutions, that is, institutions with lower net worth, hedge less; the cost of foregoing lending or cutting credit lines is higher at the margin for such institutions.

We use panel data on U.S. financial institutions, focusing on bank holding companies. We first establish a new basic stylized fact about risk management in financial institutions: across institutions, financial institutions with higher net worth hedge interest rate and foreign exchange rate risk to a greater extent; and within institutions over time, institutions whose net worth falls reduce hedging. We control for risk exposures throughout.

We then test the main prediction of the theory using a novel identification strategy by focusing on drops in financial institutions' net worth due to loan losses attributable to falls in house prices. We use 2009 as the treatment year and define treatment as institutions with a below median mortgage-weighted average local house price change in the two preceding years or a below median mortgage-weighted average local housing supply elasticity.[3] In difference-in-differences specifications using either definition of treatment, treated institutions reduce hedging economically and statistically significantly relative to otherwise similar control institutions; indeed, treated institutions cut hedging by as much as one half. Similar results obtain when treatment and control group are propensity-score matched. Treatment affects institutions' net worth significantly, but not their risk exposures. This evidence corroborates the hypothesis that financial constraints are a major determinant of hedging.

[3]A growing literature uses house prices to instrument for the collateral value of firms (see, for example, Chaney, Sraer, and Thesmar, 2012) and entrepreneurs (see, for example, Adelino, Schoar, and Severino, 2015). For financial institutions, a measure of local house prices in a similar spirit to ours, albeit at a more aggregated level, is used in several recent studies of the determinants of the supply of bank lending (see Bord, Ivashina, and Taliaferro (2018), Cuñat, Cvijanović, and Yuan (2018), and Kleiner (2015)).

We use a triple differences specification to control for differences in lending opportunities, comparing the effect of treatment across terciles of institutions based on their exposure to real estate. Treated institutions with higher real estate exposure reduce both interest rate and foreign exchange hedging differentially more, in fact, by about one half. We moreover show that for such treated institutions net worth also falls differentially more, whereas exposures do not change differentially. This suggests that the mechanism works via net worth as the theory predicts, rather than via lending opportunities or exposures.

We do not think that our results are due to alternative hypotheses for several reasons. First, since our hedging variables are scaled by total assets, our results show that treated institutions hedge less per unit of asset; thus a reduction in lending and assets itself cannot explain our findings. Second, changes in interest rate risk exposures due to changes in the lending environment are also not likely to drive our results, as we control for exposures throughout and show that treatment does not affect exposures; moreover, our results are similar for foreign exchange hedging, and arguably institutions' foreign exchange exposures are not directly affected by the domestic lending environment. Third, our results cannot be due to differences in sophistication across institutions or fixed costs of hedging, since we measure the intensive margin of hedging and not just whether institutions hedge or not and since the results hold within institutions, that is, controlling for institution fixed effects. Fourth, we do not think that the reduction of hedging by financially constrained institutions is evidence of risk shifting, because we find that these institutions reduce derivatives trading at the same time, suggesting they take less risk, not more. Furthermore, our results hold for institutions far away from distress, for which risk shifting incentives should be limited. Finally, we find that it is the net worth of financial institutions, that is, their economic value, which determines their hedging policy rather than their regulatory capital. Perhaps surprisingly, regulatory capital does not seem to be a major determinant of risk management in financial institutions.

Our paper is related to the literature on interest rate risk in banking. Purnanandam (2007) shows that the lending policy of financial institutions which engage in derivatives hedging is less sensitive to interest rate spikes than that of non-user institutions. More recently, Gomez, Landier, Sraer, and Thesmar (2016) find that the exposure of financial institutions to interest rate risk predicts the sensitivity of their lending policy to interest rates. The interaction between monetary policy and banks' exposure to interest rate risk is studied theoretically by Di Tella and Kurlat (2018) and empirically by Drechsler, Savov, and Schnabl (2017). Haddad and Sraer (2018) argue that banks' balance sheet interest rate exposures are largely determined by consumers' demand for loans and deposits.

Drechsler, Savov, and Schnabl (2018) argue that banks' interest rate exposures may be more limited than commonly thought, because deposit rates are more slow moving than their short-term maturity suggests. Hoffmann, Langfield, Pierobon, and Vuillemey (2018) study the allocation of interest rate risk in the banking sector, finding heterogenous bank exposures as well as limited hedging. The optimal management of interest rate risk by financial institutions is modeled by Vuillemey (2019). Begenau, Piazzesi, and Schneider (2015) quantify the exposure of financial institutions to interest rate risk. They find economically large interest rate exposures both in terms of balance sheet exposures and exposures due to the overall derivatives portfolios, which include trading and market-making positions. In contrast, our focus is on the dynamic determinants of hedging by financial institutions based on risk management theory.

This paper is also related to the literature on corporate risk management more broadly. Data availability presents a major challenge for inference regarding the determinants of risk management. Much of the literature is forced to rely on data that includes only dummy variables on whether firms use any derivatives or not.[4] In contrast, our data provides measures of the intensive margin of hedging, not just of the extensive margin. Further, much of the literature has access to only cross-sectional data or data with at best a limited time dimension.[5] Instead, we have panel data at the quarterly frequency for up to 19 years, that is, up to 76 quarters. This enables us to exploit the within-variation separately from the between-variation. Like us, Rampini, Sufi, and Viswanathan (2014) have panel data on the intensive margin of hedging, albeit for a much smaller sample of fuel price hedging by U.S. airlines. Another key difference is the identification strategy, as we are able to exploit exogenous variation in net worth due to house price changes. Furthermore, we provide new measures of net hedging and balance sheet risk exposures for financial institutions which allow better measurement. Finally, we focus on risk management in the financial intermediary sector, which is of quantitative importance from a macroeconomic perspective and has received widespread attention both among researchers and policy makers.

When describing the basic patterns of risk management, the existing literature has mostly emphasized a strong positive relation between hedging and the size of firms and financial institutions.[6] From the vantage point of previous theories, this positive relation

[4]Guay and Kothari (2003) emphasize that such data may be misleading when interpreting the economic magnitude of risk management. Their hand-collected data on the size of derivatives hedging positions suggests that these are quantitatively small for most non-financial firms.

[5]For example, Tufano (1996)'s noted study of risk management by gold mining firms uses only three years of data, although the data is on the intensive margin of hedging.

[6]For firms, see Nance, Smith, and Smithson (1993), Mian (1996), and Géczy, Minton, and Schrand

has long been considered a puzzle (see, for example, Stulz, 1996), because larger firms are considered less constrained.[7] The hypothesis which we test, in contrast, is consistent with the observation that large financial institutions hedge more. Guided by the dynamic theory of risk management subject to financial constraints, we provide a much more detailed empirical characterization of the dynamic behavior of hedging by financial institutions, concluding that the key determinant of hedging is net worth, as measured by several variables, not size per se. Nonetheless, the fact that hedging is increasing in the size of financial institutions is noteworthy, since it is contrary to what one might expect if Too-Big-To-Fail considerations were the main determinant of risk management.

The paper proceeds as follows. Section 2 discusses the theory of risk management subject to financial constraints, and formulates our main hypothesis. Section 3 describes the data and the measurement of interest rate and foreign exchange rate hedging by financial institutions. Section 4 establishes stylized facts on the relation between hedging and net worth, and provides our identification strategy and empirical evidence. Section 5 discusses the external validity and considers alternative hypotheses and Section 6 concludes.

2 Risk management subject to financial constraints

Financial constraints render financial institutions, and firms more broadly, effectively risk averse, giving them an incentive to hedge. However, financial constraints impede risk management at the same time. Indeed, when financing and risk management are subject to the same constraints, Rampini and Viswanathan (2010, 2013) show that a trade-off arises: financially constrained institutions must choose between using their limited internal funds to make loans and using them for risk management purposes. In their dynamic model with collateral constraints, both promises to outside financiers and to hedging counterparties need to be collateralized; in other words, unencumbered collateral can be either used to raise more funds to lend out or to back derivatives positions associated with risk management. Importantly, their model predicts that more constrained financial institutions hedge less, or not at all, that is, use their limited net worth to make loans instead of committing scarce internal funds to risk management. The paradox of risk

(1997). For financial institutions, Purnanandam (2007) shows that users of derivatives are larger than non-users and Ellul and Yerramilli (2013) construct a risk management index to measure the strength and independence of the risk management function at bank holding companies and find that larger institutions have a higher risk management index, that is, stronger and more independent risk management.

[7] Other theories of risk management include managerial risk aversion (see Stulz, 1984) and information asymmetries between managers and shareholders (see DeMarzo and Duffie (1995) and Breeden and Viswanathan (2016)); if anything, these theories would predict less hedging by large firms.

management is that while financial constraints are the raison d'être for risk management, financial constraints are also the main impediment to risk management. As a consequence, the basic prediction of this theory is that less financially constrained institutions hedge more, that is, measures of hedging and net worth are positively related. This is the prediction we test in our paper.[8] While much of the literature considers risk management in the corporate context, the same trade-off applies to financial institutions as well (see Froot and Stein, 1998; Rampini and Viswanathan, 2019).[9]

The key endogenous state variable in the model, which determines how financially constrained institutions are and thus the extent of the trade-off is (economic) net worth. In the model, net worth is defined as net operating revenues plus assets minus liabilities plus the payoff of any hedging claims.[10] Moreover, all else equal, institutions with higher net worth in the model also have higher value, deploy more capital (that is, have higher assets or loans), have higher net income, and pay higher dividends. Thus, value, size, net income, and dividends are all positively related to net worth. Based on this reasoning, we use these variables as proxies for net worth, since economic net worth itself is challenging to measure; in this spirit, we also construct a net worth index which is the first principal component of these variables, all of which proxy for net worth. In addition, leverage in the model is decreasing in net worth and, since ratings are decreasing in leverage, we can use ratings as another proxy for net worth.

Two features of the model are worth emphasizing. First, in the model, net worth

[8] Froot, Scharfstein, and Stein (1993) show that financially constrained firms are risk averse in the amount of internal funds they have, giving them an incentive to hedge, and thus formalize this rationale for risk management. Their model predicts that financial institutions should completely hedge the tradable risks they face. Moreover, since risk management should not be a concern for unconstrained institutions, they conclude that more financially constrained institutions should hedge more. In other words, their main prediction is that hedging is decreasing in measures of net worth, which is the opposite of the prediction we test. This difference in predictions is due to the fact that, in their model, hedging is frictionless and there is no concurrent investment with associated financing needs. In contrast, and consistent with the theory we test, Holmström and Tirole (2000) argue that credit-constrained entrepreneurs may choose not to buy full insurance against liquidity shocks, that is, incomplete risk management may be optimal. Mello and Parsons (2000) also argue that financial constraints could constrain hedging. However, neither of these papers predicts the positive relation between hedging and net worth that we investigate here.

[9] Vuillemey (2019) explicitly considers interest rate risk management in a dynamic quantitative model of financial institutions subject to financial constraints and finds that interest rate risk management is limited and that the sign of the hedging demand for interest rate risk can vary across institutions, which is important in interpreting the data below.

[10] Net worth is also the key state variable in the literature on macro finance models with financial intermediaries summarized in footnote 1.

is a key determinant of the size of an institution, and thus size is an important proxy for net worth based on theory. Indeed, size plays a prominent role in most indices of financial constraints in the literature. That said, differences in productivity and sources of heterogeneity outside the model could also result in variation in the size of institutions in the data. To account for variation in size not driven by net worth, we scale some variables, including value, net income, and dividends by assets. Scaling these variables by assets would also be appropriate in a constant-returns-to-scale version of the model. We discuss this in more detail in the next section. Second, the theory implies that the appropriate state variable is net worth, not cash, liquid assets, or collateral per se. Financial institutions' net worth determines their willingness to pledge collateral to back hedging positions, use it to raise additional funding, or keep it unencumbered. In other words, available cash and collateral are endogenous. Net worth is defined as total assets, including the current cash flow, net of liabilities. Thus, it includes unused debt capacity, such as unused credit lines and unencumbered assets. Importantly, the fact that financial institutions hold large amounts of liquid assets on average does not imply that they are unconstrained or that the cost of collateral is low. Indeed, a large part of these securities are encumbered, for example, pledged as collateral in the repo market; there is thus a substantial opportunity cost to encumbering additional assets to back derivatives hedging transactions.

In the theory, expected productivity, that is, investment or lending opportunities, are an additional state variable. Lending opportunities increase the marginal value of net worth in the model, making financial institutions more constrained, reducing hedging all else equal. Therefore, to isolate the effect of net worth on hedging, it may be important to control for potential changes in lending opportunities; we take this concern into account in our empirical strategy. Furthermore, any additional variation in exposures to risk factors across or within institutions outside the model would also affect the extent of hedging; we thus control for measures of exposures throughout.

To sum up, theory predicts a positive relation between hedging and net worth, which is the state variable affecting the extent of financial constraints. Theory also suggests several variables, including value, size, net income, and dividends, which can serve as proxies for net worth. Finally, theory suggests that controlling for lending opportunities may be important, as is controlling for exposures.

3 Data and measurement

This section describes our data and the measurement of financial institutions' hedging, exposures, and net worth.

3.1 Sample

We use quarterly data on U.S. bank holding companies (BHCs). Our dataset comprises balance sheet data from the call reports (form FR Y-9C), market data from CRSP, S&P credit ratings data from Capital IQ, and mortgage origination data from HMDA. Specific descriptions for all variables are in Table A1 in Appendix A. Our sample period starts in 1995Q1, when derivatives data becomes available, and extends to 2013Q4. The merged sample contains 22,723 BHC-quarter observations, that is, roughly 300 observations per quarter on average, for 76 quarters.[11] We focus on BHC-level data due to the availability of market and credit ratings data. Each BHC controls one or several banks, and for clarity we refer to BHCs as financial institutions rather than banks.[12] That said, similar results obtain at the level of individual banks as we show in Appendix B.

3.2 Measurement of hedging

We study both interest rate and foreign exchange hedging. We use two measures of hedging, gross hedging and net hedging. Gross interest rate (IR) hedging by financial institution i at time t is measured as

$$\text{Gross IR hedging}_{it} \equiv \frac{\text{Gross notional of interest rate derivatives for hedging}_{it}}{\text{Assets}_{it}}, \qquad (1)$$

where the denominator is total assets and the numerator includes all interest rate derivatives, primarily swaps but also options, futures, and forwards, across all maturities. Gross foreign exchange (FX) hedging is measured analogously. Importantly, our measures include only derivatives used for hedging purposes, not trading, as the call reports data allows us to distinguish between derivatives contracts "held for trading" and "held for purposes other than trading," that is, hedging.[13]

[11] We drop U.S. branches of foreign financial institutions, because a large part of their hedging activities is likely unobserved. We also drop the six main dealers (Bank of America, Citigroup, Goldman Sachs, J.P. Morgan Chase, Morgan Stanley and Wells Fargo), since they engage in extensive market making in derivatives markets. However, our results are robust to the inclusion of these dealers.

[12] BHCs can also engage in asset management or securities dealing. BHC-level data consolidates balance sheets of all entities within a BHC (see Avraham, Selvaggi, and Vickery, 2012).

[13] Derivatives held for trading include (i) dealer and market making activities, (ii) positions taken with the intention to resell in the short-term or to benefit from short-term price changes, (iii) positions taken

Net hedging is the economically relevant variable, and gross hedging might hence be an imperfect measure, unless institutions' hedging positions all have the same sign over the measurement period. While net hedging is not directly reported by institutions, we propose a new method to infer net interest rate hedging from reported data for BHCs.[14] Specifically, consider an institution with a net hedging position at date t with market value MV_t which is reported in our data. Suppose that between date t and $t+1$ the market value changes by $\Delta MV_{t+1} \equiv MV_{t+1} - MV_t$ whereas the relevant benchmark interest rate changes by $\Delta r_{t+1} \equiv r_{t+1} - r_t$. Using the reported data, we infer institutions' net hedging as

$$\text{Net IR hedging}_{it} \equiv \frac{\Delta MV_{it+1}/\text{Assets}_{it}}{\Delta r_{t+1}}. \tag{2}$$

Intuitively, we infer the sign and magnitude of the hedging position at date t from the joint dynamics of interest rates and the market value of the portfolio of interest rate derivatives between t and $t+1$: if the market value of the portfolio of interest rate derivatives goes up when interest rates go up, then the institution has a long position in interest rate derivatives and vice versa. This measure is an approximation and may not perfectly capture expiring or new positions with non-zero market value between t and $t+1$, and implicitly assumes a one-factor (the short rate) model of the term structure. Moreover, we winsorize net hedging at the 5th and 95th percentiles to avoid outliers in quarters when $\Delta r_{t+1} \approx 0$.[15] We anticipate here that we find very similar results using our measures of gross and net hedging throughout.[16]

3.3 Measurement of net worth

The key state variable in the theory is net worth; the marginal value of net worth reflects the extent of financial constraints and determines institutions' risk management policy. Since net worth as defined in the theory is only imperfectly measurable as discussed in Section 2, we use two approaches to measurement. Our preferred measure is a "Net Worth Index" (denoted NWIndex) that we construct, defined as the first principal component of four variables which are all positively correlated with net worth in theory: market

as an accommodation for customers, and (iv) positions taken to hedge other trading activities.

