Within-Bank Transmission of Real Estate Shocks[*]

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Abstract

By considering banks as portfolios of assets in different locations, we study the transmission of negative real estate shocks across bank's business areas and geographical locations while controlling for local demand shocks and bank location–specific factors. Affected banks recognize capital losses and cut lending across the board indicating contagion across business lines and locations. They also roll over and fail to liquidate problematic loans, in addition to reducing their operational costs and depleting their liquidity. These results provide evidence of bank balance sheet transmission and amplification of real estate shocks.

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1 Introduction

Triggered by shocks in the real estate sector, the financial crisis of 2007–2009 was associated with a loss of real output, causing upheavals in the economy. This has renewed academic interest in the transmission of economic shocks by firms across geographic and business areas and, in particular, how banks transmit real estate shocks. Evidence has shown that the reduction in the aggregate credit in the US economy comes mostly from the reduction of bank (or intermediated) credit rather than direct credit (Adrian et al.; 2012). This substitution suggests that banks' credit supply may have been substantially reduced during the crisis (especially for small firms who do not have access to the bond markets) and that banks may thus have played a major role in transmitting and potentially amplifying the shocks coming from the real estate sector.

A relevant challenge when measuring the impact or real estate shocks on banks' policies is to differentiate their direct effect on banks policies from the effects on the demand for bank services. While the literature has offered some solutions to partial-out demand effects, they are in general limited to the estimation of supply effects of homogeneous loans and data limitations often restrict the representativeness of the results. In this paper, we use an alternative approach and focus on identifying the effect of transmission mechanisms via banks' balance sheets from the effect of local demand, while being agnostic about the nature of the initial shocks. Using the geographical coverage of banks, we can consider each bank as a portfolio of real-estate locations; thus we can identify the effect of real estate losses on their lending and balance sheets, while controlling for local conditions in a given point in time.

Our approach implicitly compares the total bank-level effect of a balance sheet shock with the one that would result by adding up the individual local effects. More specifically, we measure how the aggregate exposure of a bank to real estate shocks affects its policies over and above the sum of the local effects predicted by other banks present in the same locations.[1] Using this strategy we find evidence of balance sheet transmission and amplification effects for a broad

[1] We also combine this strategy with a measure of direct real estate holdings in a difference in differences specification.

population of firms (banks) during a long period of time (the real estate crisis). Banks are particularly useful for understanding the geographical transmission of shocks, as a big part of their business is generated locally while facing aggregate constraints on total capital or liquidity. We map out this interbank transmission, not only across geographical regions, but also across banks' business areas and financial policies. We focus explicitly on local real estate shocks, as they provide a measurable and comparable shock across locations and banks.

We first show that, banks report capital losses in line with their exposure to real estate and change their policies according to these capital losses. More interestingly, we find that the aggregate exposure of a bank to real estate shocks affects its policies over and above the sum of the local effects, indicating a contagion across geographic locations and an amplification effect. Especially, when compared to local single-MSA banks, multi-MSA banks that have large negative real estate exposure elsewhere cut down their lending more.[2] This set of results echo the findings in the contagion literature, where portfolio holdings of international investors are shown to be channels via which crisis spreads (Forbes and Rigobon 2002; Boyer, Kumagai, and Yuan 2006; Jotikasthira, Lundblad and Ramadorai 2012).

Moreover, the reduction in lending also spills over across business lines including types of lending that are not directly related to real estate. We also find an interesting pattern that is informative of the portfolio implications for the deleveraging decisions of banks. Across all types of lending, interbank loans (which are relatively liquid) and commercial/industrial loans (which are relatively risky) are disproportionally more affected. This suggests that banks sell the most-liquid assets first (i.e., assets that face less-asymmetric information and are widely held by other banks). They then cut down risk exposure by lowering the holdings of the most-risky assets, consistent with the existing theory and evidence on constrained liquidation (Manconi, Massa and Yasuda 2012; Ben-David, Franzoni, and Moussawi 2012; Brown, Carlin, and Lobo 2010).

Additionally, we also find effects on the treatment of existing loans and the operational

[2] Single-MSA banks, multi-MSA banks are banks that operate only in one Metropolitan Statistical Area (henceforth MSA) or in 2 or more MSAs

decisions of banks. More affected banks: 1) Roll over loans more frequently, recognize less losses and liquidate fewer loans, accumulating more non-performing loans; 2) reduce both their operational and financial expenses, their cash and reserves and downsize their investment in liquid securities. Overall, the results show how banks reduce their operations, search for additional capital and utilize their different sources of liquidity.

Although large banks are likely to spread the effect of real estate shocks across geographical locations and business lines, we find that they cut down their lending less, relative to small banks. This set of results highlights the role played by the banks' internal capital markets, indicating the resiliency of large diversified banks. It resembles the finding of differential reactions of multinationals and local firms to negative exchange rate shocks in Desai, Foley and Forbes (2008). An optimal portfolio management of location and business lines distributes the impact of economic shocks across business lines and locations. This increases the resiliency of individual banks that have diversified operations, but also creates additional channels of contagion that generate real effects beyond a particular sector or region.[3]

To isolate the effect of real estate shocks across locations we use two different identification strategies that consider banks as a portfolio of real estate locations. In our first identification strategy we construct measures of real estate shocks that take into account the different weights that each location represents in the bank's overall business and construct bank-specific real estate price indices that aggregate prices across all the locations in which a bank operates. We then identify the effect of this aggregate bank-specific real-estate shock controlling for the local factors that affect every bank in a given location at a given point in time by saturating the model with time-location fixed effects. These time-location fixed effects aim to control for local business conditions, local loan demands or local credit shocks at a given point in time. Moreover, through a second set of bank-location fixed effects we also control for any time-invariant

[3] Similar contagion channels are shown in the hedge fund industry. Lo (2007) finds the margin constraints of multi-strategy hedge funds spread the negative shock in the single strategy hedge funds (e.g., in the area of subprime credit) across the hedge fund industries, causing the quant fund-wide crisis in August 2007.

conditions of each bank in each of its locations of operation. These include, importantly, the bank's size and reputation, its areas of specialization and the customer composition specific to each bank in each of its geographical areas of operation.

This first strategy thus aims to establish the general impact of real estate shocks via banks' balance sheet by checking if the aggregate real estate prices that a bank is exposed to have an effect beyond the sum of the local effects in each location. Some policies, like lending, are likely to be partially determined locally; in these cases, finding an effect beyond the sum of the local parts indicates an amplification effect and is a sufficient condition for some degree of contagion across geographical areas. The strategy is also applicable to other policies that are harder to disaggregate locally such as bank capital or equity issuance. For these, the results cannot be interpreted as contagion, but still suggest an amplification effect that operates when banks suffer correlated shocks across geographical areas.

Our second identification strategy investigates this effect further by introducing two refinements. First, we use the banks' own holdings of real estate assets in the form of property plant and equipment (PP&E). The distribution of PP&E across banks is a result of different forces to the specific business locations chosen by the bank, and is largely historically determined. Even if PP&E is not the main source of banks' exposure to real estate prices, it still constitutes a sizable source of exposure, and it provides a clean cross sectional source of variation. This allows for an identification strategy that is akin to a difference-in-difference estimation in which two treatment variables interact. The first difference is determined but the bank-specific real estate shocks and the second difference is determines by the bank's cross sectional exposure to real estate shocks via PP&E. Second, following Saiz (2010) we replace the actual variation in real estate prices with a predicted measure that uses only countrywide real estate price changes and local land supply price elasticities. This alternative measure of real estate price shocks is immune to reverse causality considerations. A consistent result across both specifications is useful to rule out some form of spurious correlation between the particular location structure of US banks and the distribution of real estate shocks during the period of interest.

Overall, this paper contributes in several ways to a growing body of literature on the transmission of shocks through bank balance sheets. First, we identify the transmission of real estate shocks by the population of banks in the US during a crisis, thus achieving a good balance between estimating a causal effect and applying it to a broad population of firms. Second, although the effect of negative real estate shocks on banks is a recurrent macroeconomic issue, it is relatively unexplored by scholars at the bank level, and this paper contributes to fill that gap.[4] Third, we simultaneously explore the effects on bank capital and the reactions in lending and financing decisions. Fourth, we document substantial contagion across business areas and geographical locations within banks. This transmission, which is likely to operate through the depletion of a bank's capital and the recognition of losses, has important implications for the overall transmission of shocks in the US economy. Finally, some of our results suggest that banks buy time and obfuscate their losses by managing their problematic loans. More affected banks are more likely to accumulate non-performing loans and, in relative terms, are less likely to liquidate them and recognize losses.

The paper is organized as follows. In Section 2, we discuss the related literature. Section 3 presents the data, and we discuss the empirical strategy in Section 4. We present the results in Section 5 and conclude in Section 6.

2 Related Literature

At a broad level, our paper is related to the macro literature that shows how shocks to the financial system affect the credit supply (Peek and Rosengren (1997), Kashyap et al. (1993), Kashyap and Stein (2000), among others).[5] Recently, Adrian et al. (2013) showed that during the 2007–2009 crisis, there was a sharp contraction in the supply of intermediated credit through

[4] See, Gan (2007) for a related analysis of the Japanese experience in the 1990s or Puri et al. (2011) for Germany during the current crisis.

