# Propagation of House Price Shocks through the Banking System *

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**Abstract**

This paper analyzes the propagation of house price shocks through the U.S. banking system. Although only roughly 30 percent of the mortgages that originated between 2000 and 2005 were retained on the banks' balance sheets, I find empirical evidence that exogenous negative house price shocks impacted the banks' balance sheets. Between 2006 and 2010, banks that faced a larger drop in their capital-to-assets ratio induced by exogenous house price shocks contracted the supply of new mortgages by more. Besides the propagation of house price shocks through the banks' balance sheets, the same shocks are also propagated across regions since more affected banks contract the credit supply even in areas where economic conditions didn't deteriorate. The drop in the credit supply by the banking system was attenuated by the presence of shadow banks, which face less strict regulatory constraints. The overall credit supply for new home purchases contracted by 5 percent more in counties with a higher presence of distressed banks (10th percentile) than in counties with a lower presence of affected banks (90th percentile). In terms of refinancing loans, the contraction is 12 percent higher in the most affected counties.

**Keywords:** House Prices, Bank Lending, Mortgages, Capital Ratios, Shadow Banks

**JEL Classification:** G21, G23, G20, G01, R30

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# 1 Introduction

Between 2006 and 2010, house prices in the United States fell by 23 percent in real terms, followed by an increase in foreclosures and a severe and persistent drop in economic conditions. Simultaneously, the balance sheets of the financial intermediaries deteriorated, credit flows dropped and credit spreads increased. This period is therefore characterized by balance sheet contractions for both households and banks.

The empirical literature that has studied the Great Recession has identified several channels connecting the drop in house prices and the decline in economic activity. Mian and Sufi (2014) have attributed the large decline in private employment and household consumption almost entirely to the contraction in aggregate demand. Simultaneously, several papers have looked at credit shocks to firms that, facing restricted credit access, were forced to cut employment. The empirical analyses looking at the household side tend to be silent about credit shocks that affect households' decisions. Papers focused on credit shocks to firms are usually silent about the factors and mechanisms that determine the changes in credit supply across space.

In this paper I study how local real estate shocks are propagated and amplified through the banking system. I investigate the impact of local house price shocks on bank balance sheets and the subsequent response of the banking sector. I find that banks played a big role in the transmission of shocks that originated in the housing market between 2006 and 2010. The contraction in the banks' capital ratio is an important transmission mechanism, and banks propagate local shocks across space. Contrary to most of the literature, I look at changes in the mortgage supply.

The U.S. mortgage market has several insurance mechanisms that could potentially shield banks from shocks that originated in the housing market. The presence of Government-Sponsored enterprises (GSEs) and the development of private label back-mortgage securitization identities mainly after 2000 allowed banks to originate mortgages without keeping them on their balance sheets. While in 1990 banks would keep roughly 60 percent of the mortgages that originated on their balance sheet, in 2006 this number was around 30 percent. This downwards trend was even stronger during the recession, when the share of new originations sold reached almost 80 percent. Moreover, technological development and the significant number of mergers and acquisitions (M&A) since the 1990s that created larger banks have led banks to be present in more geographic areas, allowing for higher geographic diversification. The implicit government guarantees through GSEs, the higher relevance of private label MBS and a higher diversification across space must mitigate, if not completely eliminate, the impact of local shocks on bank balance sheets. In this paper I investigate the relevance of local shocks - specifically local house price shocks - on banks' performance, and how such shocks are propagated. Exploiting heterogeneity in banks' mortgage originations across locations and using an instrumental variable approach, I identify the deterioration in the quality of bank balance sheets induced by exogenous variation in local real estate prices. I find that a significant fraction of the drop in bank capital and of the increase in net charge-offs and non-performing loans was driven by local shocks that originated in the housing markets where banks were present.

In order to isolate the balance sheet losses that result from an exogenous change in housing prices, I apply an instrumental variable approach following Charles, Hurst and Notowidigdo (2018) to correct for potential biases. This instrument consists of estimated structural breaks in the evolution of house prices between 2000 and 2006. This approach relies on the emerging consensus that much of the variation in house prices during the boom and bust derived from a speculative "bubble" and not from changes in standard determinants of housing values. Given that the size of the boom is very strongly correlated with the size of its later housing bust, these structural breaks are strongly correlated with house demand in the bust period.

Although I interpret these estimates as bank losses resulting from exogenous real estate shocks, they are not a pure partial equilibrium response, since they reflect direct housing price effects through foreclosures in addition to any general equilibrium response, including losses from other loans, such as commercial loans, that are not secured by real estate. Nevertheless, these results show that although 70 percent of the mortgages were government guaranteed, and there was rapid increase in private label MBS leading up to 2006, bank losses are still highly dependent on local conditions. Banks were then not able to diversify away their own idiosyncratic geographic risk.

This paper looks at how real estate shocks affect the credit supply and its transmission mechanisms. Contrary to most of the literature, which looks at how house price shocks drives credit supply of business loans (e.g., Chodorow-Reich, 2014; Greenstone, Mas and Nguyen, 2014; Santos, 2011), I look at the supply of mortgages. There are two main exceptions. First, Gilchrist, Siemer and Zakrajšek (2018), following a similar approach to Greenstone, Mas and Nguyen (2014), identify a contraction in the supply of credit to small business lending and mortgages lending. They find that the contraction of mortgage supply was in fact superior to the contraction in the supply of small business loans. This paper departs from Gilchrist, Siemer and Zakrajšek (2018) by identifying changes in credit supply of mortgages due to house price shocks, while their approach does not allow them to disentangle the contribution of each shock. The second exception is Cuñat, Cvijanović and Yuan (2018), which analyzes the effect of real estate shocks in the composition of the loan portfolio at the bank level. They claim that such shocks reduce real estate lending and firm lending. These results are obtained by looking at the outstanding volume of loans on the banks' balance sheet. With this approach it is not possible to disentangle previous loans from new originations, and it gives us an incomplete view of the current credit supply since it ignores any mortgage that was originated and immediately sold. Bringing it to the extreme case, bank supply of mortgages could have remained unchanged, but banks could have shifted to an originate-to-distribute business model.

To address such limitations, I use a comprehensive data set of mortgage originations from the Home Mortgage Disclosure Act (HMDA), which covers around 90 percent of the total home loans that originated in the U.S., regardless of whether such mortgages are kept on the banks' balance sheet. HMDA identifies the bank originator, which allows for a match with the balance sheet information in Call Reports. By merging such data sets I am able to analyze how mortgage supply reacts to the deterioration on bank's balance sheet induced by local house price shocks.

Specifically, I test the transmission mechanism highlighted in Paixão (2018), which analyzes in a quantitative model the transmission of house price shocks to consumption through the bank balance sheet channel. Paixão (2018) introduces a banking sector with balance sheet frictions in a model of heterogenous agents, incomplete markets and long-term collateralized debt with risk of default. Homeowners can access the mortgage market for the purchase of new homes or refinancing. Banks face a smooth leverage cost that translates into a higher funding cost when the bank leverage goes above a certain threshold. This can be seen as a flexible leverage constraint that allows banks to trade off higher leverage at a higher cost. In the case of a negative shock to their net worth, banks are not forced to deleverage immediately, as occurred during the Great Recession and is shown in Figure 2. By introducing such a constraint, the model departs from most of the literature that uses this class of models to analyze the transmission of house price shocks into consumption. In this model the credit supply no longer depends solely on the household creditworthness but also on the capitalization of the banking system. Therefore, this framework allows us to analyze and quantify the relevance of the endogenous response of the banking sector in propagating and amplifying shocks that originated in the housing market. When house prices drop exogenously, home equity drops and foreclosures increase. Such losses affect banks' capital and their leverage increases. The cost of the more leveraged banks increases, which leads to a contraction in the credit supply, higher mortgage spreads and endogenous down payments. By simulating a similar drop in the model to that observed in the data between 2006 and 2009, and through a counterfactual exercise, Paixão (2018) concludes that the endogenous response of the banking sector to house price shocks explains 22 percent and 9 percent of the change in consumption and foreclosures, respectively.

To test empirically the transmission mechanism in Paixão (2018), I regress mortgage lending on the predicted change in capital ratios induced by exogenous variation in local real estate prices. Testing this mechanism empirically raises several concerns. The main challenge is to disentangle credit supply from credit demand, since changes in house prices may simultaneously affect both. It is also necessary to control for selection bias because households that are more affected by the drop in house prices and economic conditions may borrow more from the affected banks. To address these questions I use a similar instrumental variable approach to the one described above, and due to the lack of relevant information on household creditworthiness in the HMDA data, I conduct the analysis at the county level and use county-level information to control for changes in demand.

Conducting the analysis at the county level also attenuates the selection bias. As households may concentrate their loan applications at healthy banks, we may find that the acceptance rate decreases at the healthy banks but not at the most constrained banks. By looking at mortgages at the county level, I control for selection within each county. Moreover, we ultimately care about the overall availability of credit. Even if the more affected banks contract the credit supply, more healthy banks can fill the gap, keeping the overall credit supply unchanged. The difference can be closed by banks already present in the county or banks that decide to expand to new geographies, potentially taking advantage of unrealized profitable lending opportunities. A county-level measure of the credit supply gives us a better understanding of the effective supply faced by households.

The identification strategy explores heterogeneity in counties' exposure to more constrained banks. I constructed a county-measure of bank capital ratio induced by exogenous change in house prices by aggregating across the banks present in the county. To further isolate changes in the creditworthiness at the county level that simultaneously affects banks' capital ratio and credit supply and to avoid confounding factors with demand forces, I consider only banks that operate in multiple counties and remove the contribution of that specific county to the drop in banks' capital. To aggregate the bank variables at the county level, I weight the bank variables by the share of outstanding mortgages in the county prior to the crisis. By considering only banks that operate in multiple counties and by removing the contribution of that specific county to the changes in bank capital, I identify how shocks to the bank's balance sheet in a certain county affect its lending policies elsewhere - in other words, how the credit supply in a given county is influenced by shocks that originated in other counties due to their impact on bank's capital ratio.

I find that mortgage originations decreased more in counties with a higher presence of distressed banks, i.e., banks that faced greater losses induced by real estate shocks. The effects have similar magnitude whether we look at number of originations or dollar amount. The contraction of the supply of refinancing loans is larger than for the purchase of new homes. These results show that house price shocks lead to a decrease in the credit supply through the impact of losses on banks' balance sheets. The banking system is an important source of propagation of shocks that originated in the housing market, as predicted in Paixão (2018). It also shows that the banking system propagates shocks across space, since the credit supply contracts even in areas where local economic conditions didn't deteriorate significantly.

The relevance of shadow banking in the mortgage market is significant and consistently above 30 percent prior to 2006. The effective credit supply faced by households is then a combination of the supply of traditional banks and shadow banks. Given that shadow banks face fewer regulatory constraints, it is possible that the drop in the banking credit supply is compensated for by shadow banks. By looking at total mortgages originated rather than restricting to mortgages originated by banks, I find that the drop in the credit supply is significantly mitigated. However, shadow banks are not able to completely close the gap.

Although the literature has established that a contraction in bank balance sheets leads to a contraction of credit (e.g., Chodorow-Reich, 2014; Santos, 2011), to the best of my knowledge this is one of the few papers that looks at mortgage credit rather than firms' financing. Moreover, unlike the current literature, I isolate the changes in bank balance sheets that result from variation in local house price shocks. These results highlight that despite government guarantees on conventional loans and the growth of private MBS prior to the crisis, banks' losses are still correlated with changes in local house prices. By looking only at the bank credit supply we overestimate the impact of housing shocks, since shadow banks are an important source of mitigation of such effects.

The paper is structured as follows. Section 2 reviews the related literature. In section 3, I describe the data. Section 4 lays down the empirical strategy to analyze the impact of real estate shocks on banks' balance sheets and presents the results. Section 5 examines how such shocks are propagated through the banking system and determine the credit supply. Section 6 concludes.

## 2 Related Work

This paper is part of a growing literature that studies the response of economic outcomes to housing price shocks. On the empirical side, Mian, Rao and Sufi (2013) and Kaplan, Mitman and Violante (2016) show large elasticities of consumption to the drop in housing prices and housing net worth. Mian and Sufi (2011) and Mian and Sufi (2014) also evaluate the impact of the same shocks on foreclosures and employment, respectively. But these papers omit the importance of the credit supply in such a transmission mechanism, a gap that this paper helps to fill.

Motivated by these facts, theoretical literature has built large-scale quantitative models to rationalize such relationships. Berger et al. (2018), Huo and Rios-Rull (2016), Kaplan, Mitman and Violante (2017) and Garriga and Hedlund (2017) are among the most preeminent examples. These models feature incomplete markets, income uncertainty, heterogeneous agents and housing as collateral. These papers highlight the importance of housing prices, household wealth and debt in explaining the evolution of consumption during the recession. Although these papers consider credit conditions important in explaining the evolution of consumption, foreclosures and housing prices, they employ models in which these are exogenous, neglecting the connections and feedback effects between the housing market and the banking sector. This paper shows that the financial sector is also an important force of transmission of such shocks. Moreover, the interaction between the contraction of the balance sheets of both households and financial intermediaries can be an important source of amplification that is not present in these papers. To the best of my knowledge, there are only two exceptions: Guren and Mcquade (2018) and Paixão (2018).