[14] Our measurement approach for BHC data is related to that of Begenau, Piazzesi, and Schneider (2015). In Appendix B we propose a different approach for bank-level data which allows us to infer net interest rate hedging for a subset of banks that only use interest rate swaps.

[15] Alternatively, one could drop quarters in which (the absolute value of) the interest rate change is below the median from the sample; this approach yields comparable results in our baseline specification.

[16] An analogous measure of net foreign exchange hedging could be constructed using the market value of foreign exchange derivatives and the trade-weighted effective U.S. dollar exchange rate.

capitalization over total assets, size (log total assets), net income over total assets, and dividends over total assets. Specifically, our net worth index is:

$$\text{NWIndex}_{it} \equiv 0.307 \times \frac{\text{MktCap}_{it}}{\text{Assets}_{it}} + 0.149 \times \text{Size}_{it} + 0.272 \times \frac{\text{NetInc}_{it}}{\text{Assets}_{it}} + 0.272 \times \frac{\text{Div}_{it}}{\text{Assets}_{it}}. \quad (3)$$

We observe that the net worth index loads most on market capitalization to assets (30.7%) and least on size (14.9%), in contrast to existing measures of financial constraints in the literature, including the Whited-Wu Index (see Whited and Wu, 2006), which heavily load on size.[17] Nevertheless, to isolate variation in net worth not driven by size, we construct a version of the net worth index excluding size (denoted NWIndex (ex size)), defined as the first principal component of the three variables other than size: market capitalization over total assets, net income over total assets, and dividends over total assets. Specifically, our net worth index without size is:

$$\text{NWIndex (ex size)}_{it} \equiv 0.359 \times \frac{\text{MktCap}_{it}}{\text{Assets}_{it}} + 0.329 \times \frac{\text{NetInc}_{it}}{\text{Assets}_{it}} + 0.312 \times \frac{\text{Div}_{it}}{\text{Assets}_{it}}. \quad (4)$$

The net worth index (ex size) loads roughly equally on the three included measures, and its correlation with size is only 0.228, that is, considerably lower than for our baseline net worth index (0.419); we use this version of the net worth index as our second main measure of net worth. In addition to these two indices of financial constraints, we use the component variables individually as proxies of net worth; we report results using market capitalization over total assets (MktCap/Assets) and size in the paper and using net income over assets (NetInc/Assets), dividends over assets (Div/Assets), log of market capitalization (MktCap), and credit rating (Rating) in Appendix A. Descriptive statistics for all net worth variables and the correlation matrix are in Appendix Table A2 and the time series of the distributions of key variables are plotted in Figure 1 and Appendix Figure A1.

3.4 Measurement of balance sheet risk exposures

To control for financial institutions' exposures to interest rate and foreign exchange risk, we use the following measures. We measure institutions' balance sheet exposures to interest rate risk using the one-year maturity gap, defined as

$$\text{Maturity gap}_{it} \equiv \frac{A^{IR}_{it} - L^{IR}_{it}}{\text{Assets}_{it}}, \quad (5)$$

[17] A version of the Whited-Wu Index, which is estimated for industrial firms, adapted to financial institutions yields results that are quite similar to the results for size; see the working paper version of this paper for details.

where A_{it}^{IR} and L_{it}^{IR} are assets and liabilities that mature or reprice within one year for institution i at date t. The maturity gap is effectively an institution's net floating-rate assets. The change in an institution's net interest income from assets and liabilities in the 1-year maturity bucket ΔNII_{it} is approximately proportional to the maturity gap, that is, $\Delta NII_{it} \approx \text{Maturity gap}_{it} \times \Delta r_t$, where Δr_t is the change in 1-year interest rate. A positive maturity gap implies that increases in the short rate increase an institution's net interest income at the one-year horizon, because the institution holds positive net floating-rate assets, that is, more interest rate-sensitive assets than liabilities at this maturity. The maturity gap is used by risk managers in practice (see Saunders and Cornett (2008) and Mishkin and Eakins (2009)) and is used in earlier research (see Hoffmann, Langfield, Pierobon, and Vuillemey, 2018).[18]

Financial institutions' assets and liabilities are not broken down by currency. We therefore use the share of income realized in foreign offices as a proxy for institutions' exposure to exchange rates, that is, we compute

$$\text{FX exposure}_{it} \equiv \frac{\text{Fee and interest income from loans in foreign offices}_{it}}{\text{Total interest income}_{it}}. \tag{6}$$

We use these two measures to control for institutions' risk exposures throughout.

3.5 Descriptive statistics

The descriptive statistics on financial institutions' risk management and risk exposures are in Panel A of Table 1. Interest rate and foreign exchange hedging is quite concentrated, with many institutions not hedging at all. The gross hedging data shows that the median BHC hedges interest rate risk to a limited extent and does not hedge foreign exchange risk. Furthermore, conditional on hedging, the magnitude of risk management is relatively small, except for interest rate hedging in the top decile of the distribution. Therefore, the level of risk management with derivatives is relatively limited.[19]

[18]For bank-level data, one can also construct a measure of the duration gap; see Appendix B.

[19]From the vantage point of the traditional view of banking as institutions with long-term assets and short-term liabilities, which suggests a sizeable maturity gap, the level of hedging may hence seem surprisingly low at first blush; however, recent evidence in Drechsler, Savov, and Schnabl (2018) suggests that the interest-rate sensitivity of deposit rates is quite low in practice, suggesting that deposits are less short-term than previously thought, and thus the maturity gap financial institutions face may be considerably lower than the traditional view suggests. Therefore, the limited *level* of interest rate risk management may not be so puzzling after all. In any case, the focus of our work is on understanding the variation in risk management across and within institutions, not the level, although the theory we test also predicts that the level of hedging, given exposures, may be reduced due to its opportunity cost.

We emphasize that our data allows us to distinguish between derivatives positions held for hedging and for trading purposes, and we focus on hedging positions in the bulk of our paper. Hedging positions are sizable relative to trading positions except in the tail of the distribution; indeed, trading is even more concentrated than hedging, with more than 75% (90%) of institution-year observations in our data showing no interest rate (foreign exchange rate) trading.[20] Therefore, hedging positions are economically relevant when compared to trading positions. Our measure of net interest rate hedging and the maturity gap provide information about the direction of hedging and exposure. To verify that derivatives positions held for hedging purposes are in fact used for risk management, as stated, we regress the signed measure of net interest rate hedging on institutions' signed maturity gap (see Panel B of Table 1). In specifications with and without institution fixed effects, we find a negative and statistically significant relation between hedging and exposure, consistent with these positions being used for risk management. A one standard deviation increase in the maturity gap reduces the net hedging position by one-sixth to one-eight of a standard deviation, which is quite sizable keeping in mind that many institutions do not hedge.[21]

4 Evidence on hedging and net worth

In this section, we describe the basic stylized facts on the relation between hedging and net worth and use difference-in-differences and triple differences strategies to show that net worth causally impacts risk management in financial institutions.

4.1 Stylized facts: Cross-sectional and within evidence

We first document the relation between hedging and net worth across and within financial institutions. Specifically, we estimate the relation between net worth and hedging using several specifications: a pooled time-series cross-section specification, a Tobit specification, and a specification with institution fixed effects of the form

$$Hedging_{it} = \alpha_i + \mu_t + \beta_0 \times NetWorth_{it} + \beta_1 \times Exposure_{it} + \varepsilon_{it}, \quad (7)$$

[20] In the aggregate, the derivatives trading activities of a few dealers comprise the bulk of gross trading notionals: In 2013Q4, and including the six main dealers here, the top 5 institutions account for 96.0% of all positions held for trading, and the top 10 institutions for more than 99.7% of such positions. For this reason we exclude the six main dealers in our empirical analysis (see footnote 11).

[21] For bank-level data, Figure B1 in Appendix B shows that the distribution of net hedging is shifted down substantially for banks with a high maturity gap consistent with risk management.

where $Hedging_{it}$ and $NetWorth_{it}$ are measured using several variables. All specifications control for institutions' exposures ($Exposure_{it}$) and include time fixed effects μ_t to account for time trends. We cluster standard errors at the institution and quarter level throughout. We report estimates using the four main measures of net worth in Table 2 and estimates with the four auxiliary measures of net worth in Appendix Table A3. We scale all variables by their standard deviation so that the coefficients can be interpreted as the effect of a one standard deviation change in the explanatory variable in terms of the standard deviation of the dependent variable.

Theory predicts that institutions with higher net worth choose to hedge more and that the larger the exposure in absolute value the larger (in absolute value) hedging should be. We thus measure hedging either using gross interest rate or foreign exchange hedging or the absolute value of net interest rate hedging and measure exposure using the absolute value of the maturity gap or our foreign exchange exposure measure for interest rate and foreign exchange hedging, respectively.

In the pooled time-series cross-section specification (essentially, equation (7) without institution fixed effects), we find a positive and economically and statistically significant relation between hedging and net worth for all three of our dependent variables (net interest rate, gross interest rate, and gross foreign exchange hedging) and all four of our main measures of net worth, except in one case.[22] The relation is economically significant: for example, focusing on our preferred measure, a one standard deviation increase in the net worth index increases hedging by about one-sixth of a standard deviation, or by about one third relative to the mean and more than that for foreign exchange hedging.[23] Remarkably, the magnitudes are similar across measures of both net and gross interest rate and gross foreign exchange hedging. The magnitude of the effect varies somewhat with the measure of net worth; it is a bit smaller for the net worth index (ex size) and the MktCap/Assets measure and about two to three times larger when net worth is measured using size.[24]

The Tobit specification accounts for the fact that some institutions do not hedge at all. For this specification, we report marginal effects to make the estimates comparable to those obtained in the other specifications. The Tobit estimates are remarkably similar to

[22]The results using the four auxiliary measures are similar, but we discuss these only in cases where there are differences to our main results that are noteworthy.

[23]Table 1 reports the mean and standard deviation of the dependent variables, except for the absolute value of net interest rate hedging, which has a mean of 0.082 and standard deviation of 0.151.

[24]The estimates of the effect of exposure are positive, as predicted by theory, and statistically significant, albeit somewhat less so than our measures of net worth, while the economic magnitudes vary somewhat depending on the measures used for hedging and net worth.

the ones obtained in the OLS specification, both in terms of magnitudes and significance. Together these results suggest a basic stylized fact: there is a positive relation between hedging and net worth among financial institutions in the pooled time-series cross-section data.

The results in the pooled data could in part be driven by time-invariant differences across institutions, such as the business model or sophistication, or by the fixed costs of setting up a risk management program. The specification with institution fixed effects, equation (7), isolates within-institution variation; recall that the theory predicts a positive relation between hedging and net worth within institutions, and not just across institutions. The within-estimates show a positive and significant relation between hedging and net worth very similar to the one in the pooled data, albeit of somewhat smaller magnitude; a one standard deviation increase in the net worth index increases hedging by about 10%-20% relative to the mean, and an analogous increase in size increases hedging by substantially more than that. The estimates with fixed effects show that financial institutions hedge more at times when their net worth is higher, controlling for their exposure and time trends, although these estimates do not allow a causal interpretation.

Finally, we show that this basic stylized fact is robust to controlling for two confounding factors. First, one might be concerned that the pattern is entirely driven by the size of the financial institutions, and that our various net worth measures simply pick up the correlation with size. In Appendix Table A4, we therefore estimate the main specification, first excluding the bottom size tercile with net worth measured using the net worth index (see Panel A) and then with dummy variables for each of the top two terciles of the size distribution with net worth measured using the net worth index (ex size) (see Panel B). In the pooled and Tobit specifications, our estimates of the relation between hedging and net worth are similar to the ones in the main specification albeit somewhat attenuated when size terciles dummies are included. In the within-institution specification, the relation is sizable and significant both when we exclude the bottom size tercile (see Panel A) and when we include size tercile dummies (see Panel B), and the magnitudes are very similar to the baseline estimates, too. It is worth noting that the size tercile dummies show substantial variation by size across terciles in the pooled and Tobit specifications, showing an essentially monotone effect of considerable magnitude especially for the top tercile. In the within-specifications, the estimates of the size tercile dummies are much smaller and vary in sign. We emphasize that the theory suggests that size is endogenous and in turn determined by institutions' net worth; this implies that controlling for size directly, as we do with the size tercile dummies here, is not appropriate as it amounts to over-controlling. In any case, the results corroborate our baseline estimates in our view.

Second, interest rate exposures may not be accurately measured by the maturity gap. Indeed, recent research by Drechsler, Savov, and Schnabl (2018) shows that deposit rates adjust relatively sluggishly, that is, deposits should not be considered floating rate liabilities despite their short-term maturity. To address this, in Appendix Table A5 we estimate the relation between hedging and net worth controlling for institutions' deposit share and a measure of the maturity gap which excludes demand deposits, which we refer to as the "narrow maturity gap" (see Flannery and James (1984) for a similar definition). We do indeed find that institutions with a higher share of deposits to total assets hedge less, consistent with the view that deposits reduce net interest rate exposures. That said, our estimates of the effect of net worth on hedging remain significant and of similar magnitude to our baseline results.

4.2 Identification: Difference-in-differences estimation

We now turn to our main identification strategy, a difference-in-differences strategy using a quasi-natural experiment. Specifically, we exploit the large drop in the financial institutions' net worth during the global financial crisis as our event of interest. As seen in Figure 1 and Appendix Figure A1, most net worth measures dropped significantly during the year 2009. The drop is most striking for net income, indicating that financial institutions recorded significant losses within a few quarters. However, there is significant cross-sectional heterogeneity in the extent of the drops in institutions' net worth, and, as we show below, this heterogeneity is closely related to drops in house prices at the local level. The idea behind our quasi-natural experiment is to compare otherwise similar institutions that differ in terms of the dynamics of local house prices that they face. We use data from 2005Q1 to 2013Q4 and 2009 as the treatment year, and compare institutions based on the weighted average drop in house prices they faced in the preceding two years (that is, in 2007Q1 to 2008Q4).[25]

This setup has a number of attractive features. First, real estate loans represent a large share of institutions' assets (47% on average, see Appendix Table A2). Second, changes in house prices have a significant impact on borrowers' ability to repay mortgages, and thus on financial institutions' net worth. Indeed, Bajari, Chu, and Park (2008), Mayer, Pence, and Sherlund (2009), Demyanyk and Van Hemert (2011), and Palmer (2015) all show that changes in local house prices were the main driver of mortgage defaults from 2007 onwards. Third, there is very significant variation in house price dynamics at the local level as we discuss in more detail below. Fourth, local drops in house prices are unrelated to changes in interest rates or exchange rates, which could simultaneously induce institutions to

[25] We provide direct evidence that treatment affects institutions' net worth significantly in Section 4.5.

adjust their hedging of these risks; indeed, the interest rate environment and foreign exchange rates are the same nationwide and thus for all institutions, whereas house price dynamics differed at the local level. Finally, to provide further support for this quasi-experiment, we decompose institutions net income into several components in Appendix Figure A2. As seen in the top left panel, net income (a key component of net worth in the theory) dropped significantly in 2009. This drop is not primarily due to changes in net interest income (top right panel), but instead can be mostly attributed to provisions for credit losses, which reduce net income (bottom left panel). These loan loss provisions in turn are overwhelmingly due to losses on real estate loans (bottom right panel).

To construct the treatment and control group, we define an institution-level mortgage-weighted average change in local house prices over 8 quarters between $t-8$ and t as

$$\Delta HousePrice_{it} \equiv \sum_z w_{iz,t-8} \frac{P_{z,t} - P_{z,t-8}}{P_{z,t-8}}, \tag{8}$$

where $w_{iz,t-8}$ is the share of mortgages originated by institution i in ZIP code z, and P_{zt} is the house price in ZIP code z at time t. To construct $\Delta HousePrice_{it}$, we use data from HMDA on the geographical breakdown of mortgage originations to compute $w_{iz,t-8}$, and Zillow data on house prices for P_{zt}.[26] Institutions that are exposed to larger drops in house prices experience larger drops in net worth, and we compute the weighted average by mortgage originations to capture institutions' overall exposure. We define the treatment and control group by setting $t = 2008Q4$, that is, consider the house price change in 2007 and 2008, $\Delta HousePrice_{i,2008Q4}$, using weights $w_{iz,2006Q4}$, that is, the share of mortgage originations in the two preceding years, 2005 and 2006. Institutions with below-median values of $\Delta HousePrice_{i,2008Q4}$ are considered treated, while institutions with above-median values are the control group. The weighted-average change in local house prices in the treatment group is -21.1% on average (with a median of -18.2%) compared to -6.2% on average (with a median of -4.1%) in the control group.

We estimate the following difference-in-differences specification

$$Hedging_{it} = \alpha_i + \mu_t + \beta_0 \times Post_t \times Treated_i + \beta_1 \times Exposure_{it} + \varepsilon_{it}, \tag{9}$$

where $Post_t$ equals one after 2009Q1 and $Treated_i$ equals one for treated institutions.

[26] Zillow data is at the ZIP-code level, while HMDA gives mortgage originations by census tract, which we aggregate to the ZIP-code level. We follow the use of HMDA data by Loutskina and Strahan (2011). Since the data contains only loan originations, not the stock of mortgages by ZIP code, we construct $w_{iz,t-8}$ using the share of mortgage originations in the two years preceding the house price change, that is, in quarters $t-15$ to $t-8$. Similar results obtain when using a deposit-weighted average change in house prices using ZIP-code level deposit data from the FDIC; see the working paper version of this paper, Rampini, Viswanathan, and Vuillemey (2017).