[5] The literature also argues that adverse shocks may operate through the demand of credit by affecting borrower net worth and the collateral value of assets (Bernanke and Gertler (1989); Kiyotaki and Moore (1997)). Studies such as Ashcraft and Campello (2007) have also shown that there is a firm balance-sheet channel of monetary policy.

banks that contrasts with the inelastic demand for credit from firms. The shortfall is made up of direct credit, such as bond financing, indicating that financial frictions operate mainly through the credit supply. This raises the question as to whether a dollar of credit through the banking system behaves differently from a dollar of direct credit. Our paper contributes to the existing understanding of the sharp reduction of intermediated credits by revealing how intermediaries such as banks react to adverse shocks and how the various constraints they are facing affect their responses.

At the micro level, our paper is closely related to the literature that studies how shocks to banks affect the lending relationship between banks and their borrowers, i.e., firms—specifically, the amount and terms of lending (Gan (2007); Paravisini (2008); Khwaja and Mian (2013); Jimenez et al. (2012), Iyer at al. (2014)). This prior literature relies on within-firm estimators to eliminate the effects of credit demand. Instead, we use the geographical reach of banks as a rich source of variation that allows us to control for demand-side effects.[6] The within-firm approach has the appeal of dealing easily with the correlation between firm demand and bank characteristics. This requires that demand and other selection effects effects are constant and additive within firm and across banks. Conversely, the within-bank approach has the drawback that it cannot be used for bank policies other than lending. In particular, any aggregate policy of the bank cannot be identified with a firm. We provide complementary evidence to this literature by showing how banks cope with adverse shocks to their capital by implementing a menu of policy changes that go beyond lending, including financial and commercial policies. Relative to these two previous streams of the literature, our approach allows us to document the transmission of real estate shocks on the full population of US banks for a broad period of years.

Our analysis follows research studying how real estate shocks affect capital structure choice (Cvijanović, 2014) and real investment (Chaney et al., 2012) at the firm level. Unlike firms, banks are highly leveraged. We show that in addition to affecting their lending decisions, banks

[6] Drechsler et al. (2015) also use the geographical reach of banks as a source of variation to identify how bank competition affects the deposit rates of bank branches in response to monetary shocks.

also reduce their operational costs, cut down cash reserves and issue more equity to cope with the shocks.

Our paper joins the recent emerging literature on the extent of the effect of real estate shocks on intermediated credit. Chakraborty et al. (2013) focusing on the period 1988 through 2006, study the effect of housing prices in a given state on commercial lending in other states at a bank level. In contrast with our results for years with decreasing housing prices, they look at the period of rising house prices, which ended in 2006, and they find evidence of substitution of some banks' lines of business in response to house price increases. The other studies in this area attempt to discover how securitization affects the response of the banking industry to the shocks (Ramcharan et al., 2013 among others) and how home equity-based financing contributes to household leverage and defaults (Mian and Sufi, 2011). We instead attempt to quantify the impact of direct real estate shocks on bank policies.

Our paper is also related to the literature on the deleveraging decisions of a distressed portfolio investor. This literature is mostly motivated by the liquidity crises of 1998, starting with Scholes's presidential address at AFA (2000). It was observed that at the onset of the crisis, investors who were either facing margin constraints or regulatory constraints needed to offload assets in the portfolio to raise liquidity ratios. Empirical investigation reveals that mutual funds—and particularly hedge funds—tend to sell off liquidity assets first, and more so for those funds who face constraints that are more binding (Manconi, Massa and Yasuda 2012; Ben-David, Franzoni, and Moussawi 2012). Brown, Carlin, and Lobo (2010) study the deleveraging issue theoretically and find that the distressed investors have to make a further trade-off. That is, if the distress shock has a permanent component, distressed investors might sell off some of the illiquid assets as well so that their portfolio faces less of an impact from the liquidity downward spiral when further distress shocks strike. Empirically, this means that distressed investors might sell off liquid assets first to fend off the initial round of negative shocks. When shocks become permanent, they sell off more illiquid assets to limit the illiquidity exposure of their portfolio. Our results are informative of the portfolio implications for the deleveraging decisions of banks.

One direct implication is that banks tend to liquidate assets that are most liquid, i.e., assets that face less-asymmetric information and are widely held by other banks.

3 Data

We collect bank balance sheet data from the Federal Reserve's Report of Condition and Income ("Call Reports"). Our sample consists of quarterly data on all deposit-insured commercial banks. We include only bank-quarter observations with non-missing information on total assets, total loans, and equity. The data cover the period spanning from the last quarter of 2005 to the last quarter of 2010, giving a total of 98,497 observations covering 2,435 banks. Our dataset contains detailed information from the Schedule RC – Balance Sheet on loans and leases (total loans, C&I loans, real estate loans, consumer loans, etc.), cash and balances due from depository institutions, securities, trading assets and liabilities, deposits in domestic offices, deposits in foreign offices, other assets and liabilities, derivatives and off-balance sheet items. The data also contain information about certain flow variables related to problematic loans, such as loss recognitions, loans declared non-performing and recoveries.

Information about the geographical distribution of bank deposits is obtained from the Federal Deposit Insurance Corporation (FDIC).[7] House prices are obtained from the Federal Housing Finance Agency (FHFA) and are calculated at the level of a Core Based Statistical Area (CBSA).[8] The data contain a CBSA-level house-price index for 369 CBSAs. We obtain MSA-level land supply elasticities from Saiz (2010). Elasticities are available for 269 Metropolitan Statistical Areas (MSAs) in our sample. The MSA-level elasticities are then converted to the new CBSA definitions by employing a zip-code matching procedure.

As an alternative data source for the geographical distribution of bank loans, we use the relatively new data on small business loan originations collected under the auspices of the Community Reinvestment Act (CRA). Since 1996, larger banks have been required to report the

[7] More specifically, we obtain the data from the Summary of Deposits. FDIC reports data on total deposits, location and ownership of all bank branches from 1994 onward (see http://www2.fdic.gov/sod/).
[8] A CBSA is a geographic area defined by the Office of Management and Budget (OMB). It is based around an urban center of at least 10,000 people and adjacent areas. CBSAs largely overlap with Metropolitan Statistical Areas (MSA), also defined by the OMB.

number and amount of their (calendar-year) small business loan originations by census tract.[9] Banks and thrifts report small business and farm data and community development data if they have total assets greater than $1 billion dollars (asset level adjusted annually for inflation starting in 2005). Prior to 2005, institutions with asset levels above $250 million were required to report these data. Small business loans are defined as loans in amounts of $1 million or less. Small farm loans are defined as loans in amounts of $500,000 or less. We merge the CRA small business loans data with our sample by hand matching the Respondent IDs from the CRA data with the Bank IDs.

Summary statistics for the bank balance sheet data are shown in Table 1 (Panels A, B and C). Table 1 Panel D contains summary statistics on house prices and land supply elasticities, while Panel E contains the details of our sample banks' geographical dispersion.

The characteristics of our sample are in line with other papers that use the Call Reports as the main source of data. The mean bank in our sample had $107 billion in total assets in the last quarter of 2005, with $57 billion in total loans (corresponding to 67% of total assets). The median bank had $724 million in total assets, with $495 million in total loans (corresponding to 70% of total assets). The mean total equity capital to total assets ratio is almost 11% (with the median being 9.5%). The average tier 1 capital ratio is 9.2%, with a median of 8.1%. Real estate loans as a fraction of total assets average 46.3% in our sample, with a median of 47.1%. Property, plant and equipment constitute 1.7% of total assets on average.

As shown in Panel D, the CBSA-level land supply inelasticities range from 1 (least inelastic – Indianapolis) to 4.40 (most inelastic – Miami). Here, we define land supply inelasticity e_m as [1+max(elasticity.) - elasticity_m], where elasticity_m is obtained from Saiz (2010). The national real estate price indices obscure the variation in the regional/CBSA real estate market conditions. In the period between the first quarter of 2006 and the end of the sample in the last quarter of 2010, the highest drop in local house prices was witnessed in San Diego (-48% over the five-year period). Over the same period, house prices in Portland fell by a mere 1.95%. Figure 1 shows the

[9] Available from http://www.ffiec.gov/Cra/craproducts.htm.

aggregate change in house prices for all CBSAs in the sample throughout the whole period. The figure shows quite a lot of variation across regions. During this same period, the Case-Schiller US House Price index recorded a drop of 31% in the national house price levels.

As shown in Panel E, there are 1,968 single-MSA banks and 487 multi-MSA banks in our sample, giving 40,595 (57,902, respectively) bank-MSA-quarter observations. Conditional on operating in more than one MSA, the median number of MSAs in which a bank operates is 17.

4 Empirical Strategy

We aim to explain the effect of losses induced by decreasing real estate prices on bank policies. The challenge is to isolate the effect of such losses from other mechanisms, particularly from local demand factors, while maintaining the broad applicability of our results. In particular, our object of study is the whole of the US banking sector during the 2006–2010 period, which coincides with the period of unprecedented slump in real estate prices in the U.S.

The empirical strategy considers banks as conglomerates of local branches, in which the branches in each location operate as a division. Each branch is influenced by shocks that affect the bank as a whole and shocks that affect the specific location in which the branch operates.[10] However, given that multiple banks have branches in a given location, we can partial out the local shocks that homogeneously affect all banks in a given location in an additive way.