This paper is also related to the lending channel literature. Important papers on the empirical literature include Kashyap and Stein (2000) and Jiménez et al. (2012). These papers explore cross-sectional variation in bank balance sheets to estimate the effect of contractive monetary policy and adverse economic conditions on the credit supply. My paper focuses on real estate shocks instead. In this area, Chakraborty, Goldstein and MacKinlay (2018) and Flannery and Lin (2015) look at the boom period before 2006 and study the impact of positive shocks on banks' lending opportunities, using individual bank data. The former concludes that the boom in housing prices led to an increase in mortgage lending and a decrease in commercial lending, while the latter reports an increase in both types of loans. Cuñat, Cvijanović and Yuan (2018) look at the impact of the housing market on the credit supply, but their focus is on the financial crisis period and the credit crunch caused by housing bust. Greenstone, Mas and Nguyen (2014) and Chodorow-Reich (2014) look at the transmission of housing shocks to firm employment through bank balance sheets. Santos (2011) concludes that firms paid higher loan spreads during the crisis, and this increase was higher for firms that borrowed from banks that incurred larger losses.Ivashina and Scharfstein (2010) provide support for the existence of significant supply constraints in terms of quantity. I differ from these papers by focusing on the loan supply to households, specifically mortgage loans.

This paper is also related to the literature that studies the transmission of shocks across space through the banking system. Gilje, Loutskina and Strahan (2016) show that positive funding windfalls from shale discoveries are transmitted via bank branch networks to nonshale areas and result in an increase in mortgage lending activity. Cortés and Strahan (2017) show that negative shocks from natural disasters result in reduced lending in areas connected via bank branch networks that are not directly affected by natural disasters. This paper instead looks at how real estate shocks are propagated through the impact on a bank's balance sheet during a bust.

The importance of the shadow banking in the mortgage market is also evaluated in this paper. Buchak et al. (2018) analyzes the rise of shadow banking between 2007 and 2015, especially online fintech lenders. Similar to the results of this paper, they find that shadow banks partially filled the gap generated by banks that face increasing regulatory burdens. My results complement those of Buchak et al. (2018), since instead of looking at changes in regulatory rules that affected only traditional banks, I look at shocks that affected all intermediaries in the market.

More generally, this paper relates to the credit crunch literature that highlights the impact of deleveraging on the economy, as in Eggertsson and Krugman (2012), Guerrieri and Lorenzoni (2017) and Jermann and Quadrini (2012).

# 3 Data

In this section I provide detailed information on the data sets used to analyze the propagation of house price shocks through the banking system. The analysis is conducted for the period between 2006 and 2010, the period with the sharpest house price decline, the largest changes in bank balance sheets and the largest contraction in credit. I combine data on bank balance sheets, mortgage originations and local economic activity. I restrict the sample to the 48 contiguous U.S. states.

## 3.1 Bank Balance Sheet Data

I collect bank income and balance sheet data from the Federal Reserve's Report of Condition and Income, usually known as Call Reports. They include information on all deposit-insured commercial banks operating in the United States. The data set contains detailed information on assets, loans and leases, cash, deposits, securities, trading assets and liabilities. Important to this paper, the data set also contains information on banks' capital and equity as well as information on non-performing loans and charge-offs. Although the data are available on a quarterly basis, I transform the data to the annual level to match the credit data frequency. I restrict the sample to banks with non-missing information on total assets, deposits, loans and equity.

### 3.2 Home Mortgage and Business Lending

Information on lending comes from HMDA that covers about 90 percent of the mortgage applications and approved loans in the United States. The data provide, among other things, the loan amount, the loan type and purpose, property location and some borrower characteristics, such as gender, race and income. Crucial for the analysis, the data set contains the originator's identity, which allows to linking with the balance sheet information of the depository institutions ("banks" for simplicity) present in the Call Reports. Since the HMDA requires the majority of U.S. financial institutions to disclose information about home mortgages, I am also able to capture the number and volume of mortgages that originated outside of the banking system. This gives a more comprehensive view of the entire mortgage market rather than looking only at mortgages that were originated by commercial banks. HMDA also records whether the loan is retained on the originator's balance sheet or sold within the origination year to a third party, as GSEs or private-label securitization identity. Although I can't observe whether the loan was ever sold any time after the end of the origination year, this information gives a good approximation of the share of loans retained in the originator's balance sheets.

I restrict the sample to home mortgages for single-family homes, which corresponds to the majority of the applications.[1] In most of the paper, I look separately for home purchase loans and refinancing, due to the different nature of the two types of loans.

[1] The mortgage application sample is further restricted to applications that were either denied or approved and excludes observations with ambiguous status, such as incomplete files and withdrawn applications. I focus on new loans, excluding purchases of existing loans.

### 3.3 Local Economic Activity and House Prices

The analysis relies on variation across counties, and I account for heterogeneity in economic conditions by using the unemployment rate from the Bureau of Labor Statistics, and wages and income from Internal Revenue Service (IRS) Statistics of Income.

County-level house prices are obtained from Zillow. The Zillow Home Value Index (ZHVI) is a smoothed, seasonally adjusted measure of the median estimated home value. It is a dollar-denominated alternative to repeat-sales indices. House prices are deflated using the inflation rate from the U.S. Bureau of Labor Statistics.

To mitigate the effects of outliers, I winsorize all growth rates at the bottom 1st percentile and the top 99th percentile.

## 4 House Price Shocks and Bank Balance Sheet Channel

I aim to analyze how shocks that originated in the housing market affect bank balance sheets and how banks react to such shocks in terms of their lending policies. Following Paixão (2018) I test the transmission and propagation of real estate shocks through their impact on banks' capital-to-asset ratio. The empirical strategy exploits the fact that banks in my sample originate loans across different locations that faced different evolutions of house prices. I first discuss how I construct bank-specific house price shocks and the instrumental variable approach used to infer a causal relationship between such shocks and changes in the banks' balance sheets. I then discuss how I identify the causal impact of such shocks in banks lending policies through the impact on banks' capital-to-asset ratio.

### 4.1 Bank-Specific Real Estate Shock

The empirical strategy relies on the fact that banks operate across different counties, the geographic unit used throughout this paper. The performance of each bank may depend on local shocks in the counties where operates, besides any national aggregate shock.

Given that one of the goals of this paper is to analyze how shocks that originated in the housing market affect banks' activity, I construct a bank-specific real estate shock based on the evolution of house prices in the counties where the bank operates. As the literature has shown, change in house prices is a key element in determining mortgage performance. When house prices drop, home equity decreases, inducing a higher number of non-performing loans and foreclosures. The recovery value for banks also drops as the collateral value of houses decreases. Then, a change in house prices must have a direct impact on banks' earnings and capitalization, which can drive changes in banks' lending attitudes. To test this prediction, I build a measure of changes in house prices relevant for each bank, which I denote by bank-specific real estate shock (RES). $RES_{k,t}$ stands for the real estate shock faced by bank $k$ in year $t$. It is constructed as the weighted average of the change in house prices in the counties where the bank operates and is defined according to:

$$RES_{k,t} = \sum_{j \in C_{k,t}} \omega_{k,j,05} \Delta P_{j,t} \tag{1}$$

Counties are indexed by $j$, and $C_k$ denotes the set of counties where bank $k$ operates. $\Delta P_{j,t}$ denotes the change between years $t-1$ and $t$ of real house prices in county $j$. The weight attributed to a given county, $\omega_{k,j,05}$, reflects the importance of that county in the bank's portfolio of mortgages. I consider several possible weights, as explained shortly. The weights are static and fixed at 2005 in order to consider the bank's portfolio before prices started to drop and to avoid introducing endogeneity through the weighting procedure.

**Weights**

The bank-specific RES aims to capture the relevant house price changes for each bank. Decisions on foreclosure and recovery values depend on the value of the property used as collateral. Since a valuation of each property is not available, I look at house prices at the county level.

The importance of each county must reflect the stock of mortgages in each county held by the banks on their balance sheet. The construction of the weights vector is then a crucial element of the analysis. The empirical banking literature tends to use as weights the share of deposits that each bank owns in each county. Using deposits-based weights raises several questions. First, deposits are intrinsically related to the branch network, but most of the banks issue loans even in counties with no branches. Moreover, the distance between branch location and loan originations tends to increase during booms. Given that 2000-2005 was a period of large expansion in mortgage originations with higher loan-to-value ratios, the stock of mortgages that originated during this period is particularly relevant to understand how house prices affect bank losses. Therefore, considering deposit-based weights is particularly critical to the period in question. A second limitation relates to the fact that banks can transfer resources across their branch network, potentially collecting funds in some counties and originating loans in other counties with different house price patterns.

Instead, in this paper I build weights based on mortgages originated by each bank between 1990 and 2005, using the loan-level data from the HMDA. Ultimately, I would like to consider the outstanding value of each loan in 2005, the year at which weights are computed. Such data are not available, so I approximate the outstanding loan amount in a given county by:

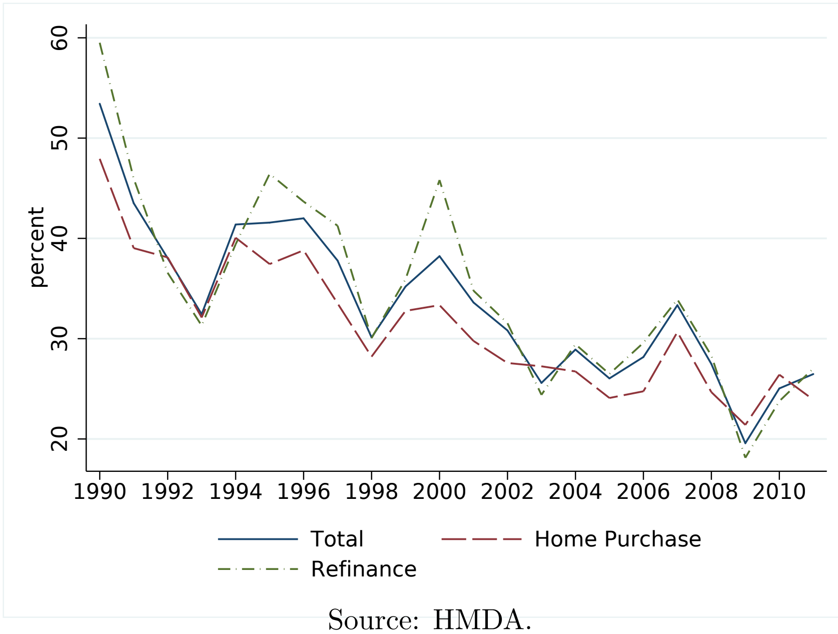
$$L_{k,j,t} = (1-\mu)(1-def_t - prepay_t)L_{k,j,t-1} \tag{2}$$

$L_{k,j,t}$ denotes the outstanding value of mortgages of bank $k$ in county $j$ at time $t$. The evolution of the outstanding amount depends on three key elements: the amortization rate $\mu$, prepayment rate $prepay_t$ and default rate $def_t$. I assume that 5 percent of the outstanding loans are prepaid every period, following Vavra (ref). The default rate is calibrated to 1.5 percent, the historical default rate in the U.S. prior to the crisis. The remaining fraction pays a constant amortization rate. Given that the majority of the mortgages in the U.S. are 30-year fixed-rate mortgages, I set $\mu$ to 1/30. It is implicitly assumed that all counties behave similarly in terms of default and prepayment and such behavior is invariant between 1990 and 2005. Using the outstanding mortgage value for each bank in a given county in 2005, the bank-county specific weights are given by:

$$\omega_{k,j,05} = \frac{L_{k,j,05}}{\sum_{j\in C_{k,05}} L_{k,j,05}} \tag{3}$$

At last, we need to consider whether to take into account the total amount of loans originated or simply the loans that were not sold and kept in the bank balance sheet. In

Figure 1: Share of Loans Kept on Banks' Balance Sheets




Source: HMDA.

HMDA we observe if a loan is sold within a year after the origination. Although there is no guarantee that a loan is not sold after one year, anecdotal evidence suggests that most of the loans are sold in a short period of time after origination.

Figure 1 shows that the fraction of loans kept on the banks balance sheets has been decreasing over time, reaching values below 30 percent after 2002. This includes loans guaranteed by GSEs or securitized by private-labeled entities. This may suggest that the weights must be constructed based only on loans not sold and retained in the banks balance sheet. However, Chakraborty, Goldstein and MacKinlay (2018) argue that even when loans are sold, the originator is likely to remain the servicer of the mortgage, maintaining exposure to the local market. When banks create the MBS, as opposed to simply selling the mortgages to another unrelated sponsor, they often retain a certain amount of the security as a signal of its quality.

The choice of the weights seems to not be important. The RES presents similar results using both weights (see Table 1). The average RES is 7 percent per year, slightly above the average house price change. In cumulative terms over the 2006-2010 period, the RES was 21.4 percent. The cross-section difference is also significant. Banks that are more affected (10th percentile) faced a RES of 15.3 per cent per year, while the least affected (90th percentile) had a yearly RES of 0.6 percent.

Table 1 also shows the summary statistics for nationwide housing price growth. Between 2006 and 2010, the house price index in real terms in the Zillow data set decreased, on average, by 5.3 percent per year and 23.1 percent over the entire period. House price changes are very heterogeneous across counties. The 90th-10th percentile differential is 16 percentage points.