Furthermore, all our specifications include a time-varying measure of balance sheet exposure to either interest rate or foreign exchange risk.[27]

The descriptive statistics for the sample used in our difference-in-differences specification are reported in Panel A of Appendix Table A6; we restrict the sample to institutions that hedge at least once before the treatment. It is worth noting that in this sample all but 14% of the institution-quarter observations show strictly positive hedging. The baseline estimation results are in Panel A of Table 3. Across all three measures of hedging, we find that risk management drops for treated institutions relative to control institutions. The drop is statistically significant in all cases, and also economically significant. Indeed, net interest rate hedging drops by about one-sixth of a standard deviation, while gross interest rate hedging drops by about one-third of a standard deviation. The drop in foreign exchange hedging is also significant, albeit of smaller magnitude (about one-tenth of a standard deviation). Relative to the mean, both gross interest rate and gross foreign exchange hedging drop by one half or more for treated institutions, while net interest rate hedging drops somewhat less.[28]

4.3 Identification: Triple differences by real estate exposure

A natural question is whether our difference-in-differences results are driven by differences in lending opportunities between treatment and control institutions. One could argue that in areas where house prices drop more, lending opportunities may also be lower, and so treatment may affect hedging not just through its effect on financial institutions' net worth, but also through its effect on lending opportunities or interest rate exposures.

Below we propose a triple differences strategy to address this concern, but before doing so, we emphasize several aspects that limit its force. First, the hedging variables are scaled by assets and thus the level of lending itself cannot be driving the results. Second, we control for measures of exposure in our difference-in-differences specification directly. Third, it is unlikely that local house prices affect foreign lending opportunities, and the fact that we find similar results for foreign exchange hedging therefore suggests that the mechanism works through net worth not through lending opportunities or exposures. Finally, while the Rampini and Viswanathan (2013) model suggests that both net worth and investment opportunities are state variables, a drop in investment opportunities itself

[27] We control for institutions' risk exposure, but similar results obtain without such controls; see the working paper version, Rampini, Viswanathan, and Vuillemey (2017).

[28] Appendix Table A6 reports the mean and standard deviation of the dependent variables in the sample used here, except for the absolute value of net interest rate hedging, which has a mean of 0.223 and standard deviation of 0.240.

reduces the opportunity cost of hedging, and thus predicts an increase in hedging, that is, the opposite sign of the net worth effect. However, if the investment opportunity mechanism were present, it would affect the magnitude of the estimates and could even lead to finding no effect at all. Our estimation strategy here allows us to tackle this as well.

Specifically, to further address this concern, we use the following triple differences approach: we estimate the differential effect of treatment across institutions that vary in terms of their real estate exposure. We group institutions in terciles by the ratio of real estate loans to total assets in 2008Q4.[29] As before, we define the treatment group as institutions with below median weighted average house prices change, but now interact the treatment variable with dummy variables based on whether institutions are in the middle or top tercile by real estate exposure. Our identifying assumption is that the treatment affects the lending opportunities of all treated institutions similarly, but affects the net worth of treated institutions with higher real estate exposure of existing loans differentially more. In sum, we estimate the following triple differences specification

$$\begin{aligned} Hedging_{it} &= \alpha_i + \mu_t + \beta_0 \times Post_t \times Treated_i + \beta_{0,MidRE} \times Post_t \times Treated_i \times MidRE_i \\ &\quad + \beta_{0,HighRE} \times Post_t \times Treated_i \times HighRE_i + \beta_1 \times Exposure_{it} \\ &\quad + \beta_{2,MidRE} \times Post_t \times MidRE_i + \beta_{2,HighRE} \times Post_t \times HighRE_i + \varepsilon_{it}, \quad (10) \end{aligned}$$

where $MidRE_i$ and $HighRE_i$ equal one for institutions in the middle and top tercile by real estate exposure in 2008Q4.

The triple differences estimates are reported in Panel A of Table 3. Overall, we find that the effect of the treatment is concentrated among institutions with higher real estate exposure of existing loans, consistent with the prediction of the theory. There is no significant drop in hedging for institutions with low exposure to real estate. There is a more substantial, albeit not typically statistically significant drop in hedging for institutions in the middle real estate exposure tercile. For institutions in the top tercile of real estate exposure, the drop in hedging is statistically significant and economically large, dropping by about one third of a standard deviation for both interest rate and foreign exchange hedging; relative to the mean, such institutions cut interest rate hedging by roughly one half and foreign exchange hedging by even more. We observe that the point estimates decrease monotonically with real estate exposure for all three measures of hedging. These results are consistent with the view that the drop in house prices affects

[29]The ratio of real estate loans to total assets in 2008Q4 varies considerably across the three terciles with a within-tercile average of 36.6%, 51.3%, and 64.9% (within-tercile median of 38.9%, 51.7%, and 63.3%), respectively.

hedging via the net worth of financial institutions rather than lending opportunities or exposure.

4.4 Estimation with propensity score matching

The treatment and control group may differ in terms of other characteristics that may be relevant for their risk management policy after 2009. To analyze this, we compare the characteristics of the treatment and control group one year before the treatment (2008Q1) using a two-sample t test in columns (1) to (3) in Panel B of Appendix Table A6. While the two groups are not statistically different along some important characteristics, such as size, maturity gap, and deposits to assets, they do differ along other dimensions such as both versions of the net worth index, market capitalization to assets, and loans to assets. We therefore use a propensity score matching estimator to make sure that differences in hedging between the treatment and control group are not driven by pre-treatment differences in characteristics. We match each institution in the treatment group to an institution in the control group based on all characteristics in Panel B of Appendix Table A6, allowing for control institutions to be matched multiple times. After matching, no significant differences between treatment and control institutions remain; see columns (4) to (6) in Panel B of Appendix Table A6. We then repeat the difference-in-differences and triple differences estimation using the propensity-score matched treatment and control groups.

The propensity-score matched estimates are reported in Panel B of Table 3. Overall, the propensity-score matched results are quite similar to the ones in the baseline specifications, both in terms of statistical significance and economic magnitude. Indeed, many of the propensity-score matched estimates are a bit larger in magnitude (in absolute value) and slightly more statistically significant; moreover, the triple differences estimates are again monotone across terciles by real estate exposure and the differential effects for the middle and top tercile by real estate exposure are now all significant. Interest rate and foreign exchange hedging drop significantly after 2009, and the drop is most substantial for institutions with high real estate exposure. Relative to the mean, the estimated effect of treatment, and the differential effect of treatment on institutions with high real estate exposure, are again on the order of one half or more. All told, the propensity-score matched findings confirm our results in Panel A of Table 3 and lead us to conclude that drops in institutions' net worth have a negative causal effect on financial risk management.

4.5 Effect of treatment on net worth and exposure measures

The mechanism we investigate works via financial institutions' net worth, not risk exposures. In our difference-in-differences and triple differences specifications, we define treatment in terms of the mortgage-weighted average house price change, arguing that treatment affects the net worth of financial institutions, but note that we do not use measures of net worth in the definition of the treatment and control group in any way. We now provide direct evidence that the treatment affects financial institutions' net worth significantly, but does not have a significant impact on exposures.

We repeat the difference-in-differences and triple differences estimation for net worth. All four of our main measures of net worth drop economically and statistically significantly for treated institutions relative to control institutions, and differentially so for institutions in the top tercile by real estate exposure; see Panel A of Table 4.[30] These results justify our interpretation of the treatment as a substantial shock to net worth.

Two aspects of these estimates are worth noting. First, the effect of treatment on net worth is economically and statistically significant even for treated institutions in the bottom tercile by real estate exposure, while we did not find a significant effect of treatment on hedging among such institutions (see Table 3). This may be a result of the countervailing force due to the effect of treatment on lending opportunities. In contrast, the differential effect for institutions in the top tercile by real estate exposure is not affected by this and thus controls for changes in lending opportunities. Second, while the effect of treatment on size is substantial, note that the within-R^2 in the specifications using size are much smaller than in the other three specifications, and thus the effect of treatment on size does not explain much of the within-variation in institutions' size.

To understand how treatment affects exposure, we repeat the difference-in-differences and triple differences estimation for our exposure measures; see Panel B of Table 4. Treatment affects neither the maturity gap nor the foreign exchange exposure significantly. Nor is there a differential effect on institutions across real estate exposure terciles; in fact, the estimates of the triple interaction terms are not just insignificant, the point estimates are close to zero. It is worth noting that all our specifications control for exposure, but it is nevertheless reassuring to know that treatment does not seem to impact exposure in any case. Based on these estimates, we conclude that the evidence is more consistent with the net worth mechanism.

[30] Appendix Table A7 reports similar results for the four auxiliary net worth measures.

4.6 Placebo tests and alternative definition of treatment

A key identifying assumption in difference-in-differences estimation is the parallel trends assumption. Trends in the outcome variable must be the same in the treatment and in the control group. We provide supporting evidence for this assumption in Table 5 by including treatment-year dummies during the pre-treatment period for our benchmark specification. Across all three hedging variables, we find no significant differences in trends during pre-treatment years. Instead, hedging in the treatment and control groups diverge significantly only from 2009 onwards. Figure 2 illustrates the parallel trends before 2009 and the effect of treatment for both interest rate and foreign exchange hedging. Therefore, this key identifying assumption seems valid.

The evolution of house prices is significantly affected by housing supply elasticity which in turn is determined largely by geography. This suggests an alternative definition of treatment in terms of the weighted average housing supply elasticity which varies across financial institutions depending on where they lend. This alternative definition of treatment also avoids using house prices altogether, which might themselves be affected by the credit supply of the banking sector.

For each institution, we compute a measure of the mortgage-weighted average housing supply elasticity using data on the housing supply elasticity at the Metropolitan Statistical Area (MSA) level from Saiz (2010).[31] We use HMDA data on mortgage originations aggregated to the MSA level to construct the institution-specific mortgage-weighted average MSA-level housing supply elasticity $\epsilon_{it} \equiv \sum_m w_{im,t-8}\epsilon_m$, where ϵ_m is the housing supply elasticity in MSA m and $w_{im,t-8}$ is the share of mortgage originations by institution i in MSA m in the two years preceding time $t-8$, that is, quarters $t-15$ to $t-8$; specifically, since the treatment year is 2009 and $t = 2008Q4$, we use data from 2005Q1 to 2006Q4 to compute the weights as before.[32]

We define the treatment (control) group as institutions below (above) the median in terms of mortgage-weighted average housing supply elasticity. The mortgage-weighted average housing supply elasticity in the treatment group is 1.54 on average (with a median of 1.56) compared to 3.18 on average (with a median of 3.19) in the control group; thus, the elasticity is about half in the treatment group.[33] Institutions in the treatment

[31]This measure, available for 269 MSAs, is constructed using satellite-generated data on terrain elevation and on the presence of water bodies, and is purely cross-sectional, that is, has no within-MSA variation over time.

[32]The construction of the mortgage-weighted average housing supply elasticity follows the construction of the mortgage-weighted average change in house prices; see footnote 26 for details.

[33]The average drop in house prices varies substantially across the treatment and control group defined using housing supply elasticity: the average of the institution-level mortgage-weighted average house

group are more likely to face large house prices drops during the treatment period. The interpretation of this pseudo-natural experiment is that areas in which the housing supply is inelastic are subject to larger house price drops during the treatment period, which affects the net worth of financial institutions which operate in these areas, especially ones with high real estate exposure.[34] We stress that the variation in mortgage-weighted average housing supply elasticity across financial institutions is largely determined by geography and not the interest rate or foreign exchange environment.

We repeat our main difference-in-differences and triple differences estimation using the alternative definition of treatment and obtain similar results overall, both in the baseline specification and in the specification with propensity score matching; see Table 6. In the difference-in-differences specification, we obtain a negative estimate for all three hedging measures, which is statistically significant in four out of six cases. In the triple differences specification, the drops in hedging are concentrated among institutions in the middle and top tercile by real estate exposure, and are monotone in real estate exposure in the estimation with propensity score matching. The economic magnitude and statistical significance are somewhat smaller than our baseline results, probably due to the higher level of aggregation at the MSA instead of the ZIP-code level. The results using the definition of treatment based on housing supply elasticity corroborate our previous findings.

4.7 Bank-level evidence

Our baseline results use data on bank holding companies (BHCs), but we obtain rather similar results using data on individual banks; see Appendix B.[35] The bank-level data has two advantages in terms of measurement. First, for the subset of banks which uses only interest rate swaps, we can construct an alternative measure of net interest rate

price change is -16.1% and -6.5% in the treatment and control group, respectively. The difference in the average house price change between treatment and control group defined using housing supply elasticity is about two thirds of the difference when treatment is defined directly in terms of house prices.

[34] While we acknowledge that housing supply elasticity may be an even better instrument for the response of house prices to positive shocks than negative shocks, due to construction activity and the irreversibility of housing investment, one would nevertheless expect house prices to drop significantly more in low housing supply elasticity areas in response to negative shocks and indeed we find a substantial difference in house price changes in the treatment and control group defined using housing supply elasticity; see the previous footnote.

[35] Our data shows that hedging occurs mostly at the bank level. Aggregating derivative exposures of individual banks within each top-tier BHC (that is, BHC that is not owned by another sample BHC), we find that these exposures represent on average 88.5% of the exposure reported by the BHC.

hedging, essentially the difference between pay-fixed and pay-floating swaps.[36] Despite its different construction, the estimates we obtain using this measure of net interest rate hedging at the bank level are remarkably similar in magnitude and significance to the ones we obtain using our other measure of net interest rate hedging at the BHC level. Moreover, there is an economically and statistically significant relation between these two measures of net interest rate hedging, suggesting that our main measure of net interest rate hedging is indeed a credible proxy; see Panel B of Appendix Table B1. Second, bank-level data also allows the construction of an alternative measure of interest rate risk exposure, the duration gap, which is essentially the difference between the duration of assets and liabilities; in contrast, the maturity gap is essentially the difference between floating-rate assets and liabilities, that is, uses only the composition of the balance sheet in terms of claims with effective maturity less than one year. Using either measure produces quite similar results.

In Appendix Table B2 we provide bank-level evidence on the cross-sectional and within-institution stylized facts (Panel A) and the difference-in-differences and triple differences specifications for hedging (Panel B), net worth (Panel C), and risk exposures (Panel D). The bank-level cross-sectional and within patterns again show an economically and statistically significant relation between hedging and net worth. Treatment results in a significant drop in interest rate and foreign exchange hedging, which is differentially larger for high real estate exposure banks; measures of net worth drop similarly, especially for high real estate exposure institutions, whereas risk exposures are not affected significantly. The magnitudes of the estimates are very similar to those obtained in BHC-level data. The bank-level evidence thus further corroborates the BHC-level findings.

5 External validity and alternative hypotheses

We now show the external validity of our results on the effect of net worth on hedging with an instrumental variables approach using house prices. We also consider two alternative hypotheses, namely that the results we find are driven by institutions' risk shifting behavior or their concern about regulatory capital.

[36] For this subset of banks, the average ratio of (the absolute value of) net hedging to gross hedging is above 90%, suggesting that our gross hedging measure is a good proxy for net hedging.

5.1 Hedging and net worth: Instrumental variable estimation

The premise of our difference-in-differences and triple differences approach is that drops in house prices result in drops in financial institutions' net worth during the global financial crisis. Based on this reasoning, we can use changes in house prices as an instrument for net worth in a instrumental variable (IV) strategy more generally, that is, using data from the full sample period.

We use the institution-level mortgage-weighted average change in local house prices defined in (8) to instrument for institutions' net worth. Our first-stage regression is

$$NetWorth_{it} = \phi_i + \lambda_t + \gamma_0 \times \Delta HousePrice_{it} + \gamma_1 \times Exposure_{it} + \nu_{it}, \tag{11}$$

and our second-stage regression,

$$Hedging_{it} = \alpha_i + \mu_t + \beta_0 \times \widehat{NetWorth}_{it} + \beta_1 \times Exposure_{it} + \varepsilon_{it}, \tag{12}$$

where $\widehat{NetWorth}_{it}$ is the instrumented net worth obtained from the first stage.

We estimate the first-stage regressions for all net worth measures, and the second-stage regressions whenever the instrument turns out to be valid in the first stage. Table 7 reports the results for our four main net worth measures, but we find similar results for the four auxiliary net worth measures (see Appendix Table A8). Among our four main net worth measures, house prices are a valid instrument in the first stage for three of the measures, the net worth index, the net worth index (ex size), and market capitalization to assets, with both statistically significant estimates and a high F-statistic (well above the conventional threshold of 10 suggested by Stock and Yogo (2005)). In the second stage, instrumented net worth has a positive effect on interest rate hedging, across all specifications, which is statistically significant for net interest rate hedging and, in some specifications, for gross interest rate hedging. The magnitudes are slightly larger than with OLS estimation, as a one standard deviation increase in net worth increases hedging by one-sixth to one-fourth of a standard deviation. Unlike in the case of interest rate hedging, the second stage regressions produce insignificant results for foreign exchange hedging. Nevertheless, the IV results overall suggest that net worth has a causal effect on hedging not just during the financial crisis, but throughout the entire sample period.