The first step of our identification strategy is to construct a bank-specific real estate price index. This is an aggregate price index across all the locations in which a bank operates. To do so, we use static weights w_{mi0} for each bank (i) - location (m) combination, according to the relative weight at the beginning of the sample, using deposits of a bank in a given location (CBSA). The weight w_{mi0} is constructed as the fraction of deposits of a bank i in location m with respect to the total deposits of the bank at $t = 0$ (we use the fourth quarter of 2005, one quarter before our estimation sample starts).[11] The *bank specific aggregate* price index $House\ Prices_{it}$ is

[10] Note that our definition of a branch is a bank-location pair, and it may include different bank offices (that are also commonly known as branches) that operate in a given location.

[11] The results are robust to using number of offices as the source of the static bank weights.

the weighted average of the real estate prices P_{mt} for each quarter t of each of the locations m in which the bank is located: $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$, and it measures the real estate price that affect a *given bank* in a *given quarter* across *all the locations* in which it operates.[12]

We consider outcome variables y_{mit}, which are bank policies (e.g. lending, equity issuance, etc.) and balance sheet items (e.g. tier 1 and tier 2 capital, etc.) defined at a bank-location-quarter level.[13] The variable may be a direct panel data variable disaggregated at a bank-location level (as in the case of the CRA small business loans variables) or it may be created as the product of an outcome variable y_{it} defined for a bank i at time t (quarter) and a time-varying bank-location weight, w_{mit}. For example, y_{mit} may represent the loans outstanding of bank i in period t in location m or any other outcome variable. The weight w_{mit} is constructed as the current fraction of deposits of bank i in location m with respect to the total deposits of the bank.[14] If the outcome variables are, on average, proportional to the deposit activity of the bank, then $y_{it} w_{mit}$ is a proxy of the dependent variable of the bank in a given location at a given point in time y_{mit}. All the estimations are then performed at the bank-location-quarter level and standard errors are clustered at a bank level.

Note that, for some of the dependent variables (such as capital), using deposit weights is just a meaningful way to allocate capital proportional to the bank's activity and check whether the aggregate effect differs from the sum of its parts. For some other variables, such as lending, there is also a local level of lending that we only observe for small business loans. It is not necessarily the case that deposit and lending activity coincide at a local level. However, it is enough to achieve consistent estimates that the deposit weights are an unbiased measure of lending activity, that is, that they do not systematically overstate or understate lending activity. We show further evidence of this lack of bias in the Appendix. Our results are robust to using the CRA database

[12] The measure uses cross-sectional weights determined at $t = 0$ (fourth quarter of 2005) to avoid introducing endogeneity via the weighting procedure.

[13] This analysis involves three sources of data. Bank-level data from CALL reports with a quarterly frequency. Information about real estate prices (quarterly) and price elasticities (cross-sectional). To construct bank weights we use deposits and the number of offices for each location obtained from the FDIC.

[14] In the Appendix we show that the results are robust to using alternative weights based on the number of offices or the amount of small business loans given.

small business lending weights, as well as to employing a bank's number of offices in each location in the weights construction procedure.

We use this independent variable in two specifications. The first one is a log specification. The second one is a level specification with an additional cross-sectional interaction that measures the amount of property plant and equipment (PP&E) in the bank's balance sheet. In this second specification, we also replace the actual real estate prices by a prediction that only uses aggregate nationwide shocks and cross sectional geographical measures. Both specifications are saturated with time-location fixed effects and location-bank fixed effects.

Specification 1: Banks as portfolios of locations

A first specification of our regressions can then be written as:

$$\log(y_{mit}) = \alpha + \beta_1 \log(House\ Prices_{it}) + \delta_{mt} + \gamma_{mi} + \varepsilon_{mit} \quad (1)$$

The natural logarithm of the dependent variable y_{mit} (e.g., loans in a given location) is regressed against the bank-specific aggregate real estate price. [15]

The term δ_{mt} represents a collection of time-location-specific dummy variables that should capture any unobserved heterogeneity that affects a given location in a given quarter. The main advantage of considering banks as portfolios of locations is that multi-location banks allow us to estimate the effect of real-estate shocks over and above the local effects captured by δ_{mt}. In particular, these dummies should absorb any location-specific demand fluctuations. Note that the set of δ_{mt} associated with a given location also has the implicit role of a location fixed effect. This implies that β_1 is only identified by those banks that operate in more than one location. However, we include all banks in the specification, as single-location banks improve the precision in estimating δ_{mt} .

The term γ_{mi} is a bank-location fixed effect. Implicit in the specification, we are assuming that there are local effects and bank-specific effects that are proportional to all branches of a location

[15] Note that the specification in (1) can be interpreted as the reduced form of an IV specification in which price exposure is calculated using running weights and then instrumented with a price variable that uses fixed cross-sectional weights.

or a bank, respectively. Balance-sheet fixed effects are assumed to be proportional to the relative exposure of each bank to each location. Note that the set of γ_{mi} associated with a given bank also has the implicit role of a bank fixed effect.

Given that the specification is in natural logs; the term β_1 measures the elasticity of the dependent variable (capital, different forms of lending, equity issuance and others) to real estate shocks, over and beyond location-time-specific and bank-specific effects. In interpreting the magnitude of the effects captured by β_1, one needs to take into account that it measures the effect above and beyond the individual impact in each of the locations in which a bank operates. For example, in regard to capital losses, it is expected that the aggregate capital loss that a bank reports is close to the sum of the capital losses across each individual location, so β_1 should be close to zero. However, in regard to lending, the aggregate real estate losses of a bank affect its local lending beyond the local lending conditions, so we expect β_1 to be positive. In essence, we can interpret the coefficient β_1 as measuring the relation between aggregate bank-specific real estate prices and the part of the dependent variable unexplained by local-time-varying conditions and pure cross-sectional (bank-MSA) conditions. Furthermore, one can interpret β_1 as the difference in lending (or other dependent variables) of two banks that operate in the same location but have different exposures to other locations. A significant β_1 coefficient indicates that bank reacts beyond what the sum of individual shocks and responses would predict and it is indicative of an amplification mechanism and a sufficient condition for some form of geographical contagion.

Specification 2: Adding Cross-Sectional Exposures and Exogenous Price Shocks

A second set of specifications interacts the real estate shock variable with a cross-sectional measure of the bank's exposure to it, while controlling for the general impact of real estate shocks on all banks. This second set of regressions can be interpreted as a difference-in-differences specification that compares banks across different real estate shocks (determined by their geographical presence) and different individual exposures to them (determined by their real estate ownership). That is, the effect is identified by comparing the different reaction of banks with more or less balance sheet exposure to real estate across different levels of real estate price shocks. The measure of balance sheet exposure to real estate shocks is related to the direct holdings of productive real estate by banks. The measure of individual real estate shocks is the same one used in the previous specification. This second specification is robust to omitted variables that are simultaneously correlated with the bank's choice of the portfolio of locations and the outcome variable y_{mit}, such as some forms of time-varying matching between lenders and borrowers.

As a measure of real estate exposure, we use the fraction of property, plant and equipment (PP&E) over total assets before the beginning of the estimation sample (PP&E/Total Assets in 2005Q4). Most of the banks' PP&E of is composed of real estate holdings in the form of offices. This directly exposes banks to real estate fluctuations through their holdings.[16] There are two characteristics that make PP&E appealing from an empirical point of view. First, although PP&E holdings account for a low fraction of bank assets (1.7% on average), they represent a substantial exposure to real estate shocks. For example, the average decrease in real estate prices in our sample throughout the whole period (2006Q1-2010Q4) is 35%, which would entail average economic capital losses of 0.6%. Given that regulatory capital in our sample is, on average, 9.2%, this implies a reduction in capital of approximately 6 percentage points. Second, PP&E varies quite a lot across banks for historical reasons or for strategic reasons unrelated to bank lending policies. PP&E over assets has a within-sample standard deviation of 1.7%, so banks are heterogeneously exposed to real estate through their PP&E for exogenous reasons, which helps identify the effects.

Consider $House\ Prices_{it}PP\&E_{i0}$ as a dollar measure of the impact of real estate prices on a bank's balance sheet through its PP&E holdings; where $House\ Prices_{it}$ measures the aggregate bank-level real estate price index as in the previous specification and $PP\&E_{i0}$ measures the dollar

[16] PP&E is normally reflected in bank balance sheets at historical values. Banks are required to provision losses if the value of PP&E goes below its historical value. They also realize capital gains/losses when they sell their properties. Finally, the value of PP&E is implicitly taken into account whenever banks merge or go bankrupt.

value of the property plant and equipment of the bank at the beginning of the sample.[17] It is useful to re-write this measure as $House\ Prices_{it}Exp_{i0}Assets_{i0}$, where Exp_{i0} measures the fraction of PP&E in the bank's assets at the beginning of the sample (PP&E$_{i0}$/Assets$_{i0}$). This measure depends on the size of the bank, so, to capture the effect of Exp_{i0} it is essential that we add as a control variable the general dollar exposure of a bank to real estate prices $House\ Prices_{it}Assets_{i0}$. To make them comparable with the dependent variable, we re-scale both variables using the relative weight of each location w_{mi0} . Note that the variable of interest $House\ Prices_{it}Exp_{i0}Assets_{i0}$ is composed of the interaction between the firm-specific real estate shock expressed in dollars $House\ Prices_{it}Assets_{i0}$ and a cross-sectional exposure measure of the balance sheet exposure of the bank Exp_{i0}. Therefore the difference-in-differences structure is completed by including $House\ Prices_{it}Assets_{i0}$ in the regression and bank-location dummies that absorb the influence of Exp_{i0}.