Table 1: RES and House Prices

| | Mean | SD | Median | Perc10 | Perc90 |
|---|---|---|---|---|---|
| **RES - Loans Kept** | | | | | |
| 2006-2010 | -.0699 | .0518 | -.0587 | -.153 | -.0058 |
| Δ 2006-2010 | -.214 | .1059 | -.279 | -.279 | -.0326 |
| **RES - Loans Originated** | | | | | |
| 2006-2010 | -.0675 | .0462 | -.06 | -.1401 | -.0132 |
| Δ 2006-2010 | -.2065 | .0966 | -.2353 | -.3026 | -.0704 |
| **Δ House Prices - Unweighted** | | | | | |
| Annual Change (2006-2010) | -.0341 | .0608 | -.0318 | -.1066 | .037 |
| Δ 2006-2010 | -.1556 | .14 | -.1264 | -.3221 | .0127 |
| **Δ House Prices - Weighted** | | | | | |
| Annual Change (2006-2010) | -.0528 | .0686 | -.0459 | -.1402 | .0215 |
| Δ 2006-2010 | -.231 | .1565 | -.2203 | -.4961 | -.0586 |

Source: Call Reports, HMDA and Zillow. House prices are weighted by county population in 2005 and RES weighted by total assets in 2005.

## 4.2 Identification

This paper aims to analyze how shocks that originated in the housing market affect banks' performance and the impact on bank lending practices. In this section, I focus on the first aspect and explain the instrumental variable approach used to infer causality.

Given the increasing relevance of the securitization market and the expansion of banks to new markets that occurred through internal expansion or by M&A, potentially allowing for a higher degree of geographical diversification, it is not obvious that banks are exposed very much to local market conditions. To test this exposure I look at how key elements of the bank balance sheet are affected by the bank-relevant RES through the estimation of the following equation:

$$\Delta Y_{k,t} = \beta_1 + \beta_2 \Delta RES_{k,t} + \beta_3 X_{k,05} + \epsilon_{k,t} \tag{4}$$

where $\Delta Y_{k,t}$ denotes the change between $t-1$ and $t$ of the variable of interest. $X_{k,05}$ is a set of bank controls to account for differences across banks before being hit by the shock. The set of controls is summarized in Table 16 in Appendix A. They consist of indicators of banks' performance in 2005, and they also capture variation in the lending standards among banks.

The specification in (4) estimates the correlation between local house prices and banks' performance but do not isolate balance sheet changes implied by house price shocks. Besides possible reverse causality due to the fact that lending policies also affect house prices, the current specification does not control for unobserved economic shocks that may simultaneously drive bank performance and house prices.

To address these concerns, I use an instrumental variable approach. The instrument corresponds to the size of the estimated structural breaks in the evolution of house prices at county level between 2000 and 2006, following the approach in Charles, Hurst and Notowidigdo (2018). This approach relies on the emerging consensus that much of the variation in housing prices during the boom and bust derived from a speculative "bubble" and not from changes in standard determinants of housing values such as income, population, or construction costs. The implicit assumption is that these "sharp breaks" are exogenous to local latent confounds, such as labor supply shocks or unobserved changes in credit changes, which are likely smoothly incorporated into house price changes. Charles, Hurst and Notowidigdo (2018) show that the estimated breaks are not, in fact, systematically related to pre-period levels and changes in many observable local characteristics. The structural breaks also strongly predict the housing demand change during the 2006-2012 bust period, a result that follows from the fact that the size of the boom is very strongly correlated with the size of its later housing bust.

By instrumentalizing local changes in house prices with the structural breaks, I am able to isolate exogenous changes in house prices that are not driven by local economic conditions and local lending practices. Counties that faced a higher structural break during the boom period are expected to have a larger house price drop during the bust for the same contraction in the housing demand. The intuition is simple. Areas subject to higher speculation, and therefore a larger structural break during the boom period, are areas with a higher share of overvalued properties. Once the demand for housing contracts brings prices back to their fundamental value, those areas tend to face a higher price correction downwards. Instead, for areas that during the boom were not subject to speculation, their house prices are more closely aligned with the fundamental value. Then house prices tend to drop less when facing a similar demand shock than in the speculative areas.

Table 2: RES and House Price break

| | Loans Kept | | | Loans Originated | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2a) | (3a) |
| RES (break) | -0.341*** | -0.321*** | -0.320*** | -0.348*** | -0.322*** | -0.321*** |
| | (0.015) | (0.015) | (0.015) | (0.014) | (0.013) | (0.013) |
| Observations | 11167 | 11164 | 11164 | 14144 | 14133 | 14133 |
| Adjusted $R^2$ | 0.151 | 0.192 | 0.313 | 0.159 | 0.202 | 0.313 |
| F | 513.1 | 60.03 | 60.08 | 642.5 | 74.91 | 75.34 |
| SD | robust | robust | robust | robust | robust | robust |
| Year FE | No | No | Yes | No | No | Yes |
| Bank controls | No | Yes | Yes | No | Yes | Yes |

Notes. Dependent variable: Real estate shock (RES). The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in appendix A, table 17.

Similar to the definition of RES in (1), the instrumental variable is built using the same weighting procedure explained above. Table 2 shows that the measure of house price breaks can explain a large portion of the real estate shocks faced by the banks. Since areas with the largest structural break in house prices prior to 2005 also suffered the biggest drop in housing prices, banks with a larger presence in counties with higher breaks saw a larger decline in their housing price index. The first stage, presented in Table 2, removes concerns about the weakness of the instrument since the F-statistics are always larger than 20. Table 2 also shows no differences using the weights based on loans kept on a bank's balance sheet or total loans originated. In the rest of the paper I present results using the first definition, but results are unchanged if I use the second one.

In the next sections, I test whether RES impact banks' balance sheets. Specifically, I look at bank capital ratio, non-performing loans, net charge-offs and provisions.

### 4.3 Bank's Capital

I analyze two definitions of capital-to-assets ratios. The first, denoted by capital ratio, is defined as total equity plus retained earnings divided by total assets. Since it uses the book value of equity and assets are not risk adjusted, this measure is equivalent to a pure leverage ratio. This definition of bank capital has a direct link to the definition used in Paixão (2018), a mechanism I am going to test in the following section.

The second ratio, denoted by risk-adjusted capital ratio, is defined by total qualifying capital allowable under the risk-based capital guidelines divided by risk-adjusted assets (results are similar if Tier 1 capital is used instead).

Figure 2: Capital Ratio

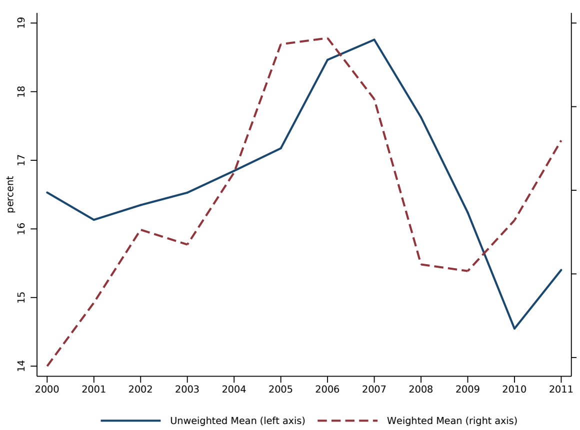
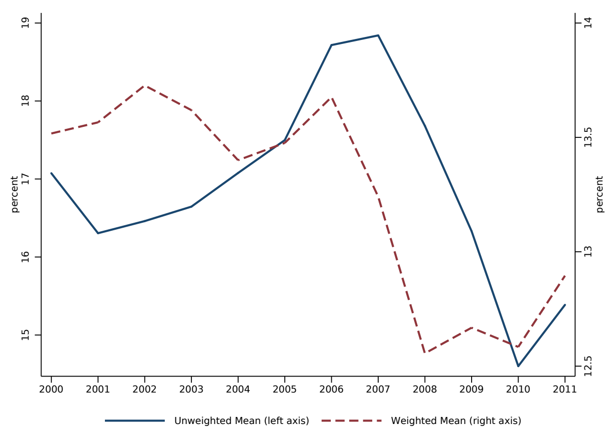



Figure 3: Risk-Adjusted Capital Ratio




Source: Call Reports.

Both definitions of capital ratios present similar patterns over the 2000-2011 period, especially in the downturn. As we can see in Figures 2 and 3, both ratios dropped on average roughly 1.5 percentage points between 2006 and 2010. If we look at the unweighted mean, the drop is higher, suggesting that smaller banks face a larger drop in their capital position.

Table 3: Capital-to-Assets Ratio

| | Mean | SD | Median | Perc10 | Perc90 |
|---|---|---|---|---|---|
| **Capital Ratio - Weighted** | | | | | |
| 2006 | 14.4102 | 6.8702 | 12.523 | 10.6074 | 18.9267 |
| 2010 | 13.3204 | 5.8794 | 13.2031 | 9.9596 | 18.365 |
| Annual Change (2006-2010) | -.4362 | 3.8408 | .0591 | -2.1955 | 1.8451 |
| **Capital Ratio - Unweighted** | | | | | |
| 2006 | 18.4638 | 14.6173 | 15.0576 | 9.8559 | 27.736 |
| 2010 | 14.5469 | 108.2701 | 14.5454 | 6.4038 | 24.1497 |
| Annual Change (2006-2010) | -1.3755 | 53.0934 | -.0857 | -3.71 | 1.4732 |
| **Risk-Adjusted Capital Ratio - Weighted** | | | | | |
| 2006 | 13.6763 | 5.7687 | 12.5964 | 10.519 | 18.1656 |
| 2010 | 12.5841 | 5.3706 | 11.9538 | 8.8333 | 16.3954 |
| Annual Change (2006-2010) | -.4935 | 3.5693 | -.0934 | -1.8702 | 1.2386 |
| **Risk-Adjusted Capital Ratio - Unweighted** | | | | | |
| 2006 | 18.7177 | 14.1595 | 15.3577 | 10.1744 | 28.3299 |
| 2010 | 14.6005 | 108.2179 | 14.5786 | 6.5526 | 24.2996 |
| Annual Change (2006-2010) | -1.4841 | 53.0859 | -.1814 | -3.815 | 1.3118 |

Source: Call Reports. Weighted statistics are computed using total assets as weights.

Table 3 presents evidence of the heterogeneity across banks. The average capital ratio decreased from 14.4 percent in 2006 to 13.3 percent in 2010, although it reached its lowest point in 2009 at 13 percentage points. On average, capital ratio decreased 0.44 percentage points per year. In 2006, banks in the 10th and 90th percentiles of the capital ratio distribution had capital ratios of 10.6 percent and 18.9 percent, respectively. The level of heterogeneity remains fairly constant over this period. The risk-adjusted capital ratio presents similar statistics in terms of both aggregate magnitudes and heterogeneity (see Table 3).

The drop in capital ratios can be explained by the RES faced by each bank, as evident in Table 4, which reports the coefficients of the regression (4). The first column shows the raw correlation between the real estate shock and changes in the capital ratio. The correlation is strong and significant at the 99 percent level.

Table 4: RES and Capital Ratio

| | OLS (1) | IV (2) | OLS (3) | IV (4) |
|---|---|---|---|---|
| RES(t) | 0.089*** | 0.120*** | 0.084*** | 0.124*** |
| | (0.006) | (0.016) | (0.006) | (0.016) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.036 | 0.031 | 0.090 | 0.084 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Variation of Capital-to-Assets Ratio. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 18.

In column (3), I control for bank characteristics, such as size (log of assets), measures related to liquidity and asset composition. I include additional bank characteristics that control for the bank's standard practices. These controls are ROA, ROE, non-performing loans, net charge-offs, provisions and allowances in 2005, before the shock hit most of the banks. This specification also controls for time fixed effects, and standard errors are clustered at the bank level. In this specification, the correlation coefficient decreases, but it is still strong and statistically significant, which indicates that bank lending standards cannot explain the observed changes in bank performance and balance sheets during the crisis.

Column (4) shows the same specification but with the RES instrumentalized with house price breaks. I conclude that a bank that faces an exogenous variation in the real estate prices of 10 percent (i.e., an average price decrease of 10 percent in the counties where the bank operates) sees its capital-to-assets ratio decrease by 1.2 percentage points. If we consider the average shock (-7 percent per year), the same ratio changes by 0.86 percentage points. Alternatively, we can interpret the same results in the following way: going from the 90th to the 10th percentile of the RES distribution (15 percentage points) implies that the capital ratio decreases by 1.86 percentage points.

Table 5: RES and Risk-Adjusted Capital Ratio

| | OLS (1) | IV (2) | OLS (3) | IV (4) |
|---|---|---|---|---|
| RES(t) | 0.085*** | 0.126*** | 0.084*** | 0.130*** |
| | (0.006) | (0.015) | (0.006) | (0.016) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.035 | 0.026 | 0.077 | 0.069 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Variation of capital-to-assets ratio. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 19.

These results show that more than half of the average drop in the capital-to-assets ratio can be explained by the shocks that originated in the housing market. Exogenous variation in house prices in the counties where banks operate are statistically and economically relevant to explain the changes in banks' balance sheets during this period. It suggests that although a large part of the mortgage market is guaranteed by the government and there was an active private MBS market before 2006, banks' losses are still highly correlated with local economic conditions, especially with changes in local house prices. The results are very similar if we use the risk-adjusted capital ratio instead (Table 5).

The marginal effect of housing shocks on bank capital ratio is invariant with bank size and bank capital position. Figure 4 shows the marginal impact of the instrumentalized RES (column 4 of Table 4) across bank size quantiles measured in terms of total assets. This shows that larger banks are not able to achieve higher geographical and product diversification than smaller banks. This result may come as a surprise since larger banks tend to sell and securitize a higher fraction of their originated loans. Similar results are obtained if we look at the banks' capital-to-asset ratio position in the previous period, as evident in Figure 5.