5.2 Hedging before distress

Another way to study the effect of the net worth of financial institutions on their risk management outside the financial crisis is by focusing on distress events over the entire sample period. Institutions in distress are severely constrained and thus theory predicts a large reduction in hedging for such institutions. Since distress is typically the result of credit losses and not primarily due to derivative exposures, these events provide plausible within-institution variation in net worth, albeit we do not observe the specific reason for distress.

We define a distress event as an institution's exit from the sample with a ratio of market capitalization to total assets below 4% in the last quarter in which the institution is in the sample.[37] We restrict the sample to institutions that hedge in at least one quarter, resulting in a sample with 53 distress events. We study the extent of hedging in the eight quarters leading up to distress by estimating

$$Hedging_{it} = \alpha_i + \mu_t + \sum_{j=0}^{8} \gamma_j \times D_{i,\tau-j} + \varepsilon_{it}, \tag{13}$$

where τ is the quarter in which institution i exits the sample in distress and $D_{i,\tau-j}$ a dummy variable equal to 1 for distressed institutions at each date $\tau - j \in \{\tau - 8, ..., \tau\}$ and 0 otherwise. This specification isolates within-institution variation and the estimation uses the whole sample, both distressed institutions and institutions that are not distressed.

The estimates in Table 8 show that both net and gross interest rate hedging drop significantly several quarters before distress. The magnitude of the effect is economically significant, as estimated coefficients imply that institutions cut hedging by about one-half in distress. Foreign exchange hedging also drops, but not statistically significantly so, perhaps due to the fact that we have 5 or less distressed institutions that engage in foreign exchange hedging at all. Note that there are no significant pre-distress patterns in exposure. Overall, these results suggest that distressed institutions, which are likely severely constrained, cut hedging substantially.[38]

5.3 Alternative hypothesis: Risk shifting

An alternative interpretation of the reduction in hedging we find is that it is evidence of risk shifting. Indeed, Jensen and Meckling (1976) argue that due to limited liability the

[37] There are several reasons why financial institutions exit the sample, including mergers and acquisitions or failures. The reason for exiting the sample is obtained from the National Information Center (NIC) transformation data. Distinguishing between actual failures and distress episodes leading to acquisitions is, however, of limited interest for our purposes. Mergers and acquisitions are in fact often arranged before FDIC assistance is provided and the institution actually fails (see Granja, Matvos, and Seru, 2017). Of the events we consider, 94.3% involve mergers or purchases before the entity actually fails, and the others are failures in which FDIC assistance is provided.

[38] Since hedging is scaled by total assets, a drop in institution size before distress would increase hedging, all else equal, and thus cannot explain these patterns.

payoffs of equityholders are convex, at least close to distress, and they thus may benefit from an increase in volatility. Leland (1998) shows that this may induce equityholders to reduce hedging as they approach default.

While we cannot rule out that this alternative hypothesis also plays a role, there are several aspects of the data that we think suggest that financial constraints, not risk shifting, explain our results. First, risk shifting by institutions should primarily be a concern close to distress. To investigate this, we repeat our baseline cross-sectional and within-institution specifications excluding the bottom tercile of institutions in terms of the pertinent measure of net worth; see Appendix Table A9. For both interest rate and foreign exchange hedging and all our main net worth variables we find estimates that are comparable to our baseline results using the full sample in Table 2, both in terms of magnitude and significance, although the within-institution estimates are attenuated in some specifications. For three of the four measures of net worth, the pooled and Tobit estimates when we exclude observations for institutions close to distress are actually larger in magnitude than in the full sample. Clearly, there is a significant relation between hedging and net worth even well away from distress, consistent with the predictions of the theory based on financial constraints.

The risk shifting hypothesis predicts that institutions close to distress take more risks. While a reduction in hedging with financial derivatives could be consistent with that prediction, another prediction of this hypothesis is that institutions close to distress in fact explicitly take more risk, for example, by increasing derivatives trading. In contrast, the theory of risk management subject to financial constraints would make no such prediction, and, to the extent that trading activities also require net worth, might in fact predict that distressed institutions reduce trading as well, the opposite prediction of the risk shifting hypothesis.

We use data on trading of interest rate and foreign exchange derivatives by financial institutions to investigate this prediction. Table 9 reports estimates for our baseline cross-sectional and within specifications using interest rate and foreign exchange trading as dependent variables. We find a positive, mostly statistically significant and economically sizable relation between trading and net worth, in both pooled OLS and Tobit specifications. In the within-specifications, we find a positive relation for interest rate trading, while the results are more mixed for foreign exchange trading, possibly because of the limited number of non-zero observations for foreign exchange trading. That said, we conclude that the relation between trading and net worth is positive in most cases. Since risk shifting should be more pertinent near distress, we also study financial institutions' trading behavior before distress along the lines of the analysis of hedging before distress in Section 5.2. We find that both interest rate and foreign exchange trading by financial institutions drop before distress, albeit only interest rate trading significantly so; see Table 8. Overall, the derivatives trading behavior of financial institutions does not show any evidence of risk shifting in our view.

While our evidence does not speak to whether distressed institutions engage in risk shifting in other ways, the evidence on hedging behavior away from distress and derivatives trading suggests that hedging policy is driven by financial constraints, not risk shifting.[39]

5.4 Alternative hypothesis: Regulatory capital

An additional alternative explanation is that the positive relation between hedging and net worth is driven not by economic measures of net worth, which we use, but by regulatory capital. If financial institutions' behavior is determined by regulatory capital instead of net worth, then the positive relation between hedging and net worth might spuriously arise due to a positive relation between net worth and regulatory capital. That said, if regulators are concerned about regulatory capital, they might require more hedging when regulatory capital is low, which would predict a negative relation between hedging and regulatory capital.

We consider two measures of regulatory capital, regulatory capital to assets and Tier 1 capital to risk-weighted assets; these two measures are very highly correlated with each other, but the correlation with our net worth measures are remarkably low and in several cases negative (see Appendix Table A1 for variable definitions and Panel B of Appendix Table A2 for correlations). The behavior of net worth and regulatory capital over time is also strikingly different: while most measures of net worth drop quite dramatically during the financial crisis, both measures of regulatory capital barely drop and then substantially increase following the crisis (see Appendix Figure A1). Therefore, it is unlikely that the variation we pick up using net worth measures arises spuriously from a correlation with regulatory capital. Nevertheless, we repeat our baseline cross-sectional and within specifications using the two measures of regulatory capital as the independent variable; see Panel A of Appendix Table A10. We find a relatively weak relation between hedging and regulatory capital; the results are mixed in terms of sign, with most estimates having a negative sign.

[39] Landier, Sraer, and Thesmar (2015) report evidence of risk shifting in the lending behavior of a large subprime mortgage originator in distress; in contrast, Andrade and Kaplan (1998) "find no evidence that the distressed firms engage in asset substitution of any kind" and Rauh (2009) concludes that the "incentive to limit costly financial distress plays a considerably larger role than risk shifting in explaining variation in pension fund investment policy among firms in the United States."

In Panel B of Appendix Table A10 we report Davidson and MacKinnon (1981) J-tests for model specification, testing specifications with economic measures of net worth against alternative specifications with regulatory capital. The residuals of the regression of hedging on regulatory capital are regressed on measures of net worth and vice versa, since such tests of model specification have no natural null hypothesis (see, for example, Greene, 2012). We report t-statistics for the second-stage regression of the test. While our model using net worth is not typically rejected in favor of the alternative model using regulatory capital, the model using regulatory capital is rejected in favor of our specification with economic net worth in all but two cases. Therefore, the evidence suggests that regulatory capital is not a major determinant of hedging by financial institutions.

6 Conclusion

We present evidence that financial institutions with higher net worth hedge more. There is a strong positive relation between hedging of both interest rate and foreign exchange risk and net worth among financial institutions; this relation obtains both in the cross-section and within institutions over time – a new and robust stylized fact. We use a difference-in-differences and triple differences specification for identification, exploiting net worth shocks arising from drops in house prices. In the difference-in-differences specification, we find that treated institutions whose net worth drops due to such shocks reduce their hedging in an economically and statistically significant way relative to otherwise similar control institutions; indeed, treated institutions cut hedging by as much as one half. Using a triple differences specification, we find that the effect of such shocks is differentially larger among institutions in the top tercile by real estate exposure, suggesting the mechanism works through net worth rather than lending opportunities. This causal effect of net worth on hedging can be explained by the theory of risk management under financial constraints of Rampini and Viswanathan (2010, 2013). We conclude that financing needs associated with hedging are a substantial barrier to risk management for financial institutions.

Auxiliary evidence suggests that the relation between hedging and net worth is not due to alternative hypotheses. Our results are not due to differences in sophistication or fixed costs of establishing a hedging program, since they hold at the intensive margin and controlling for institution fixed effects. Moreover, we control for risk exposures throughout, implying that heterogeneity in risk exposures is not the driver of our results. Changes in lending opportunities across institutions are also unlikely to drive our results, given our triple differences estimation results and since foreign exchange hedging also drops following net worth shocks, and differentially so for institutions with high real estate exposure. We do not think that our results are due to more constrained financial institutions engaging in risk shifting using derivatives for several reasons: first, the results obtain even after we exclude institution-year observations in which institutions' net worth is relatively low and they hence may be closer to distress; second, we find a strong positive relation between trading and net worth. Finally, there is no strong relation between hedging and regulatory capital, suggesting that economic measures of net worth, rather than regulatory capital, explain the hedging behavior of financial institutions.

Understanding the determinants of risk management of financial institutions is of genuine importance due to their central and quantitatively significant role in the macroeconomy. Our evidence suggests that financial constraints are a key impediment to risk management by financial institutions. Limited risk management leaves financial institutions, especially financially constrained ones, exposed to changes in interest rates and other risks, and thus affects the distribution of risk exposures with potentially significant consequences for the effects of monetary, financial, and macroeconomic shocks. Therefore, our findings are also significant from a monetary policy as well as a macro-prudential perspective.

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Table 1 – Descriptive statistics on risk management

This table provides descriptive statistics on hedging, trading, and balance sheet exposures. Panel A reports moments of the distribution of these variables in the pooled sample. Panel B reports estimates of a pooled OLS regression of net interest rate hedging on the maturity gap and time fixed effects, without and with institution fixed effects. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 1995Q1-2013Q4.

Panel A: Descriptive statistics

	Mean	S.D.	5th	10th	25th	Median	75th	90th	95th	98th	99th	Obs.
Hedging variables												
Net IR hedg.	0.016	0.325	-0.798	-0.182	0	0	0	0.236	0.986	0.986	0.986	19,832
Gross IR hedg.	0.039	0.088	0	0	0	0.001	0.034	0.120	0.203	0.344	0.570	22,723
Gross FX hedg.	0.001	0.009	0	0	0	0	0	0	0.002	0.014	0.026	22,707
Trading variables												
Gross IR trad.	0.031	0.161	0	0	0	0	0	0.019	0.110	0.504	1.218	22,723
Gross FX trad.	0.012	0.098	0	0	0	0	0	0	0.010	0.072	0.483	22,723
Exposure variables												
Maturity gap	0.094	0.178	-0.196	-0.120	-0.011	0.091	0.205	0.317	0.384	0.468	0.538	22,697
FX exposure	0.007	0.046	0	0	0	0	0	0	0.006	0.091	0.222	19,284

Panel B: Regression of net interest rate hedging on maturity gap

	Net IR hedging	
Maturity gap	-0.159***	-0.125***
	(0.052)	(0.039)
Time FE	Y	Y
Institution FE	N	Y
R^2/Within-R^2	0.033	0.033
Obs.	19,815	19,815

Table 2 – Hedging and net worth: Cross-sectional and within evidence

This table provides evidence on the relation between interest rate or foreign exchange hedging and measures of net worth. For each combination of hedging and net worth measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. Each regression includes the relevant measure of balance sheet exposure (maturity gap for interest rate hedging and foreign exchange exposure for foreign exchange hedging) as well as time fixed effects. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.161***	0.173***	0.054***	0.148***	0.156***	0.042***	0.137**	0.152***	0.022***
	(0.024)	(0.024)	(0.012)	(0.035)	(0.028)	(0.007)	(0.057)	(0.046)	(0.006)
Exposure	0.106**	0.085**	0.004	0.170***	0.115***	0.015***	0.321**	0.040*	0.090***
	(0.041)	(0.034)	(0.007)	(0.059)	(0.041)	(0.004)	(0.165)	(0.021)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.181	0.181	0.221	0.061	0.028	0.012	0.127	0.105	0.019
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270
NWIndex (ex size)	0.070***	0.078***	0.049***	0.032	0.056***	0.036***	0.106*	0.085***	0.022***
	(0.023)	(0.007)	(0.011)	(0.026)	(0.006)	(0.006)	(0.062)	(0.006)	(0.006)
Exposure	0.117***	0.098***	0.004	0.182***	0.126***	0.015***	0.328**	0.049***	0.090***
	(0.043)	(0.005)	(0.007)	(0.061)	(0.005)	(0.004)	(0.167)	(0.003)	(0.006)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.165	0.123	0.221	0.045	0.016	0.012	0.121	0.089	0.019
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270
MktCap/Assets	0.043*	0.055**	0.024**	-0.009	0.024	-0.009	0.163*	0.092**	0.048***
	(0.024)	(0.024)	(0.011)	(0.024)	(0.021)	(0.007)	(0.087)	(0.037)	(0.006)
Exposure	0.115***	0.096***	0.006	0.185***	0.127***	0.019***	0.328**	0.046**	0.091***
	(0.041)	(0.035)	(0.007)	(0.058)	(0.042)	(0.004)	(0.165)	(0.022)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.158	0.158	0.213	0.044	0.015	0.009	0.132	0.077	0.021
Obs.	19,815	19,815	19,815	22,699	22,699	22,699	19,282	19,282	19,282
Size	0.368***	0.338***	0.239***	0.457***	0.354***	0.513***	0.210***	0.208***	0.510***
	(0.017)	(0.013)	(0.055)	(0.052)	(0.029)	(0.033)	(0.046)	(0.050)	(0.051)
Exposure	0.042**	0.015	0.006	0.085***	0.038**	0.019***	0.287*	-0.010	0.087***
	(0.020)	(0.014)	(0.007)	(0.034)	(0.019)	(0.004)	(0.159)	(0.019)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.286	0.286	0.214	0.243	0.128	0.021	0.155	0.255	0.033
Obs.	19,815	19,815	19,815	22,699	22,699	22,699	19,282	19,282	19,282

Table 3 – Difference-in-differences and triple differences estimation

This table provides difference-in-differences and triple differences estimates, using measures of interest rate or foreign exchange hedging as dependent variables. Panel A provides the baseline estimates. Panel B provides estimates for specifications in which the treatment and control group are propensity-score matched. The treatment group is defined as institutions with a below-median mortgage-weighted average ZIP-code level house price change from 2007Q1 through 2008Q4. In triple differences specifications, we interact the baseline coefficient with dummy variables based on whether institutions are in the middle or top terciles of the distributions of real estate loans to total assets in 2008Q4. In both panels, the sample is restricted to institutions that hedge at least once before the treatment. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 2005Q1-2013Q4.

Panel A: Baseline estimation

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.122*	0.002	-0.309***	-0.113	-0.221***	-0.045
	(0.061)	(0.106)	(0.071)	(0.097)	(0.062)	(0.066)
$Post_t \times Treated_i \times MidRE_i$		-0.124		-0.259**		-0.185
		(0.125)		(0.115)		(0.110)
$Post_t \times Treated_i \times HighRE_i$		-0.299**		-0.325***		-0.312***
		(0.121)		(0.115)		(0.105)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.133	0.241	0.029	0.030	0.020	0.021
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Panel B: Estimation with propensity score matching

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.222*	0.006	-0.336***	-0.052	-0.192**	-0.091
	(0.140)	(0.108)	(0.111)	(0.114)	(0.095)	(0.090)
$Post_t \times Treated_i \times MidRE_i$		-0.131*		-0.245**		-0.235*
		(0.112)		(0.119)		(0.090)
$Post_t \times Treated_i \times HighRE_i$		-0.414***		-0.421***		-0.351***
		(0.121)		(0.142)		(0.120)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.142	0.231	0.035	0.041	0.024	0.027
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Table 4 – Effect of treatment on net worth and exposure measures

This table provides difference-in-differences and triple differences estimates as in Panel A of Table 3 using measures of net worth and exposure as the dependent variables. Panel A reports the difference-in-differences and triple differences estimates with the four main measures of net worth as the dependent variables. Panel B reports the difference-in-differences and triple differences estimates with measures of balance sheet exposure as the dependent variables. In triple differences specifications, we interact the baseline coefficient with dummy variables based on whether institutions are in the middle or top terciles of the distributions of real estate loans to total assets in 2008Q4. In both panels, the sample is restricted to institutions that hedge at least once before the treatment. Each regression includes time and institution fixed effects. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 2005Q1-2013Q4.