Therefore, the second specification takes the form:

$$y_{mit} = \alpha + \beta_1 House\ Prices_{it}Assets_{i0}w_{mi0} + \beta_2 House\ Prices_{it}Exp_{i0}Assets_{i0}w_{mi0} + \delta_{mt} + \gamma_{mi} + \varepsilon_{mit} \quad (2)$$

Again, we saturate the model using location-time dummies δ_{mt} and bank-location dummies γ_{mi} and they have the same interpretation and in the first specification. This allows for estimating the effects at a bank-location-quarter level. Given that there are interactions with variables determined cross-sectionally at a bank level, this second specification is run in levels (dollars) and not logs.

The main coefficient of interest is β_2, which measures the differential impact of real estate prices for two banks that experience similar real estate price fluctuations in their portfolio of assets (i.e., the same $House\ Prices_{it}Assets_{i0}w_{mi0}$), but have different levels of exposure to real estate prices in their balance sheet. The term $House\ Prices_{it}Assets_{i0}w_{mi0}$ controls for the effect

[17] A running exposure Exp_{it} would have the advantage of tracking the exposure of the bank more closely throughout the sample. However, Exp_{it} could be determined endogenously and induce biases in the estimation. Instead, we opt for a fixed Exp_{i0}, which may be a more imprecise proxy (especially for the later years of the sample), but it has the advantage of being predetermined. A similar argument can be made about the bank-location weights w_{mio} that are determined at the beginning of the sample and kept constant.

the general price fluctuations may have on the bank's policies, and as such it is an implicit control for bank size. In particular, it captures any bank-specific demand factors that are correlated with real estate price fluctuations and that affect the bank as a whole. It also captures any supply factors that are correlated with prices and affect all banks simultaneously, for example, a generalized decrease in the creditworthiness of the borrowers when the real estate prices drop.

We introduce a further modification in this last specification. We use an alternative measure of local real estate price variation. In this specification, we replace the actual real estate prices P_{jt} with predicted prices in regressions that use the product of local real estate price elasticities and the aggregate countrywide variation in prices. The real estate elasticities are constructed based on cross-sectional geographical data from Saiz (2010), so the predicted price, once we control for aggregate time effects, is not affected by the lending of banks in that particular region. Following Mian and Sufi (2010), Chaney et al. (2012) and Cvijanović (2014), to obtain an exogenous source of variation in local real estate prices, we use a measure of land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index) as our instrument for local MSA-level real estate prices.

The intuition for this instrument is straightforward: MSAs with elastic land supply should experience small real estate price appreciation in response to increases in aggregate real estate demand (as proxied by the aggregate real estate prices), since land supply is relatively easy to expand. On the other hand, inelastic land supply MSAs should witness large real estate price appreciation in response to the same aggregate real estate demand shock (Glaeser, et. al, 2008). [18] [19]As a result, the predicted real estate prices are highly correlated with the actual prices. However, as they are constructed by interacting a pure cross-sectional and a pure time-series variable, they are not driven by temporary location-specific shocks or by the feedback from local lending to real estate prices. For this same reason, we estimate this second specification in levels, as a log

[18] Two main factors restrict land supply. First, there may be topological constraints that impede real estate construction, such as steepness of terrain or presence of water bodies. Two, regulation plays an important role in restricting land development and new construction. Environmental regulation, urban planning, and zoning are just a few issues that restrict the amount of land supply.

[19] Glaeser et al. (2008) and Hilber and Vermeulen (2014) also provide evidence that the level of mean-reversion in house prices was enormous in highly inelastic places during the 1989–1996 period in the U.S., that is during 1974–1977, 1981–1982, 1990–1996 and in 2008 in the UK, thus providing further justification for using the instrument.

structure with time-location and bank-location fixed effects would absorb all the relevant variation.

Note that some of our dependent variables, such as Tier 1 capital, are not explicitly allocated to any location. In these cases, our identification strategy is similar to one with observations at the bank level in which we introduce fractional dummies according to the bank location weights and their interaction with year dummies. Our approach is, however, computationally more efficient.[20] The effect measured is the effect of prices when the bank is considered a portfolio of locations, net of the individual local effects estimated using the whole population of banks.

The specification in Equation (1) would have a similar interpretation as some of the conglomerates literature that estimates the reaction of one division to exogenous shocks to another division (see, for example, Lamont and Polk (2002); and Chang and Dasgupta (2007), among others). More closely related is the work by Murfin (2012), Gilje et al (2016) and Chakraborty et al. (2013), who also isolate the effects of shocks in a given location on bank outcomes in other locations.[21] By adding a further interaction with the level of cross-sectional exposure of the bank to real estate shocks in Equation (2), the effect is identified by banks with the same aggregate shocks but with different exposure to them.

5 Results

We examine the differential impact of real estate prices on a variety of bank policies and outcomes. To do this, we follow the empirical strategy described in the previous section involving two sets of specifications. The first set of specifications (as shown in Equation (1)) is based on estimating the differential elasticities of bank policies to real estate prices of two banks operating in the same location but with different exposure to other locations. The second specification, in levels, uses the real-estate price measure interacted with the exposure of each

[20] In particular, estimating the effect using the aggregate variables and fractional dummies would require introducing 7380 fractional dummies (369 locations times 20 quarters). These dummies are non-nested and cannot be replicated with a combination of bank and location fixed effects, so they would have to be estimated explicitly.

[21] More specifically, Murfin (2012) focuses on unexpected liquidity shocks, Gilje et. al. on oil and natural gas shale discoveries and Chakraborty et al. (2013) on the rise in real estate prices during the housing bubble. Our identification strategy can also be seen as the mirror image of that in Ashcraft and Campello (2007). While they aim to isolate local effects, controlling for bank-aggregate effects, our objective is exactly the opposite.

bank to the real estate market (PP&E) in dollars (see Equation (2)). This identification is, therefore, based on two otherwise identical banks that operate in the same location and have portfolios of locations with a similar overall real estate price shock but different exposure to the real estate market in their balance sheets. In this way, we control for potential time-varying selection effects within the same location, and we are able to generate a more precise bank-time-location estimate of the effect.

The following sections are organized as follows. In Section 5.1, we focus on the overall effects of real estate prices on capital. Section 5.2 focuses on total lending as well as lending to small businesses, where for the latter variable, we have an exact geographical identification down to the census tract level. Section 5.3 studies the disaggregated effects on different types of loans, showing how banks adjust their portfolio of loans. Section 5.4 discusses how banks address problematic loans when faced with a real-estate-induced loss. In Section 5.5, we explore how real estate losses are transmitted to a bank's other business areas, and in Section 5.6, we explore the cross-sectional heterogeneity in banks' responses to real estate market shocks in terms of their size.

5.1 Capital

In this section, we explore the effect of real estate shocks on bank's capital and total lending using the two different specifications. Panel A of Table 2 shows the results of a log specification that measures elasticities (see Equation (1)), while Panel B shows a specification in levels in which the exposure of banks to real estate loans is measured using their property plant and equipment (PP&E) and with instrumented real estate prices (along the lines of Equation (2)).

In Column 1 and 2 of panel A, the point estimates indicate that that a 10% reduction in real estate prices reduces, on average, Tier 1 capital by 1.4% relative to itself. This is a modest reduction in capital, and it is not statistically significant. This is an interesting result. The coefficient on $\log(House\ Prices_{it})$ in specification 1 can be interpreted as the effect of the aggregate bank-specific real estate shock over and above what the individual local effects predict. The result show that the sum of the local capital losses is a good predictor of the aggregate capital reduction reported by the bank. There is no evidence of capital savings through diversification across geographical regions (that would imply a negative coefficient on $\log(House\ Prices_{it})$, nor a strong sign of an amplification effect, given the small point estimate and the lack of statistical significance. This is an intuitive result, as capital losses are likely to be additive. If a bank recognizes a capital loss in one location, it does not affect the way in which the bank needs to calculate capital losses in a different location. Similarly, the effects on Tier 2 capital are not significant in this first panel.

The results in Panel B show capital losses across banks with different levels of real estate ownership. The estimation captures the fact that banks with more PP&E in their balance sheet should recognize higher capital losses when facing real estate shocks. This is because the PP&E exposure measure generates cross-sectional heterogeneity that is not captured by the location composition of a bank. The resulting coefficients are positive and significant for both Tier 1 and Tier 2 capital. As expected, banks with a higher cross-sectional exposure to real-estate prices recognize a larger fraction of capital losses. The quantitative impact of the effect can be interpreted as 3 cents of Tier 1 capital depleted per dollar of real estate losses, although, again, these have to be interpreted as over and above the common losses that other banks in the same MSA report. This second set of results is important to validate the use of property plant and equipment as a useful measure of real estate exposure. Although the direct economic impact of real estate prices on the creditworthiness of a bank via its real estate holdings is mechanical, it is also important to establish whether banks are able to offset this impact and whether they actually recognize it from an accounting point of view. Comparing two banks with the same real estate shock, the one with a higher exposure to property plant and equipment recognizes higher losses. These may be due to realized capital gains when real estate is sold or to loss recognition when the value of real estate assets is below its historical purchase value.

Overall, this section presents several preliminary results for the rest of the paper. First, overall capital losses of banks seem to be aligned with what the local effects predict. However, banks with a higher exposure to real estate shocks through their property plant and equipment do recognize higher losses than those less exposed.