Figure 4: Marginal Effects by Assets Quantiles

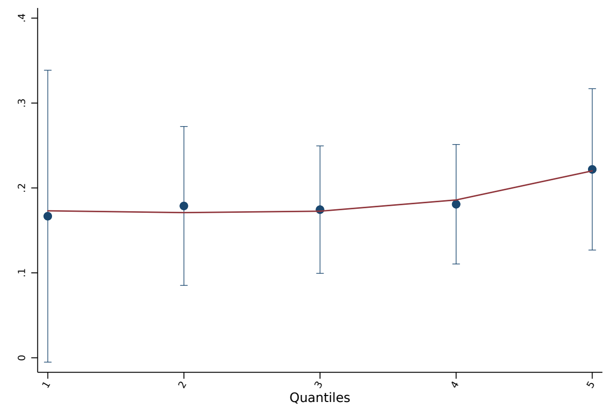
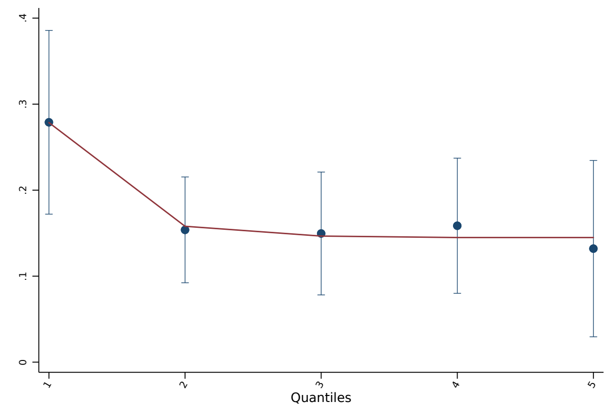



Figure 5: Marginal effects by Capital Quantiles



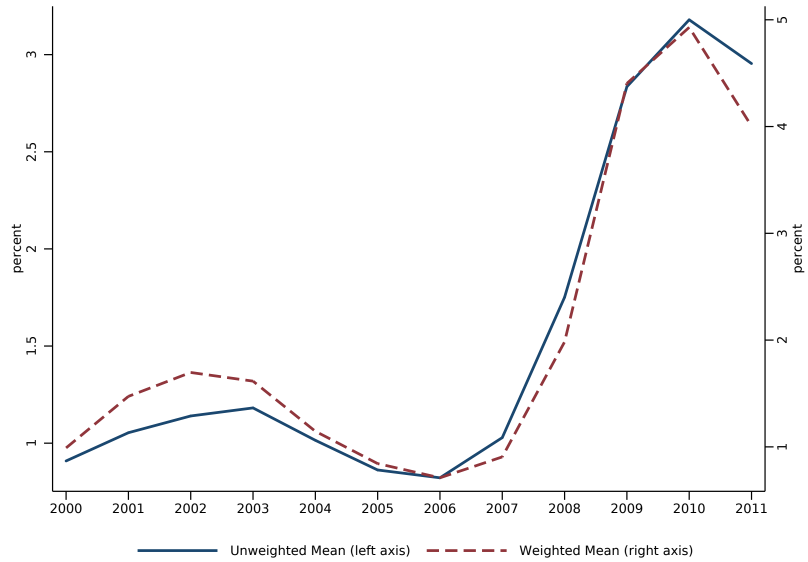

Note: The figures show the estimated marginal effects of RES on capital ratio implied by the regression specification in column (4) of Table 4 for a given quantile of total assets and capital ratio, respectively

After establishing that exogenous house price shocks affect banks' capital ratio, I am going to look at some of the components of the bank balance sheets that drove some contractions. These are components directly related to the performance of loans that faced a historical high default rates during the period in analysis. The direct effect on poor loan performance is not trivial due to the diverse mechanisms of insurance previously described. Therefore, instead of presenting a simple decomposition, I use the same approach to infer causality of house price shocks in the evolution of these key elements of a bank's capital.

### 4.4 Non-Performing Loans

Non-performing loans (NPL) are defined as the total loans and lease financing past due by 90 days or more. The fraction of non-performing loans over total loans was stable around 1 percent until 2006 but reached its peak of 5 percent in 2010. The proportional change was significantly higher for larger banks. While the unweighted mean increased by roughly 3 percentage points between 2006 and 2010, the asset weighted mean increased by 4 percentage points (Figure 6). The yearly growth rate was stable over this period with the non-performing loans ratio increasing by approximately 1.1 percentage points on a yearly basis. Table 6 shows a significant increase in the heterogeneity over time.

Figure 6: Non-Performing Loans




Source: Call Reports.

Table 6: Non-Performing Loans

| | Mean | SD | Median | Perc10 | Perc90 |
|---|---|---|---|---|---|
| **Non-Performing Loans - Weighted** | | | | | |
| 2006 | .7105 | .9437 | .5618 | .0869 | 1.472 |
| 2010 | 4.9291 | 3.3745 | 4.9353 | .7782 | 7.9338 |
| Annual Change (2006-2010) | 1.1374 | 1.8264 | .8379 | -.2128 | 3.3204 |
| **Non-Performing Loans - Unweighted** | | | | | |
| 2006 | .8217 | 1.9105 | .448 | 0 | 1.9331 |
| 2010 | 3.1796 | 4.2436 | 1.8849 | .192 | 7.3022 |
| Annual Change (2006-2010) | .6738 | 2.2162 | .2079 | -.5752 | 2.3346 |

Source: Call Reports. Non-performing loans are normalized by total loans. Weighted statistics are computed using total assets as weights.

Table 7 reports the coefficients of the regression (4) for non-performing loans. A large negative RES predicts more non-performing loans. The result is robust to the instrumentalization of house prices (column 4). A negative exogenous variation in the real estate prices of 10 percent leads to an increase of 1.3 percentage points of the non-performing loans ratio.

Table 7: RES and NPL

| | OLS | IV | OLS | IV |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| RES(t) | -0.084*** | -0.135*** | -0.076*** | -0.134*** |
| | (0.005) | (0.012) | (0.005) | (0.013) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.043 | 0.027 | 0.079 | 0.063 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Variation of non-performing loans over total loans (NPL). The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 20.

The marginal impact tends to be negatively correlated with bank size. Although the difference is not very large, Figure 7 shows some decline across quantiles. But the effect is not linear. Banks in the first and fifth quantile of bank size have similar marginal effects. If we look over capital ratio quantiles, we find a positive trend. Bigger banks tend to assume a higher fraction of NPL induced by RES. Although some negative trend is evident, the marginal effects are not statistically distinguishable across size and capital quantiles.

Figure 7: Marginal Effects by Assets Quantiles

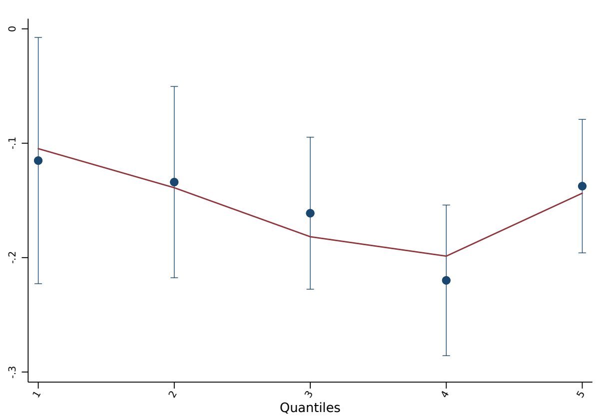
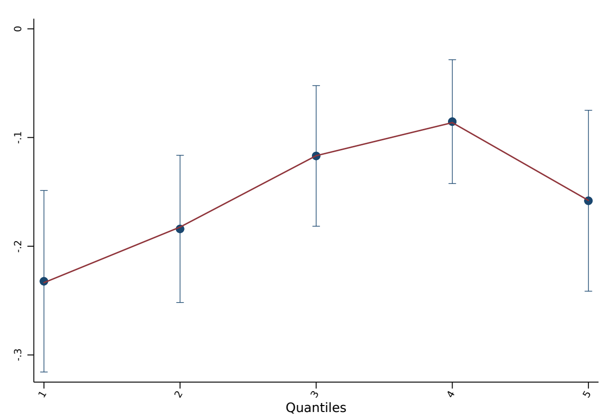



Figure 8: Marginal Effects by Capital Quantiles

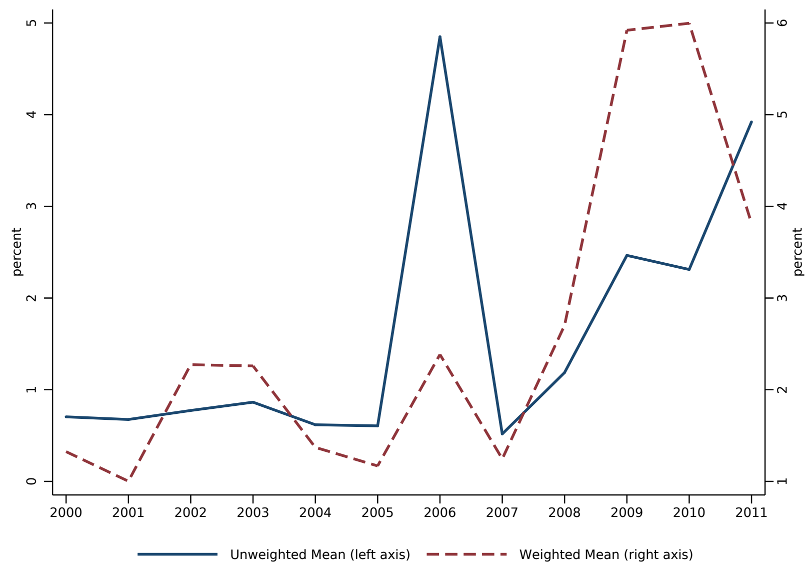



Note: The figures show the estimated marginal effects of RES on NPL ratio implied by the regression specification in column (4) of Table 7 for a given quantile of total assets and capital ratio, respectively.

### 4.5 Net Charge-Offs

Here I look at net charge-offs (NCO) normalized by total loans. Between 2000 and 2005, NCO fluctuated between 1 and 2 percent, but increased significantly in 2008 and 2009 when they reached 6 percent of the total loans. Figure 6 shows a different behavior of NCO for small and large banks. While bigger banks increased their NCO in 2008 and 2009, smaller banks faced a large increase, mostly in 2006, which explains the large dispersion of NCO across banks in 2006, as reported in Table 8.

Figure 9: Charge-Off




Source: Call Reports

Table 8: Net Charge-Offs

| | Mean | SD | Median | Perc10 | Perc90 |
|---|---|---|---|---|---|
| **NCO - Weighted** | | | | | |
| 2006 | 2.3842 | 234.2047 | .3858 | .0206 | 1.8862 |
| 2010 | 5.997 | 5.9971 | 5.2665 | .7586 | 9.1739 |
| Annual Change (2006-2010) | 1.0773 | 69.3387 | .6285 | -.9771 | 3.8569 |
| **NCO - Unweighted** | | | | | |
| 2006 | 4.8504 | 400.3613 | .1076 | -.0463 | .9472 |
| 2010 | 2.3115 | 4.0729 | 1.0055 | .0006 | 6.1268 |
| Annual Change (2006-2010) | -.6718 | 207.7758 | .1141 | -.8097 | 2.4895 |

Source: Call Reports. NCO are normalized by total loans. Weighted statistics are computed using total assets as weights.

Table 9 reports the coefficients of the regression (4) for NCO. I find that a larger negative RES predicts a larger fraction of NCO of total loans. Going from the 90th to the 10th percentile of the RES distribution (15 percentage points) implies that the NCO ratio decreases by 3 percentage points.

Table 9: RES and NCO

| | OLS<br>(1) | IV<br>(2) | OLS<br>(3) | IV<br>(4) |
|---|---|---|---|---|
| RES(t) | -0.125*** | -0.207*** | -0.132*** | -0.207*** |
| | (0.008) | (0.019) | (0.008) | (0.020) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.026 | 0.015 | 0.086 | 0.079 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in NCO over total loans. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 21.

According to figure 10, the marginal impact of RES on NCO is smaller for bigger banks, which aligns with the evidence found for NPL. However, heterogeneity in terms of capital ratios seems to not be important for explaining the impact of RES on NCO.