Panel A: Effect of treatment on net worth

	NWIndex		NWIndex (ex size)		MktCap/Assets		Size	
$Post_t \times Treated_i$	-0.412***	-0.295***	-0.438***	-0.257***	-0.263***	-0.209***	-0.205***	0.049
	(0.055)	(0.056)	(0.056)	(0.054)	(0.041)	(0.041)	(0.061)	(0.061)
$Post_t \times Treated_i \times MidRE_i$		-0.031		-0.049		0.023		-0.412***
		(0.048)		(0.051)		(0.035)		(0.052)
$Post_t \times Treated_i \times HighRE_i$		-0.517***		-0.562***		-0.239***		-0.971***
		(0.048)		(0.052)		(0.032)		(0.050)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y	Y	Y
Exposure	N	N	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y	Y	Y
Within-R^2	0.296	0.324	0.312	0.345	0.374	0.382	0.005	0.068
Obs.	4,788	4,788	4,788	4,788	4,804	4,804	4,804	4,804

Panel B: Effect of treatment on risk exposures

	Maturity gap			FX exposure		
	Unmatched	Unmatched	Matched	Unmatched	Unmatched	Matched
$Post_t \times Treated_i$	-0.159	-0.153	-0.101	0.091	0.111	0.091
	(0.133)	(0.186)	(0.164)	(0.081)	(0.135)	(0.112)
$Post_t \times Treated_i \times MidRE_i$		-0.004	0.002		-0.013	0.002
		(0.293)	(0.285)		(0.101)	(0.097)
$Post_t \times Treated_i \times HighRE_i$		-0.011	-0.022		-0.016	-0.018
		(0.262)	(0.241)		(0.102)	(0.098)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.112	0.112	0.121	0.012	0.040	0.038
Obs.	4,804	4,804	4,804	4,511	4,804	4,804

Table 5 – Difference-in-differences estimation: Placebo tests

This table provides placebo tests for the difference-in-differences specifications in Table 3 by including treatment-year dummy variables, omitting 2008. The sample is restricted to institutions that hedge at least once before the treatment. Each regression includes year and institution fixed effects. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 2005Q1-2013Q4.

	Net IR hedging		Gross IR hedging		Gross FX hedging	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
2005	-0.073	-0.003	0.049	0.043	0.066	0.035
	(0.124)	(0.123)	(0.090)	(0.092)	(0.077)	(0.068)
2006	-0.003	0.019	-0.021	0.018	0.089	0.032
	(0.134)	(0.131)	(0.090)	(0.092)	(0.077)	(0.068)
2007	0.107	0.085	-0.007	-0.002	0.121	0.060
	(0.124)	(0.123)	(0.091)	(0.092)	(0.077)	(0.068)
2008	-	-	-	-	-	-
	-	-	-	-	-	-
2009	0.072	0.020	-0.217*	-0.223*	0.051	0.045
	(0.134)	(0.128)	(0.090)	(0.092)	(0.077)	(0.068)
2010	-0.063	-0.153	-0.378***	-0.397***	-0.069	-0.141*
	(0.151)	(0.151)	(0.090)	(0.092)	(0.077)	(0.068)
2011	-0.218*	-0.270*	-0.413***	-0.418***	-0.147*	0.165**
	(0.122)	(0.125)	(0.090)	(0.092)	(0.077)	(0.068)
2012	-0.218*	-0.328**	-0.388***	-0.370***	-0.228***	-0.183***
	(0.124)	(0.124)	(0.090)	(0.092)	(0.077)	(0.068)
2013	-0.154	-0.221*	-0.327***	-0.338***	-0.269***	-0.271***
	(0.123)	(0.123)	(0.090)	(0.092)	(0.077)	(0.068)
Exposure	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.323	0.325	0.025	0.026	0.018	0.017
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Table 6 – Estimation with treatment based on housing supply elasticity

This table provides difference-in-differences and triple differences estimates, using measures of interest rate or foreign exchange hedging as dependent variables, as in Table 3, but using a definition of treatment based on housing supply elasticity. Panel A provides the baseline estimates. Panel B provides estimates for specifications in which the treatment and control group are propensity-score matched. The treatment group is defined as below-median mortgage-weighted average MSA-level housing supply elasticity (Saiz, 2010) in 2008Q4. In triple differences specifications, we interact the baseline coefficient with dummy variables based on whether institutions are in the middle or top terciles of the distributions of real estate loans to total assets in 2008Q4. In both panels, the sample is restricted to institutions that hedge at least once before the treatment. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 2005Q1-2013Q4.

Panel A: Baseline estimation

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.099	0.004	-0.201**	0.097	-0.183*	0.078
	(0.087)	(0.108)	(0.080)	(0.088)	(0.063)	(0.092)
$Post_t \times Treated_i \times MidRE_i$		-0.048		-0.269***		-0.303**
		(0.120)		(0.094)		(0.096)
$Post_t \times Treated_i \times HighRE_i$		-0.224*		-0.243**		-0.146
		(0.121)		(0.094)		(0.094)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.081	0.093	0.019	0.021	0.015	0.016
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Panel B: Estimation with propensity score matching

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.157*	0.013	-0.224**	-0.041	-0.126	0.016
	(0.082)	(0.099)	(0.110)	(0.118)	(0.090)	(0.093)
$Post_t \times Treated_i \times MidRE_i$		-0.166		-0.200**		-0.0126
		(0.128)		(0.126)		(0.092)
$Post_t \times Treated_i \times HighRE_i$		-0.252**		-0.298***		-0.195**
		(0.125)		(0.126)		(0.092)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.082	0.095	0.022	0.022	0.017	0.018
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Table 7 – Hedging and net worth: Instrumental variables estimation

This table provides evidence on the relation between hedging and net worth using an instrumental variables approach. Panel A shows the first stage in which net worth measures are instrumented using mortgage-weighted average ZIP-code level house price changes over the past two years as in equation (11). Panel B shows the second stage in which hedging measures are regressed on instrumented net worth as in equation (12). We estimate the second stage only when the instrument has sufficient statistical power in the first stage. Each regression controls for exposure and includes time fixed effects. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

Panel A: First stage

	NWIndex		NWIndex (ex size)		MktCap/Assets		Size	
Δ House prices	0.106***	0.107***	0.115***	0.121***	0.168***	0.129***	-0.001	-0.006
	(0.034)	(0.032)	(0.034)	(0.029)	(0.030)	(0.029)	(0.031)	(0.009)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y	N	Y
R^2/Within-R^2	0.295	0.436	0.312	0.431	0.391	0.562	0.017	0.693
F-statistic	17.12	16.45	18.64	17.17	23.10	21.96	5.15	15.47
Obs.	12,843	12,843	12,843	12,843	13,470	13,470	13,470	13,470

Panel B: Second stage

	Net IR hedging		Gross IR hedging		Gross FX hedging	
NWIndex (instr.)	0.227***	0.178***	0.076**	0.041	0.005	0.001
	(0.062)	(0.061)	(0.039)	(0.029)	(0.017)	(0.005)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	12,843	12,843	12,843	12,843	12,843	12,843
NWIndex (ex size) (instr.)	0.231***	0.185***	0.081**	0.048*	0.006	0.001
	(0.063)	(0.062)	(0.040)	(0.029)	(0.018)	(0.007)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	12,843	12,843	12,843	12,843	12,843	12,843
MktCap/Assets (instr.)	0.200***	0.137***	0.078**	0.030	0.002	-0.002
	(0.053)	(0.042)	(0.039)	(0.028)	(0.019)	(0.011)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	13,470	13,470	13,470	13,470	13,470	13,470

Table 8 – Hedging before distress

This table provides evidence on hedging, trading, and balance sheet exposures before distress. We report estimates from regressions of these variables on dummies for up to 8 quarters before distress as in equation (13). Each regression includes time and institution fixed effects. Distress events are defined as exits from the sample with a ratio of market capitalization to total assets below 4%. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	IR risk management				FX risk management		
	Net hedging	Gross hedging	Gross trading	Maturity gap	Gross hedging	Gross trading	FX Exp.
$\tau - 8$	0.159	-0.025	-0.111	0.032	-0.149	-0.079	0.053
	(0.157)	(0.093)	(0.078)	(0.122)	(0.413)	(0.487)	(0.254)
$\tau - 7$	0.040	-0.017	-0.121*	0.089	-0.154	-0.085	0.051
	(0.126)	(0.091)	(0.061)	(0.119)	(0.413)	(0.487)	(0.254)
$\tau - 6$	0.057	-0.092	-0.107**	0.110	-0.163	-0.107	0.040
	(0.142)	(0.091)	(0.062)	(0.119)	(0.413)	(0.487)	(0.254)
$\tau - 5$	-0.258**	-0.111	-0.126**	0.039	-0.156	-0.071	0.028
	(0.121)	(0.091)	(0.061)	(0.119)	(0.413)	(0.487)	(0.254)
$\tau - 4$	-0.296**	-0.154*	-0.114**	0.003	0.027	-0.053	0.022
	(0.124)	(0.090)	(0.062)	(0.118)	(0.414)	(0.487)	(0.255)
$\tau - 3$	-0.302**	-0.170*	-0.125**	-0.052	-0.091	-0.060	0.170
	(0.124)	(0.088)	(0.062)	(0.116)	(0.414)	(0.487)	(0.255)
$\tau - 2$	-0.341**	-0.161*	-0.123**	-0.103	0.057	-0.109	0.196
	(0.141)	(0.089)	(0.060)	(0.117)	(0.414)	(0.487)	(0.255)
$\tau - 1$	-0.343**	-0.217**	-0.117**	-0.094	-0.422	-0.118	0.226
	(0.137)	(0.088)	(0.060)	(0.116)	(0.414)	(0.487)	(0.255)
τ	-0.243*	-0.208**	-0.118**	0.008	-0.420	-0.109	0.275
	(0.142)	(0.089)	(0.059)	(0.116)	(0.414)	(0.488)	(0.255)
Time FE	Y	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y	Y
No. distressed	53	53	13	53	5	3	5
Within-R^2	0.265	0.014	0.048	0.028	0.019	0.025	0.025
Obs.	15,807	18,025	7,568	18,002	4,797	3,885	4,151

Table 9 – Trading and net worth: Cross-sectional and within evidence

This table provides evidence on the relation between interest rate or foreign exchange trading and measures of net worth. For each combination of trading and net worth measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. Each regression includes time fixed effects but not controls for balance sheet exposure. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	Gross IR trading			Gross FX trading		
	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.210***	0.207***	0.021***	0.160**	0.202***	-0.013***
	(0.053)	(0.046)	(0.005)	(0.067)	(0.062)	(0.004)
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.035	0.056	0.028	0.029	0.103	0.007
Obs.	20,568	20,568	20,568	20,568	20,568	20,568
NWIndex (ex size)	0.090**	0.097***	0.021***	0.094*	0.114***	-0.013***
	(0.038)	(0.006)	(0.005)	(0.052)	(0.006)	(0.004)
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.008	0.015	0.028	0.014	0.037	0.007
Obs.	20,568	20,568	20,568	20,568	20,568	20,568
MktCap/Assets	0.056	0.073***	0.017***	0.102	0.099**	-0.030***
	(0.041)	(0.027)	(0.006)	(0.062)	(0.038)	(0.006)
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.004	0.312	0.021	0.014	0.030	0.007
Obs.	22,723	22,723	22,723	22,723	22,723	22,723
Size	0.455***	0.270***	0.003	0.283***	0.223***	0.176***
	(0.076)	(0.031)	(0.029)	(0.084)	(0.048)	(0.029)
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.208	0.268	0.020	0.087	0.310	0.008
Obs.	22,723	22,723	22,723	22,723	22,723	22,723

Figure 1 – Distribution of main measures of net worth

This figure plots the distribution of the four main measures of net worth. There is one cross-sectional box plot for each quarter; in each of them, the horizontal dash is the median and the diamond is the mean. The whiskers represent the 5th and 95th percentiles. The grey rectangle represents the 25th and 75th percentiles. The top left panel also shows the year 2009 in dark red, which is the treatment year in the difference-in-differences and triple differences estimation. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 1995Q1-2013Q4.

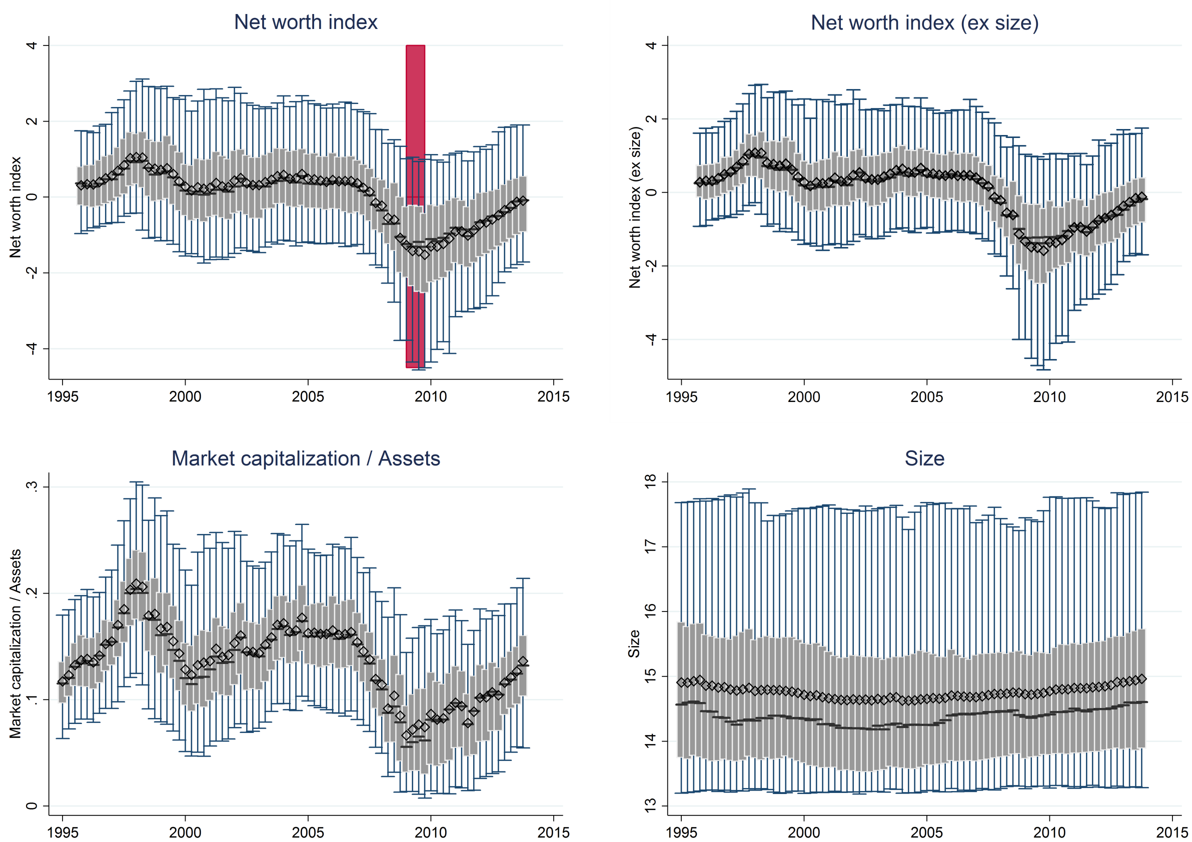
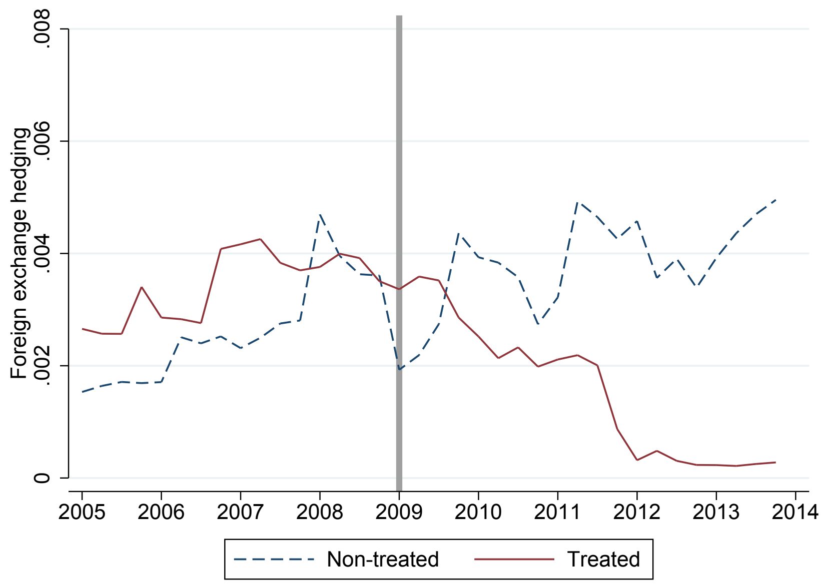


Figure 2 – Difference-in-differences: Effect of treatment on hedging

This figure plots hedging in the treatment and control group used in the difference-in-differences estimation. Panel A plots gross interest rate hedging and Panel B plots gross foreign exchange hedging. The sample is restricted to institutions that hedge at least once before the treatment year. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 2005Q1-2013Q4.

Panel A: Interest rate hedging

Panel B: Foreign exchange hedging



Appendix A: Auxiliary tables and figures

Table A1 – Variable definitions

This table provides definitions of the variables used in the empirical analysis.