5.2 Total Loans

Following the previous evidence regarding the significant capital losses banks experienced during the real estate market collapse, we next examine the effects on banks' overall lending policies. Namely, we estimate the effect of real estate market spillovers on bank "branch" lending. Column 3 in Panel A of Table 2 shows the results with respect to total lending. A positive coefficient indicates a reduction in total lending when real-estate prices drop over and above the sum of the MSA-quarter effects predicted by other banks. The effect is statistically significant; an additional 10% drop in the portfolio of real estate locations of a bank reduces the flow of small business loans by 7% over and above the local reduction by other banks. This indicates that there is an overall balance sheet transmission mechanism of real estate shocks in our sample. It is important to establish the existence of this transmission for the particular shock and channel in this paper before approaching a more detailed analysis of the transmission across business lines.

In Column 3 of Panel B of Table 2 we report the results regarding total lending for the difference in differences specification. They also show that banks that are more exposed to real estate shocks through their own real estate ownership also cut loans more intensely[22].

To further establish the validity of the proposed channel, we explore the effect of real estate prices on small business loans. This is shown in Columns 4 and 5 of Table 2. The dependent variables in these specifications are obtained from the CRA database and are measured directly at a local level rather than constructed using dynamic weights. The results using this alternative source of data are also positive and significant and are very consistent with the results that use an

[22] During the 2006-10 period, there has been a significant M&A activity in the banking sector. There were also more than 300 bank failures during this time. To address the concern that not including bank failures might underestimate our results, we estimate our main specifications while dropping the bank*MSA fixed effects, as if every bank was re-born every period. As it can be seen from the Appendix, our results remain unchanged.

imputed dependent variable using deposit weights. The effect is, in fact, larger in terms of elasticities than for the total loans variable. A reduction of 10% in real estate prices implies a reduction in small business loans of 7% relative to themselves. This result is important to validate the rest of the analysis in the paper, as it establishes that there is geographical contagion across regions in bank lending. This is a sustained assumption throughout the rest of the paper.

Summing up, this section shows that total lending is reduced due to aggregate real estate losses over and above the local effects that affect all banks. This is suggestive of contagion across geographical regions, but we also check this contagion using data on small business loans. Finally the loan reduction is more intense for those banks more exposed via their PP&E holdings.

5.3 Loan Portfolio

In the previous section, we showed evidence of significant bank capital depletion and a drop in lending that ensued when the real estate market collapsed. In the following few paragraphs, we investigate whether this effect was felt across different types of loans. This is an important objective, as it would indicate a form of transmission of real estate shocks across business areas that occurs through the balance sheet of banks.

Table 3 shows disaggregated results for different types of loans. By looking at the results presented in Panel A, we can see that the real estate market collapse had a ripple effect on various types of lending at the bank "branch" level. We decompose total lending into Real Estate Loans, Loans to Depositors, Agricultural Loans, Commercial and Industrial Loans, Foreign Loans, Obligations, Loans to non-Depositors and Leases. These are mutually exclusive categories used in the CALL reports that together comprise the total loans variable.

The results show that banks reduce their lending across different types of loans, although the effects are not homogeneous across all categories. In the log specification, the riskier forms of lending (unsecured loans to depositors and commercial loans) are the most affected. A reduction of real estate prices of 10% implies a reduction of loans to depositors of 10% and a reduction in commercial loans of 7%. Real estate loans are also affected, but to a lower extent, with a reduction of 3% associated with a 10% reduction in real estate prices. Other loan categories, such as agricultural loans or loans to foreign institutions, have large positive point estimates but are not statistically significant. Optimally downsizing a portfolio of loans involves taking into account transaction costs and the reversibility and price elasticities of the different types of loans among other variables. The fact that some lending categories are being cut more severely than real estate loans as a result of a real estate shock reflects the results of this optimization.

The results in Panel B are largely consistent with the previous results. In overall dollar terms, real estate loans are the most affected category, followed by commercial and industrial loans and individual loans. However, the relative size of each of these categories in the balance sheet of banks is not homogeneous, so one needs to rescale the effect accordingly (see Panel C in Table 1). In relative terms, commercial and industrial loans and loans to depositors are again the most affected. Loans to non-depositors are also highly affected, in relative terms, in this second specification.

These results draw a picture of how economic shocks are transmitted through the banking system back to the real economy. By construction, our paper establishes the contagion of shocks across geographical locations via banks; this is at the heart of our identification strategy. This section also indicates a channel of contagion within the different business areas of a bank.[23] Given that we measure the real estate shocks at the aggregate bank level, our specifications allow for the real estate shocks to be transmitted from one bank location to another. The results shown in Table 3 indicate that there is both a geographical transmission effect and a contagion of the real estate shock from one banking business area (i.e., real estate) to another (i.e., loans to other depository institutions, personal loans, commercial and industrial lending or consumer loans). Using log specification, we find the positive elasticity to real estate shocks across all business areas except for obligations (to state and local government) and loans to non-depository-taking institutions, although the result is statistically significant only for loans to other depository

[23] This result resembles similar effects in the literature of internal capital markets (see, for example, Lamont and Polk (2002) or, more recently, Matvos and Seru (2013)). It also contrasts with the results in Chakraborty et al. (2013), who find a substitution effect across bank business lines during the real estate boom. However, both results are mutually consistent with standard financing constraint models, in which firms are constrained either when their investment opportunities expand beyond their financing capabilities (as in Chakraborty et al. 2013) or when their financing capabilities shrink faster than their investment opportunities (our results). In both situations, non-real estate loans are expected to shrink.

institutions (i.e., interbank loans) and commercial and industrial loans (Table 3, Panel A). However, when banks' exposure to real estate shocks is instrumented using their direct of real estate holdings (Table 3, Panel B), we find that the magnitude of this spillover effect is uniformly statistically significant across all business areas. To gauge the economic significance, we compare the magnitude of estimated coefficients with the fraction of the corresponding business area (Table 1, Panel C). A consistent pattern appears across all these analyses: deleveraging banks reduce interbank and commercial/industrial lending significantly. The common understanding is that interbank loans are the most liquid and less relationship-based, while commercial/industrial loans are the most risky. This is consistent with the existing literature on constrained financial institutions' investment decisions to sell the most-liquid assets first to raise capital and then cut down risk exposure by lowering the holdings of the most-risky assets.

5.4 Loss Recognition

In this section, we measure how affected banks address problematic loans when they are more affected by real estate losses. While the real economic impact of real estate prices on mortgages is determined by their exposure to real estate and real estate prices, banks may have an incentive to manipulate or time the apparent losses they recognize from an accounting and regulatory point of view. By rolling over loans with dubious prospects of repayment, banks can postpone the recognition of losses from an accounting point of view as well as gamble on the improvement of the loans' repayment chances. Conversely, by foreclosing and liquidating some loans early, banks can provide themselves with additional liquidity. Banks also have some flexibility about which particular loans they liquidate and which ones they keep as non-performing loans in their balance sheets. Table 4 shows the effects on loss recognition, loan recoveries and non-performing loans.

The first results in Columns 1, 2 and 3 of Panel A of Table 4 show how banks that are more affected by real estate prices, do less charge offs and less loan recoveries than what is predicted by the sum of their parts. Overall, the effect on net recoveries is also negative. Moreover, in columns 1 to 7 of Panel B of Table 7, the results show that more affected banks are also having higher levels of non-performing loans. These total non-performing loans are above the sum of the effect predicted by other local banks in the same locations of operation as the multi-location banks. Given that these effects are in addition to the local effects and are related to the overall bank losses, this result indicates that affected banks were postponing the recognition of losses and not tidying up their balance sheet, even in locations in which they were not directly affected. This behavior is similar to the documented "zombie" lending activities of banks during the Japanese banking crisis, as documented by Caballero et al. (2008).

Moreover, as we can see from Panel B, banks particularly increased the total amount of outstanding non-performing loans across different loan categories, such as commercial and industrial non-performing loans (Column 2) and commercial real estate loans (Column 6), indicating that the effort to recognize less losses is done across business lines and is not restricted to new policies relative to mortgage lending. Jointly, these two effects show that more-affected banks are rolling-over more dubious loans instead of pushing for an earlier resolution that would imply recognizing some losses, but doing so would also generate additional liquidity.

The first results in Columns 4, 5 and 6 of Panel A of Table 4 show a slightly different picture. Banks that are more exposed to real estate prices in the cross section, over-react to real estate prices when it comes to loan recoveries and charge-offs. That is, they recover more loans and recognize more losses. As we show in Table 2, these are precisely the banks that suffer higher capital losses. This is consistent with a notion of more capital constrained banks recognizing more losses so as to alleviate uncertainty about their future capital requirements. The results in Panel C are consistent with those in Panel B, showing that more affected banks in the cross-section also have more non-performing loans. Jointly, the results on this second specification provide a mixed picture. While it seems that more affected banks are managing their capital losses more actively, they are also accumulating more non-performing loans. Note that these two results are not mutually exclusive, as banks have some flexibility in determining non-performing loans and on choosing the quality of the loans that they decide to foreclose. In particular, these results would be consistent with more affected banks postponing the liquidation of higher quality loans, but liquidating more actively the lower quality ones.