Figure 10: Marginal Effects by Assets Quantiles

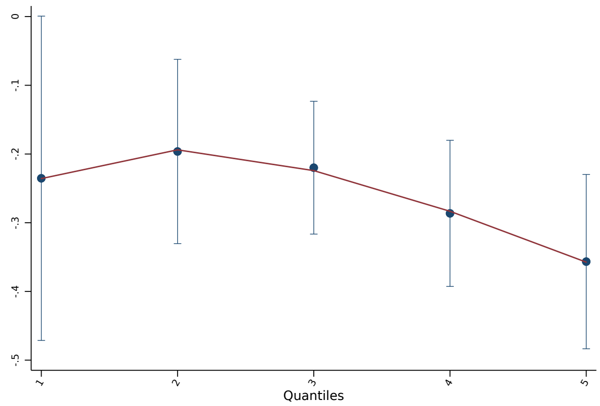
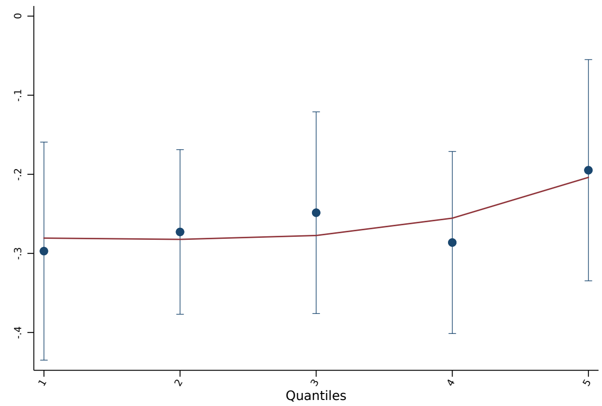



Figure 11: Marginal Effects by Capital Quantiles

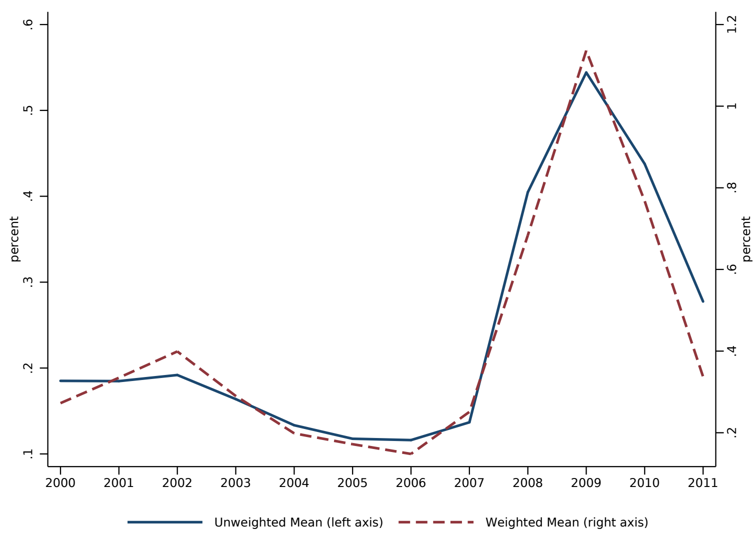



Note: The figures show the estimated marginal effects of RES on NCO ratio implied by the regression specification in column (4) of Table 9 for a given quantile of total assets and capital, respectively.

## 4.6 Provisions

Lastly, I look at provisions over total assets that increased by 1.2 percentage points between 2007 and 2009. Heterogeneity across banks is not significant but increased over time.

Figure 12: Provisions




Source: Call Reports

Table 10: Provisions

| | Mean | SD | Median | Perc10 | Perc90 |
|---|---|---|---|---|---|
| **Provisions - Weighted** | | | | | |
| 2006 | .1481 | .3122 | .0838 | 0 | .2578 |
| 2010 | .7678 | .9626 | .5355 | .0441 | 1.2659 |
| Annual Change (2006-2010) | .139 | 1.2707 | .0908 | -.4889 | .721 |
| **Provisions - Unweighted** | | | | | |
| 2006 | .1161 | .357 | .0605 | 0 | .261 |
| 2010 | .4378 | .7203 | .2175 | .0065 | 1.0762 |
| Annual Change (2006-2010) | .1194 | 4.8 | .0167 | -.1721 | .4721 |

Source: Call Reports. Provisions are normalized by total assets. Weighted statistics are computed using total assets as weights.

According to Table 11 RES also has predictor power in terms of provisions. A large negative RES predicts a larger fraction of provisions over total assets. A negative exogenous variation in the real estate prices of 10 percent leads to an increase of 0.42 percentage points of the provisions normalized by total assets.

Table 11: RES and Provisions

| | OLS (1) | IV (2) | OLS (3) | IV (4) |
|---|---|---|---|---|
| RES(t) | -0.031*** | -0.043*** | -0.027*** | -0.042*** |
| | (0.002) | (0.004) | (0.002) | (0.004) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.038 | 0.033 | 0.110 | 0.103 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in provisions over total assets. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 11.

Once again, the marginal effect tends to be lower for bigger banks but differences are not significant. But the response of provisions to RES seems to be invariant to banks' capital distribution.

Figure 13: Marginal Effects by Assets Quantiles

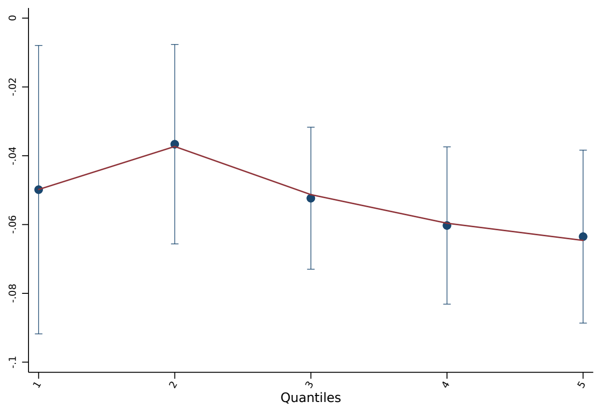
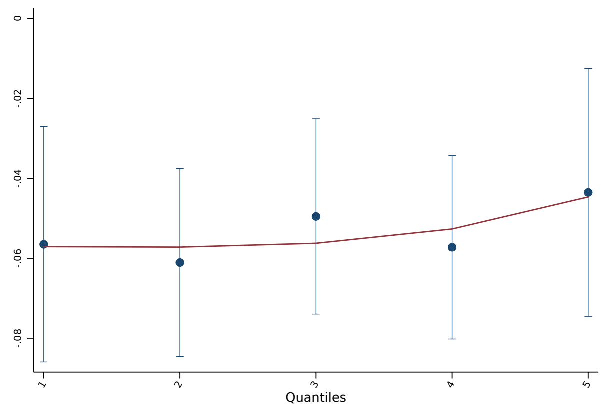



Figure 14: Marginal Effects by Capital Quantiles




Note: The figures show the estimated marginal effects of RES on provision ratio implied by the regression specification in column (4) of Table 11 for a given quantile of total assets and capital ratio, respectively.

# 5 Bank Balance Sheets and Lending

In the previous section I established a causal relationship between local house price shocks and the deterioration of several components of the banks' balance sheets. In this section I look at the impact of these shocks that originated in the housing market on the credit supply.

During the bust period we observed a large decline in mortgage originations, both in terms of quantities and dollar amount (figures 16 and 15). This drop could be entirely driven by a decline in the demand for mortgages as households decided to deleverage following the house price drop. It could also be argued that the decline in house prices was driven by an exogenous contraction in demand for housing and therefore the decline in mortgage credit reflects less need for housing finance.

Figure 15: Number of Loans Originated

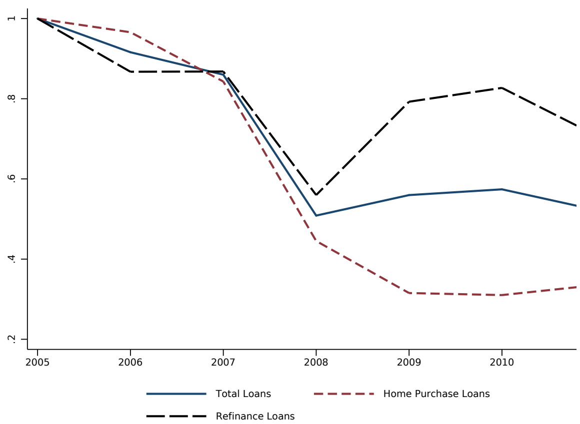
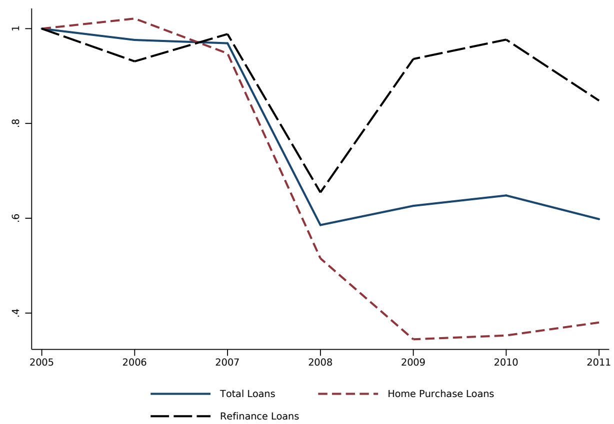



Figure 16: Loan Amount Originated




Source: HMDA

However, recent literature has shown that during this period there was in fact a contraction of the credit supply. Most of these studies tend to look at the contraction of credit supply of small business loans. One of the few exceptions that also isolates the decline of the mortgage supply is Gilchrist, Siemer and Zakrajšek (2018), which shows, using HMDA data, that the decline of supply of mortgages was actually larger than the decline of supply of business loans.

Here I revisit this question but differ from Gilchrist, Siemer and Zakrajšek (2018) by looking at the mechanism that drove such a contraction. Specifically, I analyze the mechanism of transmission of house price shocks into the mortgage supply as identified in Paixão (2018).

Most of the theoretical literature that analyzes the transmission of house price shocks assumes a frictionless financial sector. In such models, the credit supply is perfectly elastic when controlled for household risk and aggregate factors. The health of the banking system plays no role. Instead, Paixão (2018) introduces a banking sector with balance sheet frictions in a model of heterogenous agents, incomplete markets and long-term collateralized debt with risk of default. Homeowners can access the mortgage market for the purchase of new homes or refinancing. Banks face a smooth leverage cost that translates into higher funding cost when the banks' leverage goes above a certain threshold. This can be seen as a flexible leverage constraint that allows banks to trade off higher leverage at a higher cost. In the case of a negative shock to their net worth, banks are not forced to deleverage immediately, as occurred during the Great Recession and is shown in Figure 2. In opposition to most of the literature, the credit supply depends on both household risk and capitalization of the banking system. When house prices drop exogenously, home equity drops and foreclosures increase. Such losses impact banks' capital and their leverage increases. The cost of the more leveraged banks increases, which leads to a contraction in the credit supply.

In this section, I test such a mechanism; i.e., I test whether banks that became more constrained due to real estate shocks reduced their credit supply more.

### 5.1 Identification

Testing the impact of RES on loan availability through the bank balance sheet channel raises several concerns. The main challenge is to disentangle credit supply from credit demand, since changes in house prices may simultaneously affect both. Moreover, households that are more affected by the drop in house prices and economic conditions may borrow more from the affected banks.

I address these questions in two ways. First, I implement an instrumental variable approach similar to the one used in the previous section. Second, due to the lack of relevant information on household creditworthiness in the HMDA data,[2] I conduct the analysis at the county level and use county-level information to control for changes in demand for housing.

There are in fact two arguments in favor of using county as the unit of analysis rather than individual-level data. The first relates to selection in the application process. Households choose which banks to apply to. If they suspect that some bank is having difficulties and guess that it will be harder to obtain a loan from that bank, individuals in a certain county may concentrate their loan applications at healthy banks. If this happens, we might find that the acceptance rate decreases at the healthy banks but not at the most constrained banks. Therefore, we may have demand and supply moving simultaneously with changes in banks' balance sheets and, therefore, we cannot disentangle the two. My approach implicitly assumes that households do not look for mortgages outside the county where the property is located, which seems a reasonable assumption given that a county is a sufficiently large geographic area.

The second reason speaks to the fact that ultimately we care about the overall availability

[2]The HMDA data set, though it covers almost all mortgage applications in the U.S., has very little information on household characteristics, especially about how the creditworthiness of the applicant pool changes over this period. Specifically, there is no information about credit score or employment status. Applicant's information is limited to race and gender, besides property's characteristics.

of credit. Even if the more affected banks contracted the credit supply, more healthy banks can fill the gap, maintaining the overall credit supply unchanged. The difference can be closed by banks already present in the county or banks that decide to expand to new geographies, taking advantage of potentially unrealized profitable lending opportunities. This question is even more relevant due to the existence of non-depository institutions that are very active in the mortgage market and that face different regulatory rules. I explore this dimension in section 5.3.

In order to identify how exogenous variation in house prices affects the credit supply through the impact on banks' capital ratio, I explore heterogeneity in counties' exposure to more constrained banks. In other words, I regress the change in banks' capital ratio induced by the RES on yearly changes in mortgage originations in a given county, as expressed in the following equation:

$$\Delta \text{MortgageOriginated}_{j,t} = \gamma_1 + \gamma_2 \Delta \Upsilon_{j,t} + \gamma_3 \Delta H_{j,t} + \gamma_3 W_{j,05} + \epsilon_{j,t} \tag{5}$$

$\Delta \Upsilon_{j,t}$ is a measure of banking health in county $j$, $\Delta H_{j,t}$ include county-level economic conditions, and $W_{j,05}$ are bank controls. I aggregate bank-specific variables to the county level by weighting banks by their share of mortgage market in that county in 2005.

$\Delta \Upsilon_{j,t}$ corresponds to the change in the banks' capital ratio presented at county $j$ at time $t$ induced by exogenous variation in house prices. It is constructed by aggregating the bank-specific predicted value of equation (4), $\Delta \widehat{Y_{k,t,-j}}$. This variable measures the change in bank $k$ capital ratio predicted by bank-specific $RES_{k,t}$. To guarantee that the variation is exogenous, I use the predicted values of the IV regression, column 4 of regression (4). Note that $\Delta \widehat{Y_{k,t,-j}}$ is the change in capital of the bank as a whole, not the change in capital attributed to that specific county.[3] To further isolate changes in the creditworthiness at the county level simultaneously affecting banks' capital ratio and credit supply and to avoid confounding factors with demand forces, I consider only banks that operate in multiple counties and

[3] In Cuñat, Cvijanović and Yuan (2018) banks are considered to be conglomerates of local branches, and therefore they construct a measure of the bank's balance sheet at the branch level. In their formulation $Y_{it}$ would measure the change in capital of bank $i$ attributed to county $j$. However, my goal is to identify how shocks to a bank in a certain county affect lending in other counties due to the impact on that bank's balance sheet.

remove the contribution of that specific county to the drop in banks' capital. In other words, I consider the bank-specific RES net of the house prices change in that specific county:

$$\Delta\widehat{Y_{k,t,-j}} = \widehat{\beta}_1^{IV}(RES_{k,t} - RES_{k,t,j}) + controls \tag{6}$$

with $RES_{k,t}$ defined in (1) and $RES_{k,t,j} = \omega_{k,j,05}\Delta P_{j,t}$.