Variable	Definition	Data source
	Derivatives data	
Net IR hedging	Change in net market value of interest rate derivatives (*bhck8741+bhck8749-bhck8745-bhck8753*), divided by changes in the Fed funds rate, normalized by total assets; winsorized at the 5th and 95th percentiles	Call reports and FRED
Gross IR hedging	Total gross notional amount of interest rate derivatives held for purposes other than trading (*bhck8725*) over total assets; for the period 1995-2000, contracts not marked to market (*bhck8729*) are added; winsorized at the 99th percentile	Call reports
Gross FX hedging	Total gross notional amount of foreign exchange rate derivatives held for purposes other than trading (*bhck8726*) over total assets; for the period 1995-2000, contracts not marked to market (*bhck8730*) are added; winsorized at the 99th percentile	Call reports
Gross IR trading	Total gross notional amount of interest rate derivatives held for trading (*bhcka126*); winsorized at the 99th percentile	Call reports
Gross FX trading	Total gross notional amount of foreign exchange rate derivatives held for trading (*bhcka127*); winsorized at the 99th percentile	Call reports
	Net worth measures	
Size	Log of total assets (*bhck2170*)	Call reports
Market capitalization (MktCap)	Log of share mid-price at the end of each quarter multiplied by the number of shares outstanding	CRSP
Market capitalization /Assets (MktCap/Assets)	Market capitalization normalized by total assets (at book value) minus book equity plus market capitalization; winsorized at the 1st and 99th percentiles	CRSP
Net income/Assets (NetInc/Assets)	Net income (*bhck4340*) normalized by total assets; winsorized at the 1st and 99th percentiles	Call reports
Dividends/Assets (Div/Assets)	Cash dividends on common stock (bhck4460) normalized by total assets; winsorized at the 1st and 99th percentiles	Call reports
Rating	S&P credit rating coded linearly from 1 (D) to 22 (AAA)	Capital IQ
Net worth index (NWIndex)	First principal component of MktCap/Assets, Size, NetInc/Assets, and Div/Assets: NWIndex $= 0.307 \times$ MktCap/Assets $+ 0.149 \times$ Size $+ 0.272 \times$ NetInc/Assets $+ 0.272 \times$ Div/Assets	Call reports and CRSP
Net worth index excluding size (NWIndex ex size)	First principal component of MktCap/Assets, NetInc/Assets, and Div/Assets: NWIndex (ex size) $= 0.359 \times$ MktCap/Assets $+ 0.329 \times$ NetInc/Assets $+ 0.312 \times$ Div/Assets	Call reports and CRSP

Table A1 (continued) – Variable definitions

Variable	Definition	Data source
	Regulatory capital	
Regulatory capital /Assets (RegCap/Assets)	Total qualifying capital allowable under the risk-based capital guidelines (*bhck3792*) normalized by risk-weighted assets (*bhcka223*); winsorized at the 1st and 99th percentiles	Call reports
Tier 1 capital/Assets (Tier1/Assets)	Tier 1 capital allowable under the risk-based capital guidelines (*bhck8274*) normalized by risk-weighted assets (*bhcka223*); winsorized at the 1st and 99th percentiles	Call reports
	Decomposition of net income	
Net interest income	Net interest income (*bhck4074*); annualized	Call reports
Provisions	Provision for loan and lease losses (*bhck4230*); annualized	Call reports
	Other balance sheet variables	
Total assets	Total assets (*bhck2170*)	Call reports
Maturity gap	Earning assets that are repriceable or mature within one year (*bhck3197*) minus interest-bearing deposits that mature or reprice within one year (*bhck3296*) minus long-term debt that reprices or matures within one year (*bhck3298* + *bhck3409*) minus variable rate preferred stock (*bhck3408*) minus other borrowed money with a maturity of one year or less (*bhck2332*) minus commercial paper (*bhck2309*) minus federal funds and repo liabilities (*bhdmb993* + *bhckb995*), normalized by total assets	Call reports
Narrow maturity gap	Maturity gap + interest-bearing deposits that mature or reprice within one year (*bhck3296*), normalized by total assets	Call reports
FX exposure	Fee and interest income from loans in foreign offices (*bhck4059*) / Total interest income (*bhck4107*)	Call reports
Total loans	Total loans and leases, net of unearned income (*bhck2122*)	Call reports
Real estate loans	Loans secured by real estate (*bhck1410*)	Call reports
	House price and related data	
House prices	House prices by ZIP code	Zillow
Housing supply elasticity	Housing supply elasticity by MSA	Saiz (2010)
Real estate loans by zip code	Mortgage applications by ZIP code	HMDA
Deposits by ZIP code	Total amount of deposits by ZIP code	Summary of deposits FDIC

Table A2 – Descriptive statistics

This table provides descriptive statistics on net worth and regulatory capital measures, the maturity gap and related variables, and loans and house prices. Panel A reports moments of the distribution of these variables in the pooled sample. The net worth index is normalized to have a zero mean. Panel B reports pairwise correlations between all measures of net worth and regulatory capital in the pooled sample. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 1995Q1-2013Q4.

Panel A: Distribution of variables

	Mean	S.D.	10th	25th	Med.	75th	90th	Obs.
Net worth and regulatory capital								
NWIndex	-0.002	1.388	-1.660	-0.835	0.029	0.876	1.677	20,568
NWIndex (ex size)	-0.001	1.352	-1.596	-0.782	0.068	0.834	1.566	20,568
MktCap/Assets	0.135	0.060	0.057	0.096	0.133	0.171	0.209	22,723
Size	14.748	1.361	13.347	13.700	14.381	15.476	16.696	22,723
NetInc/Assets	0.008	0.010	0.001	0.006	0.010	0.012	0.015	20,704
Div/Assets	0.001	0.001	0	0.000	0.001	0.001	0.002	22,426
MktCap	12.665	1.617	10.909	11.551	12.391	13.602	14.861	22,723
Rating	BBB+	2.065	BBB-	BBB	BBB+	A	A+	3,579
RegCap/Assets	0.100	0.024	0.078	0.087	0.097	0.109	0.125	21,780
Tier1/Assets	0.088	0.023	0.066	0.074	0.085	0.097	0.112	21,780
Maturity gap, its components, and related variables								
Maturity gap	0.094	0.178	-0.120	-0.011	0.091	0.205	0.317	22,697
Earning assets < 1 yr.	0.384	0.144	0.196	0.282	0.384	0.479	0.564	22,697
Minus: interest-bearing liabilities < 1 yr.								
Interest-bearing deposits	0.276	0.146	0.116	0.175	0.248	0.353	0.500	22,697
Repricing long-term debt	0.011	0.025	0	0	0	0.011	0.039	22,697
Maturing long-term debt	0.001	0.002	0	0	0	0	0	22,697
Variable-rate pref. stock	0.000	0.001	0	0	0	0	0	22,697
Commercial paper	0.001	0.006	0	0	0	0	0	22,697
Fed funds and repo	0.026	0.045	0	0	0.005	0.037	0.075	22,697
Other borrowed money	0.029	0.038	0	0.003	0.016	0.042	0.078	22,697
For reference (not included in maturity gap):								
Non int.-bearing assets	0.027	0.015	0.011	0.016	0.024	0.034	0.046	22,697
Non int.-bearing deposits	0.120	0.066	0.045	0.076	0.111	0.149	0.201	22,697
Loans and house prices								
Total loans/ Assets	0.664	0.112	0.520	0.602	0.675	0.740	0.798	22.697
Real estate loans/ Asset	0.470	0.149	0.282	0.375	0.476	0.576	0.655	22.697
Real estate loans 2008Q4/ Assets	0.552	0.138	0.388	0.460	0.562	0.648	0.718	22,697
Mortgage-weighted house price change	-0.119	0.116	-0.268	-0.182	-0.104	-0.041	0.026	22,697
Mortgage-weighted housing supply elast.	2.537	1.433	1.059	1.563	2.259	3.190	4.391	22,697

Table A2 (continued) – Descriptive statistics

Panel B: Correlation between measures of net worth and regulatory capital

	NWIndex	NWIndex (ex size)	MktCap /Assets	Size	NetInc /Assets	Div /Assets	MktCap	Rating	RegCap /Assets
NWIndex (ex size)	0.978	1							
MktCap/Assets	0.841	0.873	1						
Size	0.419	0.228	0.207	1					
NetInc/Assets	0.759	0.799	0.554	0.105	1				
Div/Assets	0.617	0.614	0.419	0.188		1			
MktCap	0.344	0.551	0.245	0.68	0.142	0.164	1		
Rating	0.523	0.473	0.303	0.406	0.369	0.268	0.351	1	
RegCap/Assets	0.112	0.138	0.141	-0.072	0.146	0.039	-0.052	-0.310	1
Tier1/Assets	0.077	0.131	0.133	-0.202	0.152	0.026	-0.155	-0.392	0.961

Table A3 – Hedging and net worth: Cross-sectional and within evidence

This table provides evidence on the relation between interest rate or foreign exchange hedging and the four auxiliary measures of net worth, analogous to Table 2. For each combination of hedging and net worth measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NetInc/Assets	0.051***	0.042**	0.041***	0.033*	0.032**	0.025***	0.070	0.081*	-0.005
	(0.018)	(0.018)	(0.008)	(0.019)	(0.016)	(0.004)	(0.044)	(0.046)	(0.004)
Exposure	0.118***	0.100***	0.003	0.185***	0.130***	0.016***	0.329*	0.050**	0.090***
	(0.043)	(0.038)	(0.007)	(0.062)	(0.045)	(0.004)	(0.168)	(0.025)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.164	0.041	0.221	0.046	0.015	0.012	0.116	0.063	0.018
Obs.	18,500	18,500	18,500	20,681	20,681	20,681	19,282	19,282	19,282
Div/Assets	0.044**	0.051***	-0.002	0.035	0.050**	-0.005	0.029	0.027*	-0.004
	(0.017)	(0.018)	(0.007)	(0.024)	(0.020)	(0.004)	(0.027)	(0.014)	(0.003)
Exposure	0.120***	0.102***	0.005	0.185***	0.130***	0.018***	0.331*	0.055**	0.089***
	(0.042)	(0.036)	(0.007)	(0.059)	(0.043)	(0.004)	(0.168)	(0.026)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.158	0.041	0.212	0.045	0.016	0.009	0.114	0.057	0.018
Obs.	19,792	19,792	19,792	22,419	22,419	22,419	19,277	19,277	19,277
MktCap	0.340***	0.324***	0.123***	0.406***	0.333***	0.118***	0.220***	0.227***	0.016
	(0.020)	(0.015)	(0.024)	(0.051)	(0.031)	(0.014)	(0.055)	(0.053)	(0.013)
Exposure	0.048**	0.022	0.006	0.097**	0.047**	0.019***	0.291*	-0.008	0.089***
	(0.023)	(0.016)	(0.007)	(0.037)	(0.021)	(0.004)	(0.158)	(0.017)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.261	0.117	0.214	0.193	0.102	0.012	0.157	0.253	0.018
Obs.	19,815	19,815	19,815	22,699	22,699	22,699	19,282	19,282	19,282
Rating	0.158**	0.143**	0.075*	0.319**	0.267**	0.085**	0.135	0.189**	0.188***
	(0.062)	(0.059)	(0.040)	(0.133)	(0.114)	(0.033)	(0.095)	(0.094)	(0.043)
Exposure	0.110**	0.103**	0.096***	0.267**	0.229**	0.052**	0.332	0.050	0.166***
	(0.051)	(0.046)	(0.031)	(0.126)	(0.102)	(0.026)	(0.203)	(0.108)	(0.020)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.398	0.137	0.489	0.091	0.025	0.032	0.105	0.038	0.060
Obs.	3,178	3,178	3,178	3,573	3,573	3,573	3,266	3,266	3,266

Table A4 – Hedging and net worth: Evidence by size terciles

This table provides evidence on the relation between interest rate or foreign exchange hedging and the net worth index by size terciles. The table reports the cross-sectional and within-institution evidence as in Table 2. Panel A excludes the bottom size tercile and uses the net worth index as the measure of net worth. Panel B includes dummies for the middle and top tercile by size and uses the net worth index (ex size) as the measure of net worth. For each hedging measure, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

Panel A: Evidence excluding bottom size tercile

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.139***	0.151***	0.074***	0.117***	0.132***	0.034***	0.178**	0.172***	0.033***
	(0.029)	(0.008)	(0.015)	(0.042)	(0.008)	(0.008)	(0.079)	(0.008)	(0.007)
Exposure	0.180***	0.157***	0.006	0.289***	0.216***	0.025***	0.320*	0.087***	0.085***
	(0.033)	(0.008)	(0.009)	(0.064)	(0.007)	(0.005)	(0.165)	(0.003)	(0.007)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.219	0.062	0.227	0.078	0.029	0.017	0.127	0.083	0.023
Obs.	12,946	12,946	13,599	14,431	14,431	15,227	13,531	13,531	14,285

Panel B: Evidence controlling for size terciles

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex (ex size)	0.018**	0.027***	0.050***	0.060***	0.037***	0.035***	0.074***	0.023***	0.016***
	(0.008)	(0.006)	(0.011)	(0.007)	(0.005)	(0.006)	(0.008)	(0.005)	(0.006)
MidSize_i	0.162***	0.284***	0.056*	0.093***	0.206***	0.045**	-0.004	0.189***	-0.026*
	(0.016)	(0.015)	(0.029)	(0.016)	(0.013)	(0.017)	(0.016)	(0.027)	(0.014)
LargeSize_i	0.668***	0.778***	-0.019	0.692***	0.705***	0.068**	0.276***	0.604***	-0.047*
	(0.016)	(0.015)	(0.049)	(0.016)	(0.013)	(0.029)	(0.017)	(0.029)	(0.024)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.235	0.109	0.221	0.131	0.079	0.012	0.029	0.021	0.007
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270

Table A5 – Hedging and net worth: Evidence controlling for deposits

This table provides evidence on the relation between interest rate hedging and measures of net worth, controlling for the ratio of deposits to total assets and the narrow maturity gap separately, as well as time fixed effects. For each combination of hedging and net worth measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	Net IR hedging			Gross IR hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.122***	0.127***	0.049***	0.097***	0.105***	0.030***
	(0.022)	(0.022)	(0.012)	(0.031)	(0.024)	(0.007)
Deposits/ Assets	-0.230***	-0.215***	-0.053***	-0.317***	-0.248***	-0.119***
	(0.029)	(0.027)	(0.015)	(0.054)	(0.038)	(0.009)
Narrow maturity gap	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.224	0.083	0.221	0.139	0.069	0.020
Obs.	18,396	18,396	18,396	20,562	20,562	20,562
NWIndex (ex size)	0.048**	0.049***	0.045***	0.003	0.025***	0.026***
	(0.021)	(0.006)	(0.011)	(0.026)	(0.005)	(0.006)
Deposits/ Assets	-0.247***	-0.235***	-0.054***	-0.335***	-0.266***	-0.120***
	(0.030)	(0.005)	(0.015)	(0.055)	(0.005)	(0.009)
Narrow maturity gap	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.215	0.076	0.221	0.132	0.063	0.019
Obs.	18,396	18,396	18,396	20,562	20,562	20,562
MktCap/Assets	0.026	0.030	0.024**	-0.032	-0.003	-0.010
	(0.022)	(0.023)	(0.011)	(0.026)	(0.022)	(0.007)
Deposits/ Assets	-0.251***	-0.237***	-0.067***	-0.344***	-0.272***	-0.135***
	(0.028)	(0.026)	(0.014)	(0.054)	(0.038)	(0.008)
Narrow maturity gap	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.210	0.076	0.214	0.136	0.064	0.019
Obs.	19,815	19,815	19,815	22,699	22,699	22,699
Size	0.325***	0.690***	0.184***	0.397***	0.303***	0.403***
	(0.020)	(0.040)	(0.057)	(0.050)	(0.027)	(0.034)
Deposits/ Assets	-0.117***	-0.235***	-0.053***	-0.176***	-0.128***	-0.105***
	(0.025)	(0.052)	(0.015)	(0.043)	(0.028)	(0.009)
Narrow maturity gap	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.297	0.142	0.214	0.265	0.142	0.026
Obs.	19,815	19,815	19,815	22,699	22,699	22,699

Table A6 – Difference-in-differences and triple differences sample

This table describes the data used in the difference-in-differences and triple differences specifications in Tables 3, 4, 5, and 6, and in Appendix Table A7. Panel A provides the descriptive statistics for the hedging, exposure, and net worth measures. Panel B compares the treatment and control group both before and after matching. The characteristics are as of 2008Q1, that is, one year before the treatment. The treatment group is defined as institutions with a below-median mortgage-weighted average ZIP-code level house price change from 2007Q1 through 2008Q4. In both panels, the sample is restricted to institutions that hedge at least once before the treatment. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. *p*-values are in parentheses. Time frame: 2005Q1-2013Q4.