The evidence in the previous two sections jointly indicates that banks that are more affected by real estate shocks in given locations take actions in their overall business portfolio that allow them to postpone the recognition of losses and the need for additional capital. While we cannot directly observe the impact of these actions on bank profits, it is reasonable to conjecture that some of these policies are efforts to increase liquidity and current cash flows at the expense of future and aggregate discounted profits and that they may destroy value.[24]

5.5 Cost Reductions, Equity Issuance and Liquidity

In the previous sections, we have shown that in response to negative shocks to the value of their productive real estate (and their portfolios of real estate loans), banks experienced substantial capital losses that were followed by a significant cut in their aggregate lending. This shock had a ripple effect on bank business operations that involve the real estate sector, and the shock was transmitted to other banks' business operations. In this section, we explore this effect in terms of potential impact on other aspects of the way banks operate.

Column 1 in Table 5 shows the result on equity issuance. The coefficient is not statistically significant, and the point estimate is economically small in both Panel A and Panel B. This shows that, on average, banks were not able to issue additional equity when they faced real estate losses. However, this average effect does not reflect a certain degree of heterogeneous response, which we explore in the next sections.

Columns 2 to 4 show the results on several measures of operational expenses. The results show that more-affected banks reduce their operational expenses at different levels of aggregation: expenses on premises, interest expenses, and non-interest expenses. The effect is also very large when we pool interest and non-interest expenses, even though the decrease in

[24] See Garicano and Steinwender (2013) for a detailed analysis of similar policies at a firm level.

creditworthiness may increase the cost of borrowing of banks. Although all point estimates in this part of the analysis are consistently positive, only the analysis in Panel B yields statistically significant results throughout. In Panel A, only the coefficient on the pooled interest and non-interest expenses is significantly different from zero at the 10% level.

Columns 5 to 7 show the effects on different liquid assets. The results are not statistically significant in the log specification, but they are positive and significant in the relative exposure specification. Positive coefficients in all of them indicate a reduction in these liquid assets. That is, banks are selling some of their liquid assets to create liquidity that helps them address their real estate losses.

Overall, the results in Table 5 show a general inability of more-affected banks to replenish core capital with the additional issuance of equity. Moreover, more-affected banks reduce their operational costs and deplete their liquidity as part of their effort to address real estate shocks.

5.6 The Case of Large Banks

In this section, we explore the cross-sectional heterogeneity in banks' responses to the real estate market collapse in terms of their size. Given that the top 20 US banks (bank holding companies - BHCs) hold assets equal to 84.5% of the nation's entire economic output, we examine whether the nature of the banks' responses to real estate shocks was driven by their size.

To identify the "mega banks" in our sample, we rank them in Q42005 based on their total assets. The top 99th percentile contains the 20 largest banks (BHCs).[25] For each bank-location combination ("branch"), we then assign a value of 1 for the dummy variable LARGE if its parent holder (BHC) is one of the top 20 BHCs listed above. We interact the variable LARGE with the variables of the specification in (2).

The results are shown in Table 6. Column 1 of Panel B shows the results for tier 1 capital. We can see that the estimated coefficient on the interaction term (β_4) is negative but very small and

[25] These are, in in descending order: JPMorgan Chase & Co, Bank of America Corporation, Citigroup Inc., Wells Fargo & Company, Goldman Sachs Group, Morgan Stanley, US Bancorp, Bank of New York Mellon, HSBC North America Holdings, PNC Financial Services Group, Capital One, TD Bank US Holding Company, State Street Corporation, Ally Financial, BB&T Corporation, Suntrust Banks, Principal Financial Group, American Express Company, Ameriprise Financial and RBS Citizens Financial Group.

not statistically significant. In Column 2, we see a different effect for large banks in terms of tier 2 capital depletion that is only significant in the log specification (Panel A), reducing the impact by 15%.

The specification in Column 3 measures the effect on total lending and shows a slightly different picture. A large negative coefficient indicates that large banks were able to cut loans proportionally less than smaller banks. The effect is 26% of the size of the general effect. This is an interesting result: while the qualitative result is the same for both large and small banks, it seems that the transmission of shocks via lending for large banks is much smaller than for small banks. The smaller overall effect for large banks is important, given the trend toward a more concentrated banking market nationwide. One possible interpretation of the relatively smaller effect on lending for large banks could be that more-affected banks are also ones that are moving away from the originate and distribute mortgage business and are returning to a more traditional *on balance sheet* business. However, the results in Table 3 seem to go against this hypothesis. The relatively lower reduction in lending operates across all business lines and is not restricted to real estate lending.

In Column 3, we explore the differences in equity issuance across bank sizes. The result is both economically and statistically non-significant.

Overall, the results in this section do not show important qualitative differences between large banks and the rest. Quantitatively, large banks exhibit a slightly smaller sensitivity to real estate shocks. These results suggest that the nature of the real estate market price depreciation transmission on bank financing, operating and payout policy decisions was not driven by their relative size differences.

6 Conclusion

We analyze the reaction of banks to capital losses induced by real estate shocks on a comprehensive set of outcomes. By considering banks as portfolios of locations, we are able to partial out the effects of local business conditions and time-invariant bank-location effects. Our approach allows us to extend the analysis of the effects of shocks to the whole lending portfolio of banks and to analyze the reaction of banks' different lending lines. We are also able to go beyond lending and analyze how banks address non-performing loans, equity issuance, operative costs and liquidity. Our results are applicable to the whole population of US banks during the last financial crisis, although the effects across geographical regions are calculated on those banks that operate in multiple locations only.

The results show that banks recognized substantial capital losses as a result of their direct and indirect exposure to real estate prices. Banks have also changed their lending, capital structure and operational policies in accordance with this reduction in capital. More-affected banks cut lending. This reduction in lending operates across all types of lending and not just real estate loans. Overall, the lending results show a considerable level of contagion of real estate price shocks within a bank. This contagion operates across locations and across the different business lines within a bank. Moreover, the capital losses impact other decisions that affect bank operations. In particular, banks that are more affected by real estate shocks used their available sources of liquidity and cut financial and operational costs. We also find evidence of affected banks rolling over problematic loans and failing to liquidate their real estate positions in ways that resemble some of the practices documented in the Japanese banking crisis.

The results are important to understand how banks address shocks that deplete their regulatory and economic capital. Some of the results show a transmission mechanism through bank lending to final borrowers and transmission mechanisms across locations and within banks. Banks operating in multiple locations and business areas can be a source of economic resiliency by diversifying the impact of economic shocks. However, we also show that their overall reaction is amplified beyond the sum of their individual parts in several dimensions and that they can be a source of contagion. This is an important result in light of recent research that explores the geographic transmission of shocks in the US economy (Caliendo et al. 2016, Fogli et al. 2013); our results can be seen as suggestive of banks as one of the possible channels of such contagion.

These outcomes are important in understanding the transmission of economic shocks through the banking system, but they also help us understand how banks cope internally with shocks that deplete their regulatory and economic capital. They are also relevant for understanding banking crises induced by the exposure of banks to real estate investments. The recent banking crises in Spain and Ireland stem from direct and indirect exposure of banks to real estate shocks. Norway, Sweden and Japan also experienced banking crises in the 1990s with similar characteristics. Although there is abundant literature focusing on these crises, it is often difficult in these settings to isolate credit supply and credit demand factors in a broad sample of banks. Our approach measures the reaction of US banks during the current crisis and sheds some light on the forces underlying these crises.

Our results aim to capture the reaction of banks to capital losses induced by real estate shocks and, therefore, have broader applicability to any other real shocks that have a similar effect on capital losses. In particular, the results are applicable to any real estate exposure that remains within the bank when it issues off-balance sheet securities. The results should be useful to understanding the process of deleveraging and balance sheet shrinkage after a negative shock. More broadly, our paper uses a new identification strategy that documents a balance sheet contagion channel within banks and, in this sense, its results help illuminate the effects of generic shocks that affect banks' capital.