To aggregate the bank variables at the county level, I weight the bank variables by the share of outstanding mortgages in the county in 2005, expressing the relative importance of each bank in a given county:

$$\alpha_{k,j,t} = \frac{Outstd_{k,j,05}}{\sum_{k' \in B_j} Outstd_{k',j,05}} \tag{7}$$

where $B_j$ is the set of banks present in county $j$. Therefore, $\Delta\Upsilon_{j,t}$ is given by:

$$\Delta\Upsilon_{j,t} = \sum_{k \in B_j} \alpha_{k,j,05}\Delta\widehat{Y_{k,t,-j}} \tag{8}$$

Note that running this specification at the bank level would be similar to a 3-stage least square approach. Also note that by considering only banks that operate in multiple counties and by removing the contribution of that specific county to the changes in bank capital, I am identifying how shocks to a bank's balance sheet elsewhere affect the lending policies in a different county - in other words, how the credit supply in a given county is influenced by shocks that originated in other counties due to their impact on a bank's capital ratio.

The counties with the largest drop in the "county capital ratio" are those served by banks that faced a larger drop in capital ratio induced by exogenous house price shocks in other counties where banks are present.

To proxy for changes in the creditworthiness of potential borrowers, I control for changes in house prices, changes in the unemployment rate and changes in income at the county level, $\Delta H_{j,t}$. $W_{j,05}$ are bank controls at the county level, using $\alpha_{k,j,05}$ as weights.

As in Mian, Rao and Sufi (2013), all standard errors are clustered at the state level to allow for spatial correlation across counties within a state, and to allow for correlation within a state due to state-specific factors, such as foreclosure and bankruptcy laws.

## 5.2 Bank Balance Sheets and the Credit Supply

In this section I present the results of equation (5) for the 2006-2010 period using as dependent variables the percentage change in mortgage loan amount origination from depository institutions (banks present in Call Reports) and the number of mortgages at the county level. I look separately for home purchase mortgages and refinancing.

From Table 12 I conclude that counties that face a larger drop in their capital ratio induced by RES faced a larger decline in the total number and volume of mortgages originated for home purchase. The results are both statistically and economically significant at all specifications. The first column shows the results with year and state fixed effects and the second column with year and county fixed effects. To better isolate changes in the demand for loans, I consider state-time fixed effects and include changes in house prices, wages, income and unemployment rate at the county level in column 3.

Table 12: Home Purchase Loans Originated by Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ capital ratio | 87.427* | 155.238** | 107.771*** | 110.812* | 190.043** | 106.569*** |
| | (35.507) | (44.958) | (24.543) | (42.348) | (54.449) | (24.578) |
| Δ house prices | 0.613 | -0.273 | 1.316 | -0.920 | -1.837 | 0.571 |
| | (0.693) | (1.029) | (0.771) | (0.935) | (1.268) | (0.763) |
| Δ wages | -1.318 | -3.177 | -1.026 | -4.207 | -6.904 | -2.375 |
| | (3.351) | (4.369) | (2.051) | (4.078) | (5.473) | (1.714) |
| Δ income | -1.619 | -2.136 | -0.744 | -0.893 | -1.432 | -0.386 |
| | (0.983) | (1.083) | (1.039) | (1.080) | (1.116) | (0.870) |
| Δ unemp rate | -0.126 | -0.105 | -0.068 | -0.171 | -0.150 | -0.048 |
| | (0.101) | (0.100) | (0.039) | (0.120) | (0.123) | (0.044) |
| Observations | 2973 | 2973 | 2963 | 2973 | 2973 | 2963 |
| Adjusted $R^2$ | 0.340 | 0.283 | 0.562 | 0.331 | 0.249 | 0.610 |
| Cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Notes. Dependent variable: Change in home purchase loans originated by banks only. The unit of observation is a county. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 23.

According to the last specification, going from the 90th to the 10th percentile of the change in capital ratio in the cross-section distribution (1.3 percentage points) implies a decrease in the supply of home purchase mortgages of 140 percent in terms of volume originated.

Although column (3) presents similar results for both the number and the amount of the supply of home purchase mortgages, the first two specifications suggest a larger drop in the number than in the volume of originations. This result is aligned with the evidence that the average mortgage size increased during this period. This result also indicates that the credit supply may have shifted to less risky borrowers that tend to purchase larger homes.

Table 13: Refinance Loans Originated by Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ capital ratio | 172.674** | 306.758*** | 171.476*** | 206.502** | 362.023*** | 177.033*** |
| | (50.479) | (67.645) | (43.688) | (63.019) | (82.727) | (48.492) |
| Δ house prices | -1.419 | -3.967* | -0.944 | -1.964 | -4.534* | 0.498 |
| | (1.241) | (1.482) | (1.597) | (1.583) | (2.049) | (1.583) |
| Δ wages | -9.996 | -15.807* | -6.534 | -13.709 | -21.775* | -9.993* |
| | (5.954) | (7.063) | (3.275) | (7.797) | (10.028) | (4.195) |
| Δ income | -0.691 | -1.193 | 0.337 | -1.607 | -2.080 | -0.317 |
| | (1.851) | (2.027) | (1.551) | (1.911) | (2.203) | (1.028) |
| Δ unemp rate | -0.211 | -0.188 | -0.089 | -0.245 | -0.220 | -0.047 |
| | (0.210) | (0.219) | (0.083) | (0.265) | (0.278) | (0.088) |
| Observations | 2976 | 2976 | 2966 | 2976 | 2976 | 2966 |
| Adjusted $R^2$ | 0.419 | 0.364 | 0.636 | 0.399 | 0.324 | 0.686 |
| Cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Notes. Change in refinance loans originated by banks only. The unit of observation is a county. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 24.

The effects are even stronger if we look at the refinance loans (see Table 13). The most conservative estimate predicts that counties with a larger drop in the "county capital ratio" (10th percentile) face a drop in the credit supply of refinance loans 107 percentage points higher than the less affected counties (90th percentile).

These results show that house price shocks lead to a decrease in the credit supply through the impact of losses on banks' balance sheets. Therefore, the banking system is an important source of propagation of shocks that originated in the housing market. The decline in the credit supply must reinforce endogenously the initial drop in house prices and, therefore, also be an important source of amplification, confirming the theoretical results in Paixão (2018).

Given that I restrict the sample to banks present in multiple counties and that I exclude the contribution of the county itself in the measure of the county-level predicted drop in capital ratio, the results identify how shocks in the different locations affect the lending in other areas, irrespective of the local conditions. So, the banking system propagates and amplifies house price shocks across space due to the impact of local shocks on banks' overall capital ratio.

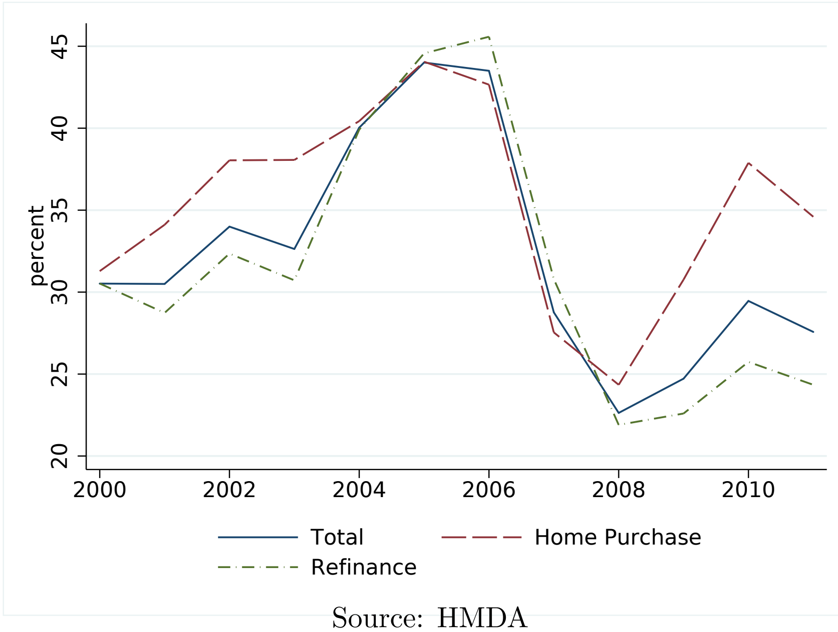
### 5.3 Bank Balance Sheets and Shadow Banking

In the analyses above I look at the change in the credit supply of depository institutions. However, the share of mortgages originated by shadow banks, non-depository institutions that face less strict regulatory constraints, was consistently above 30 percent, reaching its peak in 2005 with a share of 43 percent. Although it dropped considerably in 2007 and 2008, it started increasing again in 2009 and 2010 (see Figure 17).

In this section I analyze whether the contraction of the banking credit supply was attenuated by the presence of shadow banks in the mortgage market. Since house price shocks contract the credit supply through the effect on banks' capital ratio, institutions that face less strict regulatory constraints may behave differently. It may then be possible that the shadow banks closes the gap created by traditional banks. This is a crucial question, since ultimately we care about the impact of house price shocks on the overall credit supply.

To address this question I redo the previous exercise looking at the overall change in the credit supply (supply of traditional banks and shadow banks).

Figure 17: Share of Loans Originated by Shadow Banks




Source: HMDA

Table 14: Home Purchase Loans Originated by Banks and Shadow Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ capital ratio | 4.995** | 4.198* | 5.066** | 5.395*** | 4.427* | 5.873** |
| | (1.501) | (1.696) | (1.804) | (1.516) | (2.066) | (1.682) |
| Δ house prices | 0.366*** | 0.266* | 0.214 | -0.017 | -0.083 | 0.007 |
| | (0.084) | (0.106) | (0.115) | (0.107) | (0.131) | (0.129) |
| Δ wages | 0.612** | 0.866*** | 0.894*** | 0.430* | 0.615** | 0.712*** |
| | (0.195) | (0.219) | (0.179) | (0.192) | (0.214) | (0.187) |
| Δ income | 0.236* | 0.182 | 0.144 | 0.218* | 0.207* | 0.117 |
| | (0.099) | (0.107) | (0.079) | (0.090) | (0.098) | (0.081) |
| Δ unemployment rate | -0.017*** | -0.014** | -0.007 | -0.015** | -0.014** | -0.005 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| Observations | 3073 | 3073 | 3063 | 3073 | 3073 | 3063 |
| Adjusted $R^2$ | 0.439 | 0.351 | 0.417 | 0.395 | 0.291 | 0.392 |
| Cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Notes. Dependent variable: Change in home purchase loans originated by banks and shadow banks. The unit of observation is a county. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in Appendix A, Table 25.

The results presented in Table 14 are striking when compared with Table 12. Although shadow banks don't eliminate the contraction in credit of the traditional banking sector, the results show that they are an important source of mitigation. Counties with a higher presence of affected banks still face a higher drop in the credit supply of home purchase loans, but the difference in the cross-section between the counties in the 90th and 10th percentile is reduced to 7.5 percent.

Table 15: Refinance Loans Originated by Banks and Shadow Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ capital ratio | 13.451*** | 19.838*** | 11.919** | 11.319*** | 19.533*** | 12.669** |
| | (2.918) | (5.228) | (4.084) | (2.437) | (4.676) | (3.873) |
| Δ house prices | 0.973*** | 0.694* | 0.503 | 0.771** | 0.560* | 0.495 |
| | (0.236) | (0.268) | (0.266) | (0.223) | (0.245) | (0.257) |
| Δ wages | 1.396*** | 1.154** | 1.023* | 0.908** | 0.335 | 0.180 |
| | (0.332) | (0.414) | (0.443) | (0.315) | (0.393) | (0.360) |
| Δ income | -0.096 | -0.173 | -0.398** | -0.187 | -0.227 | -0.381** |
| | (0.155) | (0.161) | (0.143) | (0.140) | (0.157) | (0.133) |
| Δ unemployment rate | -0.020 | -0.009 | -0.023 | -0.018 | -0.010 | -0.022 |
| | (0.017) | (0.018) | (0.014) | (0.015) | (0.015) | (0.011) |
| Observations | 3073 | 3073 | 3063 | 3073 | 3073 | 3063 |
| Adjusted $R^2$ | 0.711 | 0.672 | 0.789 | 0.708 | 0.674 | 0.798 |
| Cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Notes. Dependent variable: Change in Refinancing loans originated by banks and shadow banks. The unit of observation is a county. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively. The complete regression table is available in appendix A, table 26.

Shadow banks also have a mitigating effect in terms of refinancing loans, although the difference across counties remains higher than when compared with home purchase loans (see Table 15), the proportional change is actually higher.

These results then show that the banking sector reacts strongly to the contraction in house prices. However, shadow banking is important in mitigating the drop in the overall credit supply for homeowners. This is a crucial result since by looking only at the depository institutions, we are overestimating the real effect of house price shocks.

## 6 Conclusion

In this paper I study how local real estate shocks are propagated and amplified through the banking system. I investigate the impact of local house price shocks on bank balance sheets and the subsequent response of the banking sector.

Using regional variation and an instrumental variable approach following Charles, Hurst and Notowidigdo (2018), I find that banks played a big role in the transmission of shocks that originated in the housing market between 2006 and 2010. Banks with branches in counties that faced a higher exogenous housing price decline experienced a greater decrease in capital ratio and a larger increase in NCO and NPL. I don't find that these marginal effects vary substantially with bank size or capital position.