Panel A: Descriptive statistics

	Mean	S.D.	10th	25th	Med.	75th	90th	Obs.
Net IR hedging	0.026	0.413	-0.500	-0.047	0	0.049	0.666	4,268
Gross IR hedging	0.054	0.089	0	0.003	0.016	0.066	0.161	4,804
Gross FX hedging	0.001	0.003	0	0	0	0	0.001	4,804
Maturity gap	0.106	0.176	-0.106	-0.000	0.105	0.217	0.328	4,804
FX exposure	0.004	0.030	0	0	0	0	0.014	4,804
NWIndex	-0.055	1.355	-1.764	-0.837	0.041	0.789	1.590	4,788
NWIndex (ex size)	-0.177	1.363	-1.789	-0.976	-0.090	0.689	1.420	4,788
MktCap/Assets	0.128	0.064	0.045	0.085	0.124	0.166	0.209	4,804
Size	15.346	1.389	13.731	14.368	15.036	16.135	17.286	4,804
NetInc/Assets	0.006	0.011	-0.003	0.005	0.009	0.011	0.014	4,788
Div/Assets	0.001	0.001	0.000	0.000	0.001	0.001	0.002	4,804
MktCap	13.121	1.596	11.163	12.057	12.975	14.086	15.110	4,804
Rating	BBB+	0.789	BB+	BBB-	BBB+	A-	A	1,056

Panel B: Comparison of treatment and control group

	Before matching			After matching		
Variable	Control	Treatment	*p*-value	Control	Treatment	*p*-value
NWIndex	0.327	-0.208	(0.017)	0.075	-0.208	(0.176)
NWIndex (ex size)	0.272	-0.219	(0.021)	0.043	-0.219	(0.168)
MktCap/Assets	0.135	0.099	(0.001)	0.111	0.099	(0.102)
Size	15.291	15.382	(0.761)	15.308	15.382	(0.834)
NetInc/Assets	0.009	0.004	(0.000)	0.008	0.004	(0.175)
Book equity/Assets	0.093	0.094	(0.744)	0.093	0.094	(0.803)
Loans/Assets	0.699	0.751	(0.010)	0.724	0.751	(0.223)
Real estate loans/Assets	0.492	0.580	(0.001)	0.535	0.580	(0.148)
Securities/Assets	0.173	0.130	(0.023)	0.158	0.130	(0.297)
Deposits/Assets	0.714	0.721	(0.683)	0.715	0.721	(0.873)
Maturity gap	0.075	0.102	(0.419)	0.083	0.102	(0.648)

Table A7 – Effect of treatment on net worth

This table provides the difference-in-differences and triple differences estimates, using the four auxiliary measures of net worth as dependent variables, analogous to Panel A of Table 4. The treatment group is defined as institutions with a below-median mortgage-weighted average ZIP-code level house price change from 2007Q1 through 2008Q4. In triple differences specifications, we interact the baseline coefficient with dummy variables based on whether institutions are in the middle or top terciles of the distributions of real estate loans to total assets in 2008Q4. The sample is restricted to institutions that hedge at least once before the treatment. We control for time fixed effects as in Table 2. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 2005Q1-2013Q4.

	NetInc/Assets		Div/Assets		MktCap		Rating	
$Post_t \times Treated_i$	-0.192***	-0.134**	-0.291***	-0.269***	-0.259***	-0.041	-0.721***	-0.919***
	(0.053)	(0.053)	(0.055)	(0.057)	(0.059)	(0.059)	(0.148)	(0.152)
$Post_t \times Treated_i$ $\times MidRE_i$		0.083*		0.033		-0.326***		0.588***
		(0.047)		(0.050)		(0.052)		(0.121)
$Post_t \times Treated_i$ $\times HighRE_i$		-0.331***		-0.118**		-0.991***		-0.162
		(0.048)		(0.051)		(0.053)		(0.292)
$Post_t \times MidRE_i / HighRE_i$	Y	Y	Y	Y	Y	Y	Y	Y
Exposure	N	N	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y	Y	Y
Within-R^2	0.288	0.300	0.145	0.147	0.033	0.105	0.106	0.126
Obs.	4,788	4,788	4,804	4,804	4,804	4,804	1,056	1,056

Table A8 – Hedging and net worth: Instrumental variables estimation

This table provides evidence on the relation between hedging and net worth using an instrumental variables approach, analogous to Table 7. Panel A shows the first stage in which the four auxiliary net worth measures are instrumented using mortgage-weighted average ZIP-code level house price changes over the past two years as in equation (11). Panel B shows the second stage in which hedging measures are regressed on instrumented net worth as in equation (12). We estimate the second stage only when the instrument has sufficient statistical power in the first stage. Each regression controls for exposure and includes time fixed effects. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

Panel A: First stage

	NetInc/Assets		Div/Assets		MktCap		Rating	
Δ House prices	0.172***	0.146***	-0.054*	0.000	0.062**	0.039***	0.196***	0.231***
	(0.031)	(0.041)	(0.033)	(0.022)	(0.032)	(0.015)	(0.057)	(0.068)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y	N	Y
R^2/Within-R^2	0.231	0.334	0.096	0.127	0.061	0.371	0.040	0.135
F-statistic	9.06	7.12	4.74	5.21	27.35	32.10	10.45	10.11
Obs.	9,911	9,911	13,338	13,338	11,736	11,736	1,868	1,868

Panel B: Second stage

	Net IR hedging		Gross IR hedging		Gross FX hedging	
NetInc/Assets (instr.)	0.171***	0.148***	0.112**	0.108**	0.005	-0.002
	(0.053)	(0.053)	(0.049)	(0.046)	(0.016)	(0.010)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	9,911	9,911	9,911	9,911	9,911	9,911
MktCap (instr.)	0.199***	0.121*	0.232***	0.105*	-0.001	0.002
	(0.052)	(0.052)	(0.061)	(0.054)	(0.005)	(0.003)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	11,736	11,736	11,736	11,736	11,736	11,736
Rating (instr.)	0.142**	0.087*	0.251**	0.082**	0.004	0.002
	(0.061)	(0.042)	(0.110)	(0.032)	(0.004)	(0.003)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	1,868	1,868	1,868	1,868	1,868	1,868

Table A9 – Hedging and net worth: Evidence excluding bottom tercile

This table provides evidence on the relation between interest rate or foreign exchange hedging and the four main measures of net worth, dropping institutions in the bottom tercile of the distribution of the relevant net worth variable, analogous to Table 2. For each combination of hedging and net worth measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.203***	0.230***	0.008	0.236***	0.235***	0.069***	0.289**	0.215***	-0.004
	(0.040)	(0.038)	(0.022)	(0.061)	(0.049)	(0.012)	(0.139)	(0.075)	(0.011)
Exposure	0.124**	0.105**	-0.005	0.182**	0.134**	0.002	0.053	0.054*	0.052***
	(0.057)	(0.049)	(0.008)	(0.075)	(0.056)	(0.004)	(0.038)	(0.031)	(0.006)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.211	0.066	0.234	0.065	0.031	0.014	0.033	0.055	0.014
Obs.	12,470	12,470	12,470	13,776	13,776	13,776	13,773	13,773	13,773
NWIndex (ex size)	0.072*	0.087***	0.002	0.038	0.063***	0.060***	0.215*	0.112***	-0.006
	(0.040)	(0.011)	(0.020)	(0.043)	(0.010)	(0.011)	(0.125)	(0.009)	(0.010)
Exposure	0.123**	0.106***	-0.006	0.186**	0.137***	0.001	0.346*	0.092***	0.054
	(0.056)	(0.006)	(0.008)	(0.076)	(0.006)	(0.004)	(0.181)	(0.004)	(0.006)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.188	0.051	0.235	0.048	0.018	0.014	0.131	0.065	0.014
Obs.	12,466	12,466	13,155	13,776	13,776	14,580	12,863	12,863	13,637
MktCap/Assets	0.031	0.039	-0.012	-0.037	-0.005	-0.018	0.243*	0.091**	-0.032
	(0.035)	(0.034)	(0.017)	(0.035)	(0.068)	(0.023)	(0.143)	(0.043)	(0.037)
Exposure	0.119**	0.101**	-0.005	0.182***	0.130**	0.009**	0.492**	0.117***	0.064***
	(0.051)	(0.044)	(0.007)	(0.069)	(0.051)	(0.004)	(0.231)	(0.038)	(0.007)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.175	0.046	0.225	0.045	0.015	0.011	0.186	0.083	0.015
Obs.	13,408	13,408	13,408	15,205	15,205	15,205	12,894	12,894	12,894
Size	0.409***	0.382***	0.219**	0.551***	0.436***	0.653***	0.290***	0.262***	0.650***
	(0.022)	(0.018)	(0.086)	(0.068)	(0.041)	(0.049)	(0.068)	(0.054)	(0.046)
Exposure	0.067***	0.040*	0.004	0.133***	0.081**	0.024***	0.284*	0.055**	0.080***
	(0.025)	(0.023)	(0.009)	(0.051)	(0.035)	(0.005)	(0.157)	(0.025)	(0.007)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.315	0.125	0.219	0.257	0.113	0.026	0.161	0.207	0.037
Obs.	13,482	13,482	13,482	15,204	15,204	15,204	13,539	13,539	13,539

Table A10 – Hedging and regulatory capital

This table provides evidence on the relation between interest rate or foreign exchange hedging and measures of regulatory capital. In Panel A, for each combination of hedging and regulatory capital measures, we estimate a pooled OLS specification, a Tobit specification, and a specification with institution fixed effects. We control for exposure and time fixed effects as in Table 2. We use the absolute value of net interest rate hedging and the maturity gap. Data is at the BHC level and variables are normalized and defined in Appendix Table A1. For Tobit specifications, marginal effects are reported. Standard errors (in parentheses) are double clustered at the institution and quarter level. Panel B provides the results for Davidson-MacKinnon J-tests of whether the specifications with measures of regulatory capital and net worth are nested. The t-statistics are reported and p-values are in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4.

Panel A: Cross-sectional and within evidence

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
RegCap/Assets	-0.055**	-0.070***	0.025**	-0.062**	-0.068**	-0.008	0.008	-0.013	0.020***
	(0.024)	(0.026)	(0.010)	(0.029)	(0.026)	(0.006)	(0.034)	(0.020)	(0.005)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.161	0.042	0.216	0.043	0.016	0.010	0.006	0.022	0.005
Obs.	19,123	19,123	19,123	21,753	21,753	21,753	21,749	21,749	21,749
Tier1/Assets	-0.131***	-0.150***	0.016	-0.161***	-0.154***	-0.031***	-0.036	-0.087***	0.013**
	(0.028)	(0.031)	(0.010)	(0.039)	(0.036)	(0.006)	(0.030)	(0.031)	(0.005)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.174	0.052	0.216	0.063	0.028	0.011	0.007	0.037	0.004
Obs.	19,123	19,123	19,123	21,753	21,753	21,753	21,749	21,749	21,749

Panel B: Davidson-MacKinnon (1981)'s J-test

	Net IR hedging		Gross IR hedging		Gross FX hedging	
	RegCap	Tier1	RegCap	Tier1	RegCap	Tier1
H0: Net worth / H1: Regulatory capital						
NWIndex	3.21***	5.51***	0.62	3.03***	0.03	1.59
	(0.001)	(0.000)	(0.537)	(0.002)	(0.972)	(0.113)
NWIndex (ex size)	2.87***	5.32***	0.97	2.80***	0.11	1.74*
	(0.004)	(0.000)	(0.330)	(0.005)	(0.914)	(0.082)
MktCap/Assets	2.62***	3.20***	0.91	1.92*	-0.29	2.36**
	(0.009)	(0.001)	(0.365)	(0.056)	(0.773)	(0.018)
Size	1.07	2.73***	3.34***	-1.64	1.12	-0.82
	(0.285)	(0.006)	(0.001)	(0.101)	(0.261)	(0.412)
H0: Regulatory capital / H1: Net worth						
NWIndex	5.89***	6.30***	5.07***	5.54***	2.75***	2.74***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.006)
NWIndex (ex size)	2.96***	3.57***	1.13	1.66*	2.06**	2.14**
	(0.003)	(0.000)	(0.260)	(0.097)	(0.040)	(0.033)
MktCap/Assets	2.40**	5.18***	1.30	2.83***	2.14**	2.22**
	(0.017)	(0.000)	(0.194)	(0.005)	(0.033)	(0.026)
Size	11.49***	11.46***	22.37***	21.77***	4.21***	4.12***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Figure A1 – Distribution of measures of net worth and regulatory capital

This figure plots the distribution of the four auxiliary measures of net worth and regulatory capital, analogous to Figure 1. There is one cross-sectional box plot for each quarter; in each of them, the horizontal dash is the median and the diamond is the mean. The whiskers represent the 5th and 95th percentiles. The grey rectangle represents the 25th and 75th percentiles. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 1995Q1-2013Q4.

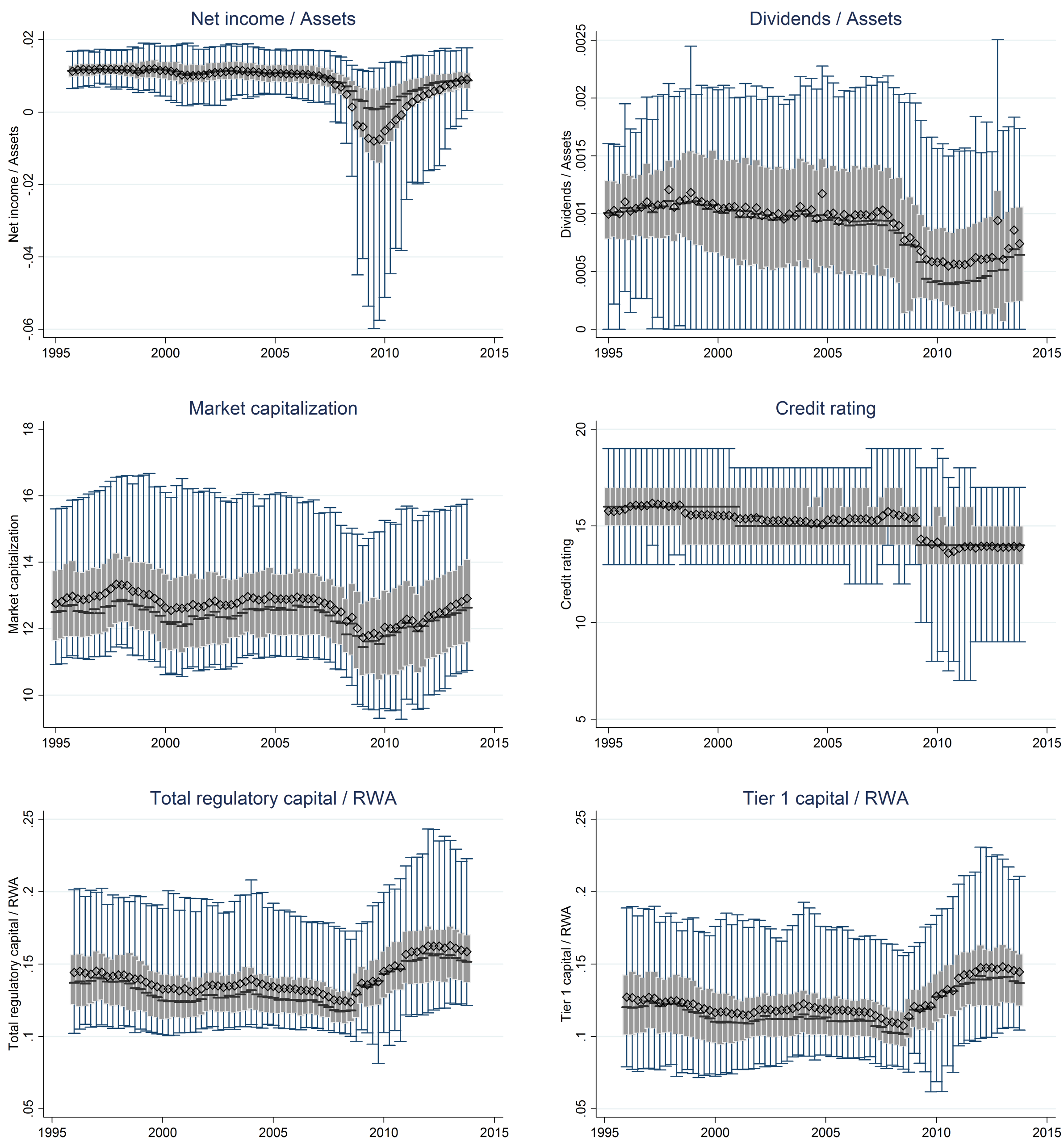
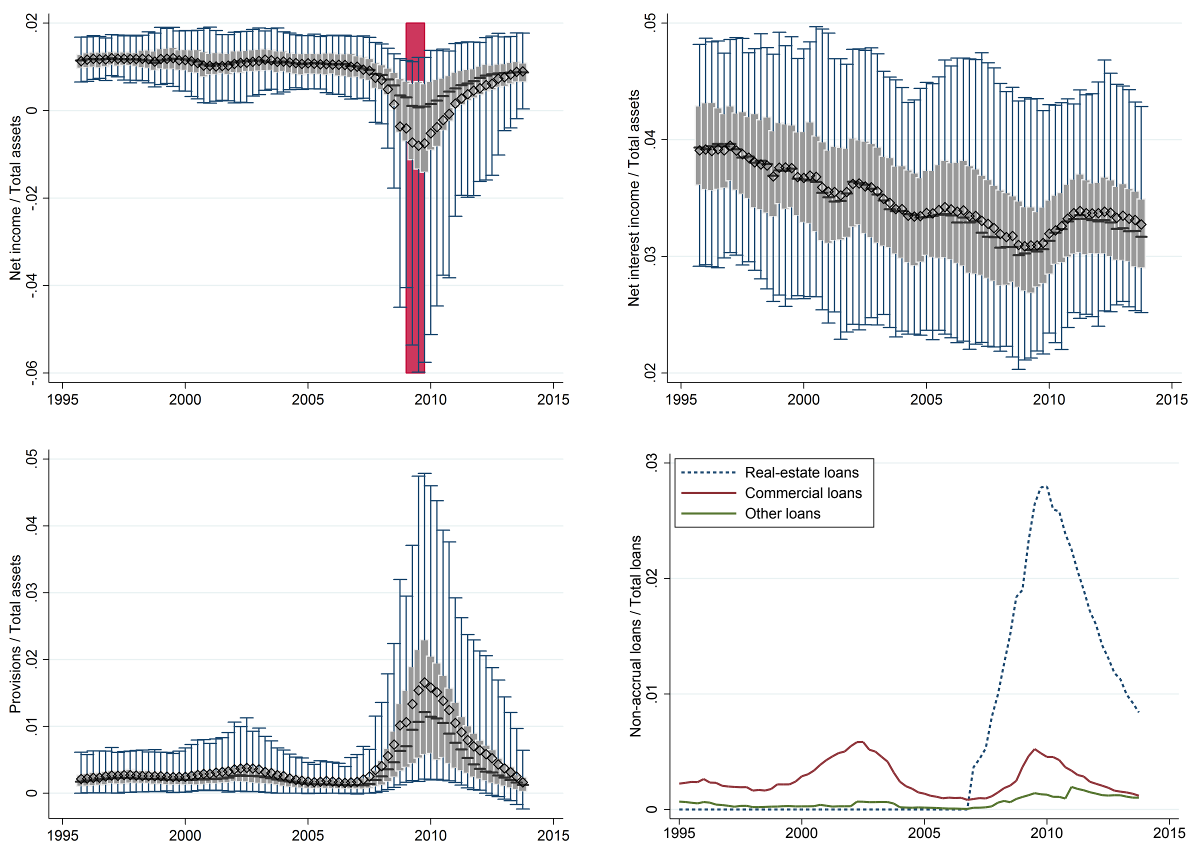