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Figure 1

CBSA Real Estate Price Growth 2005–2011

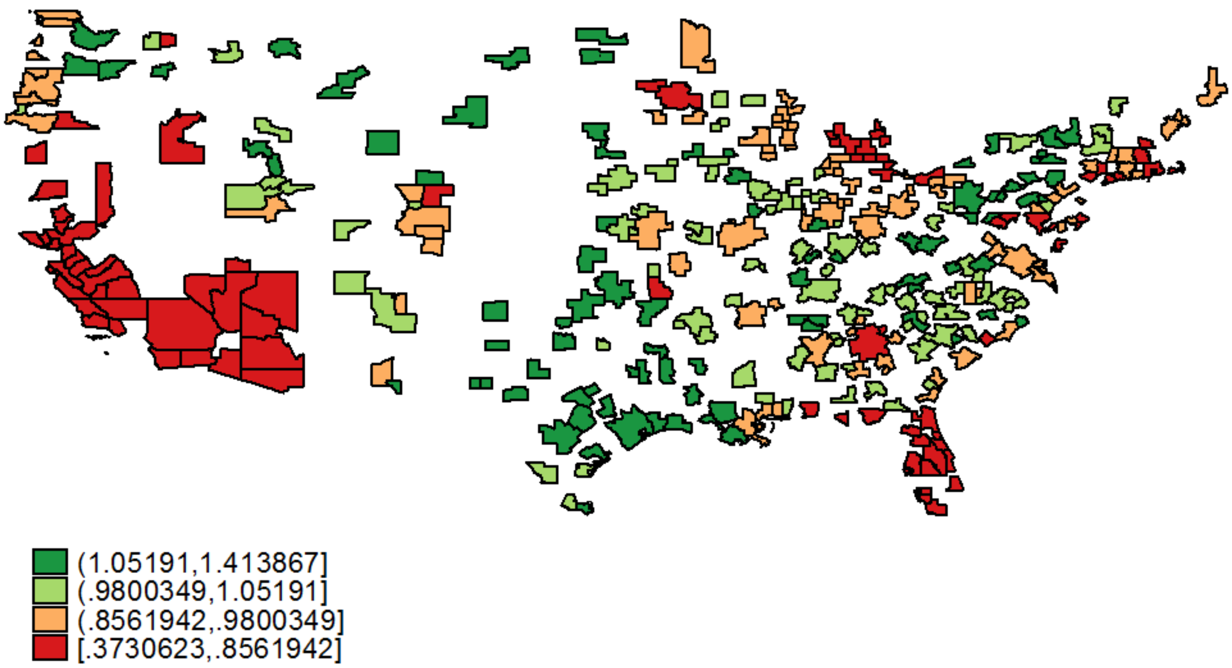

Table 1: Summary statistics

This table presents summary statistics of the sample of bank holding companies, obtained from Call Reports, merged with the geographical distribution of bank deposits as obtained from the Federal Deposit Insurance Corporation (FDIC). House prices are obtained from the Federal Housing Finance Association (FHFA). Our sample consists of quarterly data on all deposit-insured commercial banks. We include only bank-quarter observations with non-missing information on total assets, total loans, and equity. The data cover the period spanning from the first quarter of 2005 to the last quarter of 2010.

Panel A: Bank summary statistics (as of Q42005)

	mean	sd	p25	p50	p75
Total Assets	107,000,000	271,000,000	159,986	723,580	36,300,000
Total Loans	57,600,000	134,000,000	110,145	494,696	25,100,000
MBS	13,700,000	41,100,000	2,037	39,248	3,002,975
PP&E	841,408	1,934,679	2,890	12,304	411,273
Total Equity Capital	10,100,000	24,900,000	16,086	69,927	3,563,262
Tier 1 Capital	6,778,542	17,000,000	15,527	66,208	2,151,723
Tier 2 Capital	2,185,870	5,197,550	1,215	6,314	577,367

Panel B: Bank summary statistics, scaled by total assets (as of Q42005)

	mean	sd	p25	p50	p75
Total Loans	0.669	0.150	0.599	0.691	0.762
MBS	0.081	0.084	0.01	0.062	0.125
PP&E	0.017	0.014	0.008	0.013	0.022
Total Equity Capital	0.109	0.073	0.083	0.095	0.111
Tier 1 Capital	0.092	0.058	0.067	0.081	0.096
Tier 2 Capital	0.013	0.009	0.007	0.009	0.015

Panel C: Types of lending

Scaled by total assets

	Real estate loans	Loans to depository inst.	Agri loans	Commercial & industrial loans	Individual loans	Foreign loans	Obligations	Loans to non-depository inst.	Leases
Mean	0.4666	0.0033	0.0096	0.0765	0.0555	0.0001	0.0045	0.0082	0.0075

Scaled by total lending

	Real estate loans	Loans to depository inst.	Agri loans	Commercial & industrial loans	Individual loans	Foreign loans	Obligations	Loans to non-depository inst.	Leases
Mean	0.6883	0.0071	0.0150	0.1169	0.0862	0.0001	0.0074	0.0145	0.0114

Panel D: Real estate price summary statistics

	Mean	SD	Min	p25	p50	p75	Max
Case-Shiller US house price index	162.68	22.61	130.84	135.98	170.49	186.26	190.5
MSA House Prices Index	186.43	39.84	114.94	159.14	175.01	200.14	365.1
Inelasticity	2.93	0.88	1	2.29	2.7	3.76	4.4

Panel E: Bank location summary statistics

By bank-MSA	**Avg number of MSAs**	**Median number of MSAs**
Whole sample	29.8	2
Single-MSA banks	1	1
Multi-MSA banks	49.9	17
By bank		
Whole sample	1.97	1
Single-MSA banks	1	1
Multi-MSA banks	6.22	2

	Unique bank-MSA-date	**Total Observations (bank-MSA-date)**
Whole sample	2,435	98,497
Single-MSA banks	1968	40,595
Multi-MSA banks	487	57,902
Avg MSA weight	0.448	
Median MSA weight	0.198	

Panel F: Bank-specific aggregate real estate price index *House Prices$_{it}$*

		House Prices$_{it}$		
By bank, across quarters	Avg Single-MSA	Demeaned Single-MSA	Avg Multi-MSA	Demeaned Multi-MSA
mean	220.70	-6.03×10^{-7}	227.31	-5.01×10^{-6}
sd	49.84	27.87954	34.90	26.31

By quarter, across banks	Avg Single-MSA	Demeaned Single-MSA	Avg Multi-MSA	Demeaned Multi-MSA
mean	220.7	2.17×10^{-6}	227.32	1.40×10^{-6}
sd	0.67	57.11	0.71	43.71

Table 2: The effect of real estate prices on bank capital and lending policies

Panel A shows the results of estimating the log specification as in Equation (1), while Panel B shows the results of estimating Equation (2). The dependent variables y_{mit} are obtained from the FDIC call reports and CRA small business loans. From FDIC call reports we obtain: tier 1 capital (RCFD8274), total loans (RCFD2122), tier 2 capital (RCFD8275). From the CRA small business loans data set we obtain the total originated and purchased small business loans and total originated small business loans. Dependent variables y_{mit} are defined at a bank-location-quarter level that is created as the product of an outcome variable y_{it} defined for bank *i* at time *t* (quarter) and a time-varying bank-location weight, w_{mit}. For example, y_{mit} may represent the loans outstanding of bank *i* in period *t* in location *m* or any other outcome variable. The weight w_{mit} is constructed as the fraction of deposits of bank *i* in location *m* with respect to the total deposits of the bank. The independent variable in Panel A, *Log(House Prices$_{it}$),* is the main independent variable that captures the real estate shock that a given bank is facing. It can be written as $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$ It measures the weighted average of the real estate prices P_{mt} of each of the locations in which the bank is located, using as weights the relative importance of each location in terms of deposits (w_{im0} is a static weight at t_0). In Panel B, P_{mt} (local MSA-level real estate price) is predicted using land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index). All specifications include bank-MSA and MSA-quarter fixed effects. In all specifications, we report robust standard errors that cluster at the bank level.

Panel A

All dep. variables in logs	(1) Tier 1 Capital	(2) Tier 2 Capital	(3) Loans	(4) Total Loans (Originated + Purchased)	(5) Total Loans (Originated)
Log(House Prices$_{it}$)	0.144	-0.061	0.185*	0.689*	0.708*
	(1.30)	(-0.40)	(1.65)	(1.72)	(1.72)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes
Obs	97,565	97,048	97,239	15,683	15,683
R^2	0.674	0.787	0.712	0.782	0.802

Panel B

	(1) Tier 1 Capital	(2) Tier 2 Capital	(3) Loans	(4) Total Loans (Originated + Purchased)	(5) Total Loans (Originated)
House $Prices_{it}$ * $PP\&E_{branch,2005}$	0.031***	0.013***	0.254***	2.184***	2.187***
	(14.06)	(9.87)	(6.61)	(3.30)	(3.30)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes
Obs	95,987	95,987	95,987	15,683	15,683
R^2	0.699	0.707	0.714	0.513	0.512

Table 3: The effect of real estate prices on banks' loan composition

Panel A shows the results of estimating the log specification as in Equation (1), while Panel B shows the results of estimating Equation (2). The dependent variables y_{mit} are: real estate loans (RCFD1410), loans to depository institutions and acceptances of other banks, agricultural and farmers loans (RCFD1590), commercial and industrial loans, individual loans (RCFD1975), loans to foreign governments and official institutions (including foreign central banks), obligations (other than securities and leases) of states and political subdivisions in the U.S., and lease financing receivables (RCON2165). Dependent variable y_{mit} is defined at a bank-location level that is created as the product of an outcome variable y_{it} defined for bank *i* at time *t* (quarter) and a time-varying bank-location weight, w_{mit}. The independent variable in Panel A, *Log(House Prices$_{it}$)*, is the main independent variable that captures the real estate shock that a given bank is facing. It can be written as $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$. It measures the weighted average of the real estate prices P_{mt} of each of the locations in which the bank is located, using as weights the relative importance of each location in terms of deposits (w_{im0} is a static weight at t_0). In Panel B, P_{mt} (local MSA-level real estate price) is predicted using land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index). All specifications include bank-MSA and MSA-quarter fixed effects. In all specifications, we report robust standard errors that cluster at the bank level.