Despite the existence of several insurance mechanisms in the U.S. mortgage market (GSEs, securitization) that could potentially shield banks from shocks that originated in the housing market, these results show that bank losses are still very correlated with local economic conditions and that banks were then not able to diversify away from their own idiosyncratic geographic risk.

In the second part I test the transmission mechanism highlighted in Paixão (2018), which states that house price shocks are propagated through the banking system due to the impact on bank capital ratio.

The identification strategy explores heterogeneity in counties' exposure to more constrained banks. I construct a county-measure of capital ratio induced by exogenous change in house prices by aggregating across the banks present in the county. I find that mortgage originations decreased more in counties with a higher presence of distressed banks, i.e., banks that faced greater losses induced by real estate shocks. The banking system also propagates shocks across space, since credit supply contracts even in areas where local economic conditions didn't deteriorate significantly.

However, by focusing only on mortgages originated by banks, we tend to overestimate the negative impact of house prices on the credit supply. The drop in the credit supply by the banking system was attenuated by the presence of shadow banks, which face less strict regulatory constraints. The overall credit supply for new home purchases contracted by 5 percent more in counties with a higher presence of distressed banks (10th percentile) than in counties with a lower presence of affected banks (90th percentile). In terms of refinancing loans, the contraction is 12 percent higher in the most affected counties.

These results contribute to the current literature by revealing the impact of bank balance sheet shocks on the mortgage supply rather than corporate financing. Moreover, unlike in the current literature, I isolate the changes in the bank balance sheets resulting from variation in housing prices instead of monetary policy shocks. Finally, I show that we need to look at total mortgages originations rather than focusing only on bank-originated mortgages, since shadow banks are an important source of mitigation of such effects.

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# A Appendix

Table 16: Bank Controls

| | 2005 | | 2006-2009 | | 2006-2010 | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| log(assets) | 17.72114 | 2.63953 | -.0198028 | .2306353 | .0489068 | .213657 |
| Cash | .0433825 | .0484731 | .02944 | .0715453 | .0073514 | .0647065 |
| Deposits | .6285732 | .1988702 | .0350567 | .0420396 | .0129798 | .0476636 |
| Loans | .5467162 | .2034257 | -.0100137 | .0508883 | -.0126243 | .0562386 |
| Real Estate Loans | .4818417 | .2772164 | .0264964 | .0493967 | .0021581 | .0293224 |
| ROA | .007759 | .0061539 | -.0036406 | .0901358 | .0033857 | .1923383 |
| Loss Income | .0003356 | .0009964 | .0000116 | .0006085 | -.0000326 | .0003459 |
| Net Charge-offs | .0018164 | .0044291 | .0044356 | .0058142 | -.0001236 | .0057859 |
| Late Loans | .0022434 | .0036579 | .0081239 | .00936 | .0033162 | .0081757 |
| Late Loans - RE | .0029617 | .0039289 | .0191449 | .0187922 | .0080955 | .0139373 |
| Provisions | .0017198 | .0045511 | .0044722 | .0072674 | -.0045113 | .0074495 |
| Allowances | .0075387 | .0065248 | .0056279 | .0065008 | .0013776 | .0064074 |
| MBS | .1040957 | .0941221 | .0019536 | .0332171 | . | . |
| Deposit Interests | .0103453 | .003748 | -.006314 | .0025744 | -.0024565 | .0021145 |
| Interest Income | .0284993 | .0097444 | -.0053235 | .0704344 | -.0017348 | .0051541 |
| Interest Cost | .0107661 | .0030243 | -.006033 | .0109148 | -.0019804 | .001655 |

Source: Call Reports.

Table 17: RES and House Price breaks

| | Loans Kept | | | Loans Originated | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2a) | (3a) |
| RES (break) | -0.341*** | -0.312*** | -0.310*** | -0.348*** | -0.313*** | -0.312*** |
| | (0.015) | (0.015) | (0.015) | (0.014) | (0.013) | (0.013) |
| log(assets) | | -0.006*** | -0.006*** | | -0.005*** | -0.004*** |
| | | (0.001) | (0.001) | | (0.001) | (0.001) |
| Cash | | -0.039 | -0.041 | | -0.046* | -0.048* |
| | | (0.022) | (0.022) | | (0.021) | (0.020) |
| Deposits | | -0.024* | -0.024* | | -0.023** | -0.023** |
| | | (0.011) | (0.011) | | (0.009) | (0.009) |
| Loans | | -0.030*** | -0.029*** | | -0.027*** | -0.027*** |
| | | (0.007) | (0.007) | | (0.006) | (0.006) |
| Loans RE | | -0.051*** | -0.050*** | | -0.055*** | -0.054*** |
| | | (0.005) | (0.005) | | (0.004) | (0.004) |
| ROA | | -0.040 | -0.042 | | -0.053 | -0.055 |
| | | (0.045) | (0.045) | | (0.041) | (0.040) |
| ROE | | 0.056** | 0.058** | | 0.058*** | 0.059*** |
| | | (0.020) | (0.020) | | (0.017) | (0.016) |
| Late Loans | | -0.183 | -0.182 | | -0.094 | -0.095 |
| | | (0.139) | (0.139) | | (0.126) | (0.126) |
| Late Loans RE | | 0.311** | 0.312** | | 0.274* | 0.273* |
| | | (0.119) | (0.118) | | (0.108) | (0.107) |
| Net Charge-offs | | 0.196** | 0.196** | | 0.178** | 0.175** |
| | | (0.072) | (0.071) | | (0.062) | (0.062) |
| Allowances | | -0.170 | -0.168 | | -0.118 | -0.111 |
| | | (0.130) | (0.130) | | (0.112) | (0.111) |
| Provisions | | -0.066 | -0.064 | | -0.045 | -0.043 |
| | | (0.075) | (0.074) | | (0.060) | (0.060) |
| MBS | | -0.015 | -0.014 | | -0.017 | -0.016 |
| | | (0.010) | (0.010) | | (0.009) | (0.009) |
| Dep Interests | | 0.507** | 0.508** | | 0.528*** | 0.540*** |
| | | (0.160) | (0.159) | | (0.142) | (0.142) |
| Interest Income | | -0.054 | -0.050 | | -0.079 | -0.075 |
| | | (0.151) | (0.150) | | (0.132) | (0.131) |
| Observations | 11167 | 11164 | 11164 | 14144 | 14133 | 14133 |
| Adjusted $R^2$ | 0.151 | 0.204 | 0.325 | 0.159 | 0.210 | 0.321 |
| F | 513.1 | 63.45 | 63.58 | 642.5 | 78.83 | 79.33 |
| SD | robust | robust | robust | robust | robust | robust |
| Year FE | No | No | Yes | No | No | Yes |
| Bank controls | No | Yes | Yes | No | Yes | Yes |

Notes. Dependent variable: Real estate shock (RES). The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 18: RES and Capital Ratio

| | OLS<br>(1) | IV<br>(2) | OLS<br>(3) | IV<br>(4) |
|---|---|---|---|---|
| RES(t) | 0.089*** | 0.120*** | 0.084*** | 0.124*** |
| | (0.006) | (0.016) | (0.006) | (0.016) |
| Cash | | | 0.001 | 0.003 |
| | | | (0.009) | (0.009) |
| Deposits | | | 0.001 | 0.001 |
| | | | (0.004) | (0.004) |
| Loans | | | -0.001 | 0.001 |
| | | | (0.003) | (0.003) |
| Loans RE | | | -0.006*** | -0.004 |
| | | | (0.002) | (0.002) |
| ROA | | | -0.199*** | -0.198*** |
| | | | (0.030) | (0.031) |
| ROE | | | 0.100*** | 0.099*** |
| | | | (0.010) | (0.010) |
| Late Loans | | | -0.028 | -0.024 |
| | | | (0.061) | (0.062) |
| Late Loans RE | | | -0.049 | -0.071 |
| | | | (0.055) | (0.057) |
| Net Charge-offs | | | 0.063 | 0.046 |
| | | | (0.037) | (0.037) |
| Allowances | | | 0.041 | 0.057 |
| | | | (0.056) | (0.057) |
| Provisions | | | -0.120*** | -0.106** |
| | | | (0.034) | (0.033) |
| MBS | | | 0.001 | 0.002 |
| | | | (0.004) | (0.004) |
| Dep Interests | | | -0.158* | -0.191** |
| | | | (0.062) | (0.064) |
| Interest Income | | | -0.207*** | -0.216*** |
| | | | (0.060) | (0.060) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.036 | 0.031 | 0.090 | 0.084 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in Capital to Assets Ratio. Variables are normalized by total assets. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 19: RES and Risk-adjusted Capital Ratio

| | OLS<br>(1) | IV<br>(2) | OLS<br>(3) | IV<br>(4) |
|---|---|---|---|---|
| RES(t) | 0.085*** | 0.126*** | 0.084*** | 0.130*** |
| | (0.006) | (0.015) | (0.006) | (0.016) |
| Cash | | | -0.002 | 0.001 |
| | | | (0.009) | (0.009) |
| Deposits | | | 0.000 | 0.000 |
| | | | (0.004) | (0.004) |
| Loans | | | 0.000 | 0.003 |
| | | | (0.003) | (0.003) |
| Loans RE | | | -0.005** | -0.003 |
| | | | (0.002) | (0.002) |
| ROA | | | -0.167*** | -0.165*** |
| | | | (0.029) | (0.030) |
| ROE | | | 0.085*** | 0.083*** |
| | | | (0.009) | (0.010) |
| Late Loans | | | -0.019 | -0.015 |
| | | | (0.060) | (0.062) |
| Late Loans RE | | | -0.039 | -0.065 |
| | | | (0.055) | (0.057) |
| Net Charge-offs | | | 0.055 | 0.035 |
| | | | (0.037) | (0.037) |
| Allowances | | | -0.016 | 0.003 |
| | | | (0.055) | (0.057) |
| Provisions | | | -0.113*** | -0.098** |
| | | | (0.034) | (0.034) |
| MBS | | | -0.001 | 0.001 |
| | | | (0.003) | (0.004) |
| Dep Interests | | | -0.154* | -0.192** |
| | | | (0.060) | (0.063) |
| Interest Income | | | -0.230*** | -0.241*** |
| | | | (0.058) | (0.059) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.035 | 0.026 | 0.077 | 0.069 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in Risk-adjusted Capital to Assets Ratio. The unit of observation is a bank. **,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 20: RES and NPL

| | OLS<br>(1) | IV<br>(2) | OLS<br>(3) | IV<br>(4) |
|---|---|---|---|---|
| RES(t) | -0.084*** | -0.135*** | -0.076*** | -0.134*** |
| | (0.005) | (0.012) | (0.005) | (0.013) |
| Cash | | | 0.003 | -0.001 |
| | | | (0.007) | (0.007) |
| Deposits | | | 0.001 | 0.002 |
| | | | (0.003) | (0.003) |
| Loans | | | 0.004* | 0.001 |
| | | | (0.002) | (0.002) |
| Loans RE | | | 0.009*** | 0.006*** |
| | | | (0.001) | (0.001) |
| ROA | | | 0.025 | 0.023 |
| | | | (0.019) | (0.020) |
| ROE | | | 0.002 | 0.004 |
| | | | (0.007) | (0.007) |
| Late Loans | | | -0.054 | -0.060 |
| | | | (0.045) | (0.048) |
| Late Loans RE | | | 0.034 | 0.065 |
| | | | (0.041) | (0.043) |
| Net Charge-offs | | | -0.065* | -0.040 |
| | | | (0.029) | (0.029) |
| Allowances | | | 0.026 | 0.002 |
| | | | (0.045) | (0.046) |
| Provisions | | | 0.110*** | 0.091*** |
| | | | (0.028) | (0.027) |
| MBS | | | -0.001 | -0.003 |
| | | | (0.002) | (0.002) |
| Dep Interests | | | 0.208*** | 0.255*** |
| | | | (0.045) | (0.048) |
| Interest Income | | | 0.105* | 0.118* |
| | | | (0.045) | (0.046) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.043 | 0.027 | 0.079 | 0.063 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in NPL. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 21: RES and NCO

| | OLS (1) | IV (2) | OLS (3) | IV (4) |
|---|---|---|---|---|
| RES(t) | -0.125*** | -0.207*** | -0.132*** | -0.207*** |
| | (0.008) | (0.019) | (0.008) | (0.020) |
| Cash | | | -0.007 | -0.011 |
| | | | (0.009) | (0.009) |
| Deposits | | | -0.009* | -0.009* |
| | | | (0.004) | (0.004) |
| Loans | | | 0.012*** | 0.008** |
| | | | (0.003) | (0.003) |
| Loans RE | | | 0.004* | -0.000 |
| | | | (0.002) | (0.002) |
| ROA | | | 0.059 | 0.057 |
| | | | (0.033) | (0.034) |
| ROE | | | 0.006 | 0.008 |
| | | | (0.011) | (0.011) |
| Late Loans | | | -0.142* | -0.149* |
| | | | (0.064) | (0.066) |
| Late Loans RE | | | 0.077 | 0.117 |
| | | | (0.061) | (0.063) |
| Net Charge-offs | | | -0.033 | -0.001 |
| | | | (0.045) | (0.045) |
| Allowances | | | 0.160* | 0.129 |
| | | | (0.069) | (0.071) |
| Provisions | | | 0.151*** | 0.127** |
| | | | (0.044) | (0.043) |
| MBS | | | 0.000 | -0.003 |
| | | | (0.004) | (0.004) |
| Dep Interests | | | 0.333*** | 0.392*** |
| | | | (0.067) | (0.071) |
| Interest Income | | | 0.010 | 0.027 |
| | | | (0.069) | (0.070) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.026 | 0.015 | 0.086 | 0.079 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in NCO. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 22: RES and Provisions

| | OLS (1) | IV (2) | OLS (3) | IV (4) |
|---|---|---|---|---|
| RES(t) | -0.031*** | -0.043*** | -0.027*** | -0.042*** |
| | (0.002) | (0.004) | (0.002) | (0.004) |
| Cash | | | -0.002 | -0.003 |
| | | | (0.002) | (0.002) |
| Deposits | | | -0.001 | -0.001 |
| | | | (0.001) | (0.001) |
| Loans | | | 0.003*** | 0.003*** |
| | | | (0.001) | (0.001) |
| Loans RE | | | 0.001* | -0.000 |
| | | | (0.000) | (0.000) |
| ROA | | | 0.010 | 0.009 |
| | | | (0.006) | (0.006) |
| ROE | | | 0.001 | 0.001 |
| | | | (0.002) | (0.002) |
| Late Loans | | | -0.027* | -0.028* |
| | | | (0.013) | (0.014) |
| Late Loans RE | | | 0.018 | 0.026* |
| | | | (0.012) | (0.013) |
| Net Charge-offs | | | -0.007 | -0.001 |
| | | | (0.008) | (0.008) |
| Allowances | | | 0.033* | 0.026* |
| | | | (0.013) | (0.013) |
| Provisions | | | 0.017* | 0.012 |
| | | | (0.007) | (0.007) |
| MBS | | | -0.001 | -0.001 |
| | | | (0.001) | (0.001) |
| Dep Interests | | | 0.062*** | 0.074*** |
| | | | (0.013) | (0.014) |
| Interest Income | | | 0.007 | 0.010 |
| | | | (0.013) | (0.013) |
| Observations | 11167 | 11167 | 11164 | 11164 |
| Adjusted $R^2$ | 0.038 | 0.033 | 0.110 | 0.103 |
| Cluster | Bank | Bank | Bank | Bank |
| Bank Controls | No | No | Yes | Yes |
| Year FE | No | No | Yes | Yes |

Notes. Dependent variable: Change in Provisions. The unit of observation is a bank. ***,**,* Coefficients significant at the 1%, 5% and 10% levels, respectively.

Table 23: Home Purchase Loans - Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ Capital Ratio | 87.427* | 155.238** | 107.771*** | 110.812* | 190.043** | 106.569*** |
| | (35.507) | (44.958) | (24.543) | (42.348) | (54.449) | (24.578) |
| Δ house prices | 0.613 | -0.273 | 1.316 | -0.920 | -1.837 | 0.571 |
| | (0.693) | (1.029) | (0.771) | (0.935) | (1.268) | (0.763) |
| Δ wages | -1.318 | -3.177 | -1.026 | -4.207 | -6.904 | -2.375 |
| | (3.351) | (4.369) | (2.051) | (4.078) | (5.473) | (1.714) |
| Δ income | -1.619 | -2.136 | -0.744 | -0.893 | -1.432 | -0.386 |
| | (0.983) | (1.083) | (1.039) | (1.080) | (1.116) | (0.870) |
| Δ unemp rate | -0.126 | -0.105 | -0.068 | -0.171 | -0.150 | -0.048 |
| | (0.101) | (0.100) | (0.039) | (0.120) | (0.123) | (0.044) |
| log(assets) | 0.078 | | | 0.046 | | |
| | (0.061) | | | (0.068) | | |
| Cash | -1.712 | | | -1.805 | | |
| | (4.986) | | | (5.063) | | |
| Deposits | -2.249* | | | -3.361* | | |
| | (1.112) | | | (1.351) | | |
| Loans | -1.372* | | | -1.399 | | |
| | (0.623) | | | (0.715) | | |
| RE Loans | -0.896 | | | -1.245* | | |
| | (0.479) | | | (0.533) | | |
| ROA | 7.937 | | | 8.201 | | |
| | (7.981) | | | (9.094) | | |
| ROE | -4.249 | | | -5.615 | | |
| | (3.438) | | | (3.920) | | |
| NPL | -45.670 | | | -42.448 | | |
| | (27.872) | | | (27.781) | | |
| NPL - RE | -4.704 | | | -11.279 | | |
| | (21.502) | | | (27.261) | | |
| Provisions | 41.622 | | | 70.711 | | |
| | (61.226) | | | (71.818) | | |
| Allowances | -63.748* | | | -80.369* | | |
| | (31.282) | | | (34.428) | | |
| NCO | -62.937 | | | -92.601 | | |
| | (57.498) | | | (64.919) | | |
| NPL | 131.498** | | | 139.914** | | |
| | (38.390) | | | (41.159) | | |
| MBS | 0.009 | | | -0.117 | | |
| | (1.057) | | | (1.089) | | |
| Deposit Interests | 42.149* | | | 47.853* | | |
| | (17.871) | | | (18.882) | | |
| Interest Income | -40.359 | | | -44.439 | | |
| | (24.663) | | | (27.253) | | |
| Observations | 2973 | 2973 | 2963 | 2973 | 2973 | 2963 |
| Adjusted $R^2$ | 0.340 | 0.283 | 0.562 | 0.331 | 0.249 | 0.610 |
| cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Table 24: Refinancing Loans - Banks

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ Capital Ratio | 172.674** | 306.758*** | 171.476*** | 206.502** | 362.023*** | 177.033*** |
| | (50.479) | (67.645) | (43.688) | (63.019) | (82.727) | (48.492) |
| Δ house prices | -1.419 | -3.967* | -0.944 | -1.964 | -4.534* | 0.498 |
| | (1.241) | (1.482) | (1.597) | (1.583) | (2.049) | (1.583) |
| Δ wages | -9.996 | -15.807* | -6.534 | -13.709 | -21.775* | -9.993* |
| | (5.954) | (7.063) | (3.275) | (7.797) | (10.028) | (4.195) |
| Δ income | -0.691 | -1.193 | 0.337 | -1.607 | -2.080 | -0.317 |
| | (1.851) | (2.027) | (1.551) | (1.911) | (2.203) | (1.028) |
| Δ unemp rate | -0.211 | -0.188 | -0.089 | -0.245 | -0.220 | -0.047 |
| | (0.210) | (0.219) | (0.083) | (0.265) | (0.278) | (0.088) |
| log(assets) | 0.282* | | | 0.268 | | |
| | (0.111) | | | (0.134) | | |
| Cash | -5.984 | | | -4.796 | | |
| | (5.947) | | | (6.940) | | |
| Deposits | -3.533* | | | -5.516* | | |
| | (1.716) | | | (2.625) | | |
| Loans | -1.603 | | | -2.293 | | |
| | (0.957) | | | (1.320) | | |
| RE Loans | -1.514 | | | -1.881 | | |
| | (0.912) | | | (1.347) | | |
| ROA | 11.156 | | | 6.889 | | |
| | (14.738) | | | (15.111) | | |
| ROE | -6.992 | | | -8.315 | | |
| | (6.409) | | | (6.744) | | |
| NPL | -89.340 | | | -12.464 | | |
| | (56.168) | | | (61.875) | | |
| NPL - RE | -2.960 | | | -49.862 | | |
| | (72.574) | | | (76.986) | | |
| Provisions | -41.084 | | | -17.728 | | |
| | (82.200) | | | (85.687) | | |
| Allowances | -151.979** | | | -183.425** | | |
| | (45.845) | | | (53.337) | | |
| NCO | -12.862 | | | -82.145 | | |
| | (78.083) | | | (84.337) | | |
| NPL | 241.038** | | | 204.604 | | |
| | (79.773) | | | (110.843) | | |
| MBS | 2.582 | | | 0.802 | | |
| | (2.265) | | | (2.336) | | |
| Deposit Interests | 98.938* | | | 131.093** | | |
| | (37.025) | | | (44.641) | | |
| Interest Income | -51.830 | | | -53.901 | | |
| | (30.707) | | | (38.317) | | |
| Observations | 2976 | 2976 | 2966 | 2976 | 2976 | 2966 |
| Adjusted $R^2$ | 0.419 | 0.364 | 0.636 | 0.399 | 0.324 | 0.686 |
| cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Table 25: Home Purchase Loans - Total

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ Capital Ratio | 4.995** | 4.198* | 5.066** | 5.395*** | 4.427* | 5.873** |
| | (1.501) | (1.696) | (1.804) | (1.516) | (2.066) | (1.682) |
| Δ house prices | 0.366*** | 0.266* | 0.214 | -0.017 | -0.083 | 0.007 |
| | (0.084) | (0.106) | (0.115) | (0.107) | (0.131) | (0.129) |
| Δ wages | 0.612** | 0.866*** | 0.894*** | 0.430* | 0.615** | 0.712*** |
| | (0.195) | (0.219) | (0.179) | (0.192) | (0.214) | (0.187) |
| Δ income | 0.236* | 0.182 | 0.144 | 0.218* | 0.207* | 0.117 |
| | (0.099) | (0.107) | (0.079) | (0.090) | (0.098) | (0.081) |
| Δ unemployment rate | -0.017*** | -0.014** | -0.007 | -0.015** | -0.014** | -0.005 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| log(assets) | -0.001 | | | 0.001 | | |
| | (0.006) | | | (0.006) | | |
| Cash | 0.152 | | | 0.090 | | |
| | (0.358) | | | (0.319) | | |
| Deposits | -0.013 | | | -0.035 | | |
| | (0.074) | | | (0.094) | | |
| Loans | -0.001 | | | -0.012 | | |
| | (0.062) | | | (0.075) | | |
| RE Loans | -0.005 | | | -0.011 | | |
| | (0.042) | | | (0.055) | | |
| ROA | 1.136 | | | 1.008 | | |
| | (0.817) | | | (0.739) | | |
| ROE | -0.468 | | | -0.417 | | |
| | (0.331) | | | (0.314) | | |
| NPL | 1.438 | | | 0.641 | | |
| | (3.008) | | | (3.037) | | |
| NPL - RE | -1.437 | | | 0.045 | | |
| | (1.740) | | | (1.852) | | |
| Provisions | 1.911 | | | 0.067 | | |
| | (5.345) | | | (4.216) | | |
| Allowances | -3.679 | | | -3.470 | | |
| | (2.059) | | | (1.867) | | |
| NCO | 0.762 | | | 4.029 | | |
| | (3.991) | | | (3.272) | | |
| NPL | 1.831 | | | 0.918 | | |
| | (4.135) | | | (4.233) | | |
| MBS | 0.009 | | | -0.037 | | |
| | (0.091) | | | (0.084) | | |
| Deposit Interests | 1.785 | | | 0.631 | | |
| | (1.392) | | | (1.203) | | |
| Interest Income | 0.087 | | | 0.317 | | |
| | (1.414) | | | (1.271) | | |
| Observations | 3073 | 3073 | 3063 | 3073 | 3073 | 3063 |
| Adjusted $R^2$ | 0.439 | 0.351 | 0.417 | 0.395 | 0.291 | 0.392 |
| cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |

Table 26: Refinancing Loans - Total

| | Amount | | | Number | | |
|---|---|---|---|---|---|---|
| | (1a) | (2a) | (3a) | (1b) | (2b) | (3b) |
| Δ Capital Ratio | 13.451*** | 19.838*** | 11.919** | 11.319*** | 19.533*** | 12.669** |
| | (2.918) | (5.228) | (4.084) | (2.437) | (4.676) | (3.873) |
| Δ house prices | 0.973*** | 0.694* | 0.503 | 0.771** | 0.560* | 0.495 |
| | (0.236) | (0.268) | (0.266) | (0.223) | (0.245) | (0.257) |
| Δ wages | 1.396*** | 1.154** | 1.023* | 0.908** | 0.335 | 0.180 |
| | (0.332) | (0.414) | (0.443) | (0.315) | (0.393) | (0.360) |
| Δ income | -0.096 | -0.173 | -0.398** | -0.187 | -0.227 | -0.381** |
| | (0.155) | (0.161) | (0.143) | (0.140) | (0.157) | (0.133) |
| Δ unemployment rate | -0.020 | -0.009 | -0.023 | -0.018 | -0.010 | -0.022 |
| | (0.017) | (0.018) | (0.014) | (0.015) | (0.015) | (0.011) |
| log(assets) | 0.010 | | | 0.014 | | |
| | (0.011) | | | (0.011) | | |
| Cash | -0.310 | | | 0.011 | | |
| | (0.634) | | | (0.603) | | |
| Deposits | -0.114 | | | -0.074 | | |
| | (0.220) | | | (0.215) | | |
| Loans | 0.272 | | | 0.244 | | |
| | (0.160) | | | (0.173) | | |
| RE Loans | 0.471*** | | | 0.492*** | | |
| | (0.120) | | | (0.117) | | |
| ROA | 3.727** | | | 2.359 | | |
| | (1.319) | | | (1.353) | | |
| ROE | -1.002 | | | -0.371 | | |
| | (0.519) | | | (0.528) | | |
| NPL | 5.178 | | | 5.494 | | |
| | (5.518) | | | (4.633) | | |
| NPL - RE | -10.152 | | | -8.181 | | |
| | (6.720) | | | (6.606) | | |
| Provisions | -2.005 | | | -9.290 | | |
| | (6.773) | | | (7.787) | | |
| Allowances | 0.537 | | | -1.750 | | |
| | (4.314) | | | (4.424) | | |
| NCO