Figure A2 – Decomposition of net income

This figure shows the distribution of net income and some of its key components over the sample period. The top left panel shows the distribution of net income (normalized by total assets); this panel also shows the year 2009 in dark red, which is the treatment year in the difference-in-differences and triple differences estimation. The top right panel shows the distribution of net interest income (normalized by total assets); the bottom left panel shows the distribution of provisions for loan losses (normalized by total assets). Provisions enter negatively in the calculation of net income. The bottom right panel shows the ratio of non-accrual loans to total assets, broken down by loan type. In the top two panels and bottom left panel, there is one cross-sectional box plot for each quarter. In each of them, the horizontal dash is the median and the diamond is the mean. The whiskers represent the 5th and 95th percentiles. The grey rectangle represents the 25th and 75th percentiles. Data is at the BHC level and variables are defined in Appendix Table A1. Time frame: 1995Q1-2013Q4.



Appendix B: Bank-level evidence

This appendix replicates some of the main results at the bank level. The additional contribution of bank-level data is that it allows us to construct an alternative measure of net interest rate hedging (Section B.1) and an alternative measure of balance sheet interest rate exposure (Section B.2). That said, the results at the bank level mirror those at the BHC level both in terms of statistical significance and economic magnitude; indeed, the bank-level results are remarkably similar to those obtained using BHC data.

B.1 Measuring net interest rate hedging at bank level

Bank-level data allows us to construct an alternative measure of net interest rate hedging for the subset of banks that use only swaps and no other types of interest rate derivatives. For such banks, we can infer net hedging as follows: first, banks report the notional amount of interest rate *derivatives* held for hedging purposes; second, banks report the notional amount of *swaps* held for hedging on which they pay a fixed rate. The notional amount of swaps held for hedging on which they pay a floating rate, while not reported, can then be inferred from these two numbers for the subset of banks that only use swaps. Thus, for a bank i at time t which reports using only swaps, we construct a measure of net hedging as

$$\text{Net interest rate hedging}_{it} = \frac{\text{Pay-fixed swaps}_{it} - \text{Pay-float swaps}_{it}}{\text{Assets}_{it}}. \tag{B1}$$

This ratio can be computed for 28.7% of all bank-quarter observations for banks that use derivatives. Banks for which net hedging can be computed are relatively large and have a median size of 13.58 (in log assets), which is above the 90th percentile of the bank size distribution. An analogous measure cannot be constructed at the BHC level due to differences in the reporting requirements for BHCs and banks.

A positive (negative) value of net interest rate hedging means that an institution is taking a net pay-fixed (pay-float) position, that is, hedges against increases (decreases) in interest rates. To corroborate that derivatives which banks report as being used for hedging purposes are indeed used for risk management, we plot the distribution of net hedging conditional on banks' maturity gap being above the 75th percentile vs. below the 25th percentile in Figure B1; the shift in the distributions is evident and consistent with hedging: banks with a more negative maturity gap, that is, more net floating rate liabilities, tend to have a net pay-fixed position in interest rate swaps, and vice-versa.

B.2 Duration gap as measure of interest rate exposure

Bank-level data also allows us to obtain an alternative measure of balance sheet exposure to interest rate risk, the duration gap. The duration gap is essentially the difference between the duration of assets and liabilities. In contrast to the maturity gap, which measures only the difference between assets and liabilities that mature or reprice within one year, the duration gap measures differences in maturities and repricing frequencies across all maturities.

Denote the market value of a bank's assets, liabilities, and equity by A, L and E, respectively, with $A = L + E$. Total assets and liabilities are comprised of contracts in various duration categories, respectively indexed by i and j, where $A = \sum_i A_i$ and $L = \sum_j L_j$, and D_i (D_j) denotes the duration in category i (j). The duration of assets and liabilities, respectively, are $D_A = \sum_i \frac{A_i}{A} D_i$ and $D_L = \sum_j \frac{L_j}{L} D_j$, and we define the *duration gap* as

$$D_{gap} \equiv D_A - \frac{L}{A} D_L.$$

Since $E = A - L$, the *duration of equity* is

$$D_E = \sum_i \frac{A_i}{E} D_i - \sum_j \frac{L_j}{E} D_j = \frac{A}{E} D_{gap};$$

thus, the duration gap is essentially the deleveraged duration of equity.

To understand the connection between these measures and the maturity gap, suppose there were only two types of assets – short-term assets A_s and long-term assets A_l – and analogously two types of liabilities, L_s and L_l. Suppose moreover that short-term (resp. long-term) assets and liabilities have the same duration, and that $D_s = 0$ whereas $D_l = 1$. Then the duration gap can be written as $D_{gap} = \frac{E}{A} - \frac{A_s - L_s}{A} = \frac{E}{A} - M_{gap}$, where $M_{gap} \equiv \frac{A_s - L_s}{A}$ is the maturity gap, and the duration of equity can be written as $D_E = 1 - \frac{A}{E} M_{gap}$. Under these stark simplifying assumptions, if the bank were fully levered, the duration gap would just be the negative of the maturity gap, and if the bank were fully equity financed, the duration of equity would be one minus the maturity gap. More generally, one should thus expect the duration gap and the maturity gap to move in opposite directions.[40]

In the bank-level data, a detailed breakdown of assets and liabilities by remaining maturity (for fixed-rate instruments) or repricing date (for variable-rate instruments) is available from 1997Q2 onwards. The call reports provide a breakdown in 6 maturity buckets: $[0, 3m]$, $(3m, 1y]$, $(1y, 3y]$, $(3y, 5y]$, $(5y, 15y]$, and $\{> 15y\}$ (where m is months and y is years). We use the mid-point of each bucket as our measure of duration (and duration 20 for the top bucket). On the assets and liabilities side, the breakdown is available for 26 and 11 categories of instruments, respectively, which together comprise more than 90% of assets and liabilities. For assets and liabilities for which no maturity/repricing information is available, we assign the weighted average duration by bank and quarter. Finally, we assign a duration of zero to demand deposits, even though their actual maturity or repricing frequency is likely to be higher, due to the slow-moving nature of deposit rates (see Drechsler, Savov, and Schnabl, 2018).

[40] English, Van den Heuvel, and Zakrajsek (2018) define a different notion of the duration gap, namely, $D_{gap}^{\text{EVZ}} \equiv D_A - D_L$, that is, simply the difference between the duration of assets and liabilities; this measure does not incorporate the effect of leverage and is less closely related to the duration of equity.

B.3 Adapting net worth index for bank level data

We adapt the net worth index for bank level data, since market capitalization is not generally available at the bank level. We replace market capitalization over assets with book equity (BkEqty) over assets in the net worth index, keeping the other three components (size, net income over assets, and dividends over assets) unchanged. Following the same procedure as at the BHC level, we compute the first principal component and obtain the following bank-level net worth index:

$$\text{NWIndex}_{it}^{bank} \equiv 0.201 \times \frac{\text{BkEqty}_{it}}{\text{Assets}_{it}} + 0.181 \times \text{Size}_{it} + 0.314 \times \frac{\text{NetInc}_{it}}{\text{Assets}_{it}} + 0.307 \times \frac{\text{Div}_{it}}{\text{Assets}_{it}}.$$

For comparison, if we construct the analogous index at the BHC level, we obtain the following loadings: book equity over assets (0.235), size (0.190), net income over assets (0.293), dividends over assets (0.298). Thus the loadings obtained in bank-level and BHC-level data are rather similar. Moreover, these loadings are similar to those obtained in our baseline net worth index, which uses the market capitalization (see equation (3) and Appendix Table A1); the main difference is that the baseline index loads relatively more on market capitalization and relatively less on size compared to the index using book equity.[41]

B.4 Results at bank level

We use the bank-level data to replicate some of our main findings obtained at the BHC level (see Appendix Table B1 for the summary statistics of the bank-level data and Appendix Table B2 for the results) obtaining rather similar results throughout. Panel A shows the cross-sectional and within-bank stylized facts, using both the net worth index and size as measures of net worth. Across all specifications, we find a positive and significant relation between hedging and net worth, of similar magnitude as that obtained using BHC data (see Table 2).

Panel B replicates our main difference-in-differences and triple differences specifications. Most notably, the results obtained with the bank-level net interest rate hedging measure are remarkably similar to the results obtained using the measure of net hedging we constructed at the BHC level (see Panel A of Table 3), suggesting that our new measure is a plausible measure of net interest rate hedging for BHCs.

Finally, Panels C and D replicate the difference-in-differences and triple differences specifications with net worth and exposure measures as the dependent variable, respectively. As in Table 4, we find that treatment has a statistically and economically significant effect of similar magnitude on net worth, concentrated among banks with high real estate exposure, but not on measures of exposure (including the bank-level duration gap measure). All told, the bank-level evidence corroborates our findings at the BHC level.

[41] At the BHC level the correlation between the baseline net worth index and the index using book equity is 0.91.

Table B1 – Descriptive statistics: Bank-level data

This table provides descriptive statistics on hedging, exposure, and net worth measures for the bank-level data. Panel A provides the descriptive statistics used in the difference-in-differences and triple differences specifications in Appendix Table B2, Panels B to D. The sample is restricted to banks that hedge at least once before the treatment. Variables are the bank-level equivalents of the BHC-level variables defined in Appendix Table A1 and in Appendix B. Panel B reports estimates of a pooled OLS regression of our baseline measure of net interest rate hedging on the bank-level measure of net interest rate hedging based on swaps data and time fixed effects, without and with bank fixed effects. Time frame: 2005Q1-2013Q4 (Panel A); 1995Q1-2013Q4 (Panel B).

Panel A: Descriptive statistics

	Mean	S.D.	10th	25th	Med.	75th	90th	Obs.
Net IR hedging	-0.012	0.112	-0.098	-0.043	-0.003	0.014	0.052	45,770
Gross IR hedging	0.052	0.081	0	0.002	0.014	0.064	0.152	45,770
Gross FX hedging	0.001	0.003	0	0	0	0	0.001	45,770
Maturity gap	0.012	0.151	-0.182	-0.111	-0.017	0.145	0.202	45,770
Duration gap	4.522	1.728	2.401	3.468	4.451	5.852	7.114	45,770
FX exposure	0.003	0.025	0	0	0	0	0.012	45,770
NWIndex	-0.033	1.212	-1.604	-0.777	0.051	0.764	1.654	45,770
Size	13.492	1.421	11.682	12.675	13.569	14.201	15.210	45,770

Panel B: Relation between net IR hedging measures

	Net IR hedging (baseline measure)	
Net IR hedging (swaps data)	0.189**	0.117*
	(0.086)	(0.070)
Time FE	Y	Y
Institution FE	N	Y
R^2/Within-R^2	0.142	0.083
Obs.	42,143	42,143

Table B2 – Hedging and net worth: Bank-level evidence

This table provides evidence on the relation between interest rate or foreign exchange hedging and measures of net worth at the bank level. Panel A replicates the cross-sectional and within evidence of Table 2; Panel B replicates the difference-in-differences and triple differences estimation of Table 3, Panel A; and Panels C and D report the effect of treatment on net worth and exposure measures, respectively, replicating Table 4. Panel B includes evidence using the bank-level measure of net interest rate hedging and Panel D includes evidence using the bank-level measure of the duration gap. Data is at the bank level and variables are normalized and defined in Appendix Table A1 and in Appendix B. Summary statistics for the sample used in Panels B to D are in Appendix Table B1. Standard errors (in parentheses) are double clustered at the bank and quarter level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level. Time frame: 1995Q1-2013Q4 (Panel A); 2005Q1-2013Q4 (Panels B to D).

Panel A: Cross-sectional and within evidence

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.151***	0.149***	0.070***	0.132***	0.141***	0.069***	0.167***	0.179***	0.087***
	(0.023)	(0.023)	(0.010)	(0.025)	(0.024)	(0.011)	(0.022)	(0.023)	(0.012)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.148	0.151	0.156	0.177	0.163	0.153	0.132	0.133	0.129
Obs.	95,650	95,650	95,650	95,650	95,650	95,650	95,650	95,650	95,650
Size	0.332***	0.345***	0.401***	0.357***	0.369***	0.412***	0.256***	0.297***	0.301***
	(0.017)	(0.019)	(0.021)	(0.023)	(0.026)	(0.019)	(0.034)	(0.031)	(0.029)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bank FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.201	0.223	0.179	0.231	0.235	0.201	0.179	0.177	0.147
Obs.	95,650	95,650	95,650	95,650	95,650	95,650	95,650	95,650	95,650

Panel B: Difference-in-differences and triple differences estimation

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$\text{Post}_t \times \text{Treated}_i$	-0.158*	0.011	-0.198**	0.010	-0.103*	0.046
	(0.079)	(0.056)	(0.080)	(0.036)	(0.050)	(0.079)
$\text{Post}_t \times \text{Treated}_i \times \text{MidRE}_i$		-0.129		-0.175		-0.218
		(0.087)		(0.998)		(0.199)
$\text{Post}_t \times \text{Treated}_i \times \text{HighRE}_i$		-0.255***		-0.287***		-0.425***
		(0.079)		(0.079)		(0.162)
$\text{Post}_t \times \text{MidRE}_i/\text{HighRE}_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.017	0.019	0.018	0.020	0.020	0.021
Obs.	45,770	45,770	45,770	45,770	45,770	45,770

Table B2 (continued) – Hedging and net worth: Bank-level evidence

Panel C: Effect of treatment on net worth

	NWIndex		Size	
$\text{Post}_t \times \text{Treated}_i$	-0.371***	-0.213***	-0.189***	0.014
	(0.054)	(0.054)	(0.061)	(0.063)
$\text{Post}_t \times \text{Treated}_i \times \text{MidRE}_i$		-0.056		-0.262***
		(0.053)		(0.056)
$\text{Post}_t \times \text{Treated}_i \times \text{HighRE}_i$		-0.283***		-0.517***
		(0.051)		(0.053)
$\text{Post}_t \times \text{MidRE}_i/\text{HighRE}_i$	Y	Y	Y	Y
Exposure	N	N	N	N
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Within-R^2	0.016	0.017	0.016	0.018
Obs.	45,770	45,770	45,770	45,770

Panel D: Effect of treatment on risk exposure

	Maturity gap		Duration gap		FX exposure	
$\text{Post}_t \times \text{Treated}_i$	0.025	0.024	-0.009	-0.003	0.059	0.060
	(0.028)	(0.027)	(0.030)	(0.031)	(0.075)	(0.075)
$\text{Post}_t \times \text{Treated}_i \times \text{MidRE}_i$		0.013		-0.013		0.055
		(0.015)		(0.033)		(0.066)
$\text{Post}_t \times \text{Treated}_i \times \text{HighRE}_i$		-0.018		-0.022		0.019
		(0.021)		(0.034)		(0.020)
$\text{Post}_t \times \text{MidRE}_i/\text{HighRE}_i$	Y	Y	Y	Y	Y	Y
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.019	0.020	0.022	0.026	0.021	0.024
Obs.	45,770	45,770	45,770	45,770	45,770	45,770

Figure B1 – Net interest rate hedging conditional on maturity gap

This figure shows the distribution of the net interest rate hedging position of banks in the first and fourth quartiles of the maturity gap distribution. The bank-level measure of net interest rate hedging is defined in equation (B1). Time frame: 1995Q1-2013Q4.