Panel A

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All dep. variables in logs	ReLoans	LoansToDep	AgriLoans	CILoans	IndividualLoans	ForeignLoans	Obligations	Loans-NonDep	Leases
Log(House Prices$_{it}$)	0.313***	1.012**	0.281	0.703***	0.075	0.455	-0.265	-0.135	0.241
	(3.63)	(1.98)	(1.63)	(2.98)	(0.66)	(1.30)	(-1.59)	(-0.67)	(0.81)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	92,202	92,202	92,202	92,202	92,202	92,202	92,202	92,202	92,202
R^2	0.970	0.937	0.947	0.942	0.964	0.874	0.938	0.916	0.966

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ReLoans	LoansToDep	AgriLoans	CILoans	IndividualLoans	ForeignLoans	Obligations	Loans-NonDep	Leases
House Prices$_{it}$ * PP&E$_{branch,2005}$	0.142***	0.006***	0.001**	0.054***	0.029***	0.001***	0.002***	0.011***	0.007***
	(5.27)	(4.07)	(2.33)	(7.10)	(11.72)	(4.38)	(3.95)	(4.81)	(3.00)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	90,356	90,356	90,356	90,356	90,356	90,356	90,356	90,356	90,356
R^2	0.727	0.057	0.342	0.699	0.101	0.120	0.463	0.662	0.531

Table 4: The effect of real estate prices on loan loss recognition, recoveries and non-performing loans

In Panel A, we report estimation results of Equation (2) in columns 1 and 2, and estimation results of Equation (1) in columns 3 and 4. The dependent variables y_{mit} in Panel A are: loan recoveries (RIAD4605), loan charge offs (RIAD4635) and net charge offs, defined as the difference between loan recoveries and loan charge offs. In Panels B and C, we show the results for total non-performing loans (defined as the sum of total loans past due 90 days or more and non-accruals). We split them by type of non-performing loans: commercial and industrial non-performing loans, farmer non-performing loans, restructured non-performing loans, other non-performing bank assets, commercial real estate non-performing loans, and credit card non-performing loans. Panel B shows the results of estimating Equation (1), and Panel C shows the results of estimating Equation (2). Dependent variable y_{mit} is defined at a bank-location level that is created as the product of an outcome variable y_{it} defined for bank *i* at time *t* (quarter) and a time-varying bank-location weight, w_{mit}. The weight w_{mit} is constructed as the fraction of deposits of bank *i* in location *m* with respect to the total deposits of the bank. The independent variable in Panel B, *Log(House Prices$_{it}$)*, is the main independent variable that captures the real estate shock that a given bank is facing. It can be written as $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$. It measures the weighted average of the real estate prices P_{mt} of each of the locations in which the bank is located, using as weights the relative importance of each location in terms of deposits (w_{im0} is a static weight at t_0). In Panel A and Panel C, P_{mt} (local MSA-level real estate price) is predicted using land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index). All specifications include bank-MSA and MSA-quarter fixed effects. In all specifications, we report robust standard errors that cluster at the bank level.

Panel A

	(1) log(Loan recoveries)	(2) log(Loan charge offs)	(3) log(Net charge offs)	(4) Loan recoveries	(5) Loan charge offs	(6) Net charge offs
Log(House Prices$_{it}$)	0.000***	0.002***	0.001***			
	(5.81)	(6.17)	(6.11)			
House Prices$_{it}$ * PP&Ebranch,2005				-0.364**	-1.709***	-2.083***
				(-1.97)	(-5.63)	(-6.50)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	97,969	97,969	91,362	95,987	95,987	95,987
R^2	0.879	0.858	0.855	0.647	0.443	0.412

Panel B

	Non-performing loans by type						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All dep. variables in logs	Non-performing loans	Commercial and Industrial	Farmer	Restructured loans	Other non-performing assets	Commercial real estate	Credit card
Log(House Prices$_{it}$)	-2.365***	-1.686***	-2.171***	-5.633***	-2.059***	-2.996***	-0.687*
	(-6.76)	(-4.96)	(-2.60)	(-6.79)	(-5.21)	(-4.68)	(-1.65)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	97,930	97,969	97,969	97,924	97,969	97,969	97,889
R^2	0.785	0.974	0.774	0.713	0.917	0.825	0.776

Panel C

	Non-performing loans by type						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Non-performing loans	Commercial and Industrial	Farmer	Restructured loans	Other non-performing assets	Commercial real estate	Credit card
House $Prices_{it}$ * $PP\&E_{branch,2005}$	-0.006**	-0.002***	-0.001	-0.001***	-0.001**	-0.001***	-0.003
	(-2.12)	(-2.88)	(-0.63)	(-4.14)	(-2.00)	(-3.67)	(-1.37)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	95,987	95,987	95,987	95,987	95,987	95,987	95,987
R^2	0.072	0.021	0.063	0.061	-0.024	0.091	0.036

Table 5: The effect of real estate prices on banks' financing and operating activities.

Panel A shows the results of estimating the log specification as in Equation (1), while Panel B shows the results of estimating Equation (2). The dependent variables y_{mit} are: equity issuance (defined as the quarterly change in tier 1 capital), expenses on premises (RIAD4217), non-interest expense (RIAD4093), interest and non-interest expense (RIAD4130), trading assets (RCFD3545), investment securities (RCFD0391) and cash and balances (RCFD0010). Dependent variable y_{mit} is defined at a bank-location level that is created as the product of an outcome variable y_{it} defined for bank *i* at time *t* (quarter) and a time-varying bank-location weight, w_{mit}. The weight w_{mit} is constructed as the fraction of deposits of bank *i* in location *m* with respect to the total deposits of the bank. The independent variable in Panel A, *Log(House Prices$_{it}$)*, is the main independent variable that captures the real estate shock that a given bank is facing. It can be written as $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$. It measures the weighted average of the real estate prices P_{mt} of each of the locations in which the bank is located, using as weights the relative importance of each location in terms of deposits (w_{im0} is a static weight at t_0). In Panel B, P_{mt} (local MSA-level real estate price) is predicted using land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index). All specifications include bank-MSA and MSA-quarter fixed effects. In all specifications, we report robust standard errors that cluster at the bank level.

Panel A

All dep. variables in logs	(1) Equity Issuance	(2) Expenses on premises	(3) Non-interest expense	(4) Interest and non-interest expense	(5) Trading assets	(6) Investment securities	(7) Cash and balances
Log(House Prices$_{it}$)	-0.011	0.091	0.166	0.341**	-0.198	0.153	-0.035
	(-0.04)	(0.66)	(1.20)	(2.27)	(-0.57)	(0.31)	(-0.20)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	49,569	97,954	97,969	97,969	97,969	93,440	97,967
R^2	0.694	0.940	0.936	0.933	0.962	0.904	0.918

Panel B

	(1) Equity Issuance	(2) Expenses on premises	(3) Non-interest expense	(4) Interest and non-interest expense	(5) Trading assets	(6) Investment securities	(7) Cash and balances
House Prices$_{it}$ * PP&Ebranch,2005	0.001	0.001***	0.008***	0.014***	0.055***	0.069***	0.021***
	(1.36)	(21.37)	(20.14)	(20.79)	(2.77)	(6.26)	(10.03)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	91,436	95,987	95,987	95,987	95,987	91,522	95,987
R^2	0.012	0.709	0.779	0.776	0.612	0.705	0.433

Table 6: The effect of real estate prices on banks' operations: large banks

Panel A shows the results of estimating the log specification as in Equation (1), while Panel B shows the results of estimating Equation (2). The dependent variables y_{mit} are: tier 1 capital (RCFD8274), total loans (RCFD2122), tier 2 capital (RCFD8275) and equity issuance (defined as the quarterly change in tier 1 capital). Dependent variables y_{mit} are defined at a bank-location level that is created as the product of an outcome variable y_{it} defined for bank *i* at time *t* (quarter) and a time-varying bank-location weight, w_{mit}. The weight w_{mit} is constructed as the fraction of deposits of bank *i* in location *m* with respect to the total deposits of the bank. Dummy variable *Large* takes the value 1 if the bank-branch belongs to a top-20 bank holding company in terms of total assets. The independent variable in Panel A, *Log(House Prices$_{it}$)*, captures the real estate shock that a given bank is facing. It can be written as $House\ Prices_{it} = \sum_{m=1}^{M} w_{mi0} P_{mt}$. It measures the weighted average of the real estate prices P_{mt} of each of the locations in which the bank is located, using as weights the relative importance of each location in terms of deposits (w_{im0} is a static weight at t_0). In Panel B, P_{mt} (local MSA-level real estate price) is predicted using land supply inelasticity interacted with aggregate (national) real estate prices (as measured by the Case-Shiller US House Price Index). All specifications include bank-MSA and MSA-quarter fixed effects. In all specifications, we report robust standard errors that cluster at the bank level.

Panel A

All dep. variables in logs	(1) Tier 1 Capital	(2) Tier 2 Capital	(3) Loans	(4) Equity Issuance
Log(House Prices$_{it}$)	0.142	-0.059	0.182*	0.023
	(1.28)	(-0.39)	(1.67)	(0.10)
Log(House Prices$_{it}$)*Large bank	0.010	-0.009**	0.014	-0.010
	(1.32)	(-2.05)	(0.93)	(-0.23)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes
Obs	97,565	97,048	97,239	49,569
R^2	0.674	0.787	0.712	0.566

Panel B

	(1) Tier 1 Capital	(2) Tier 2 Capital	(3) Loans	(4) Equity Issuance
House Prices$_{it}$ * PP&Ebranch,2005	0.031***	0.014***	0.269***	0.000
	(12.64)	(8.17)	(6.92)	(1.23)
Large bank*House Prices$_{it}$ * PP&Ebranch,2005	-0.001	-0.002	-0.069***	0.001
	(-0.79)	(-0.85)	(-3.01)	(0.65)
Bank*MSA fixed effect	Yes	Yes	Yes	Yes
MSA*quarter fixed effect	Yes	Yes	Yes	Yes
Obs	95,987	95,987	95,987	91,436
R^2	0.851	0.785	0.814	0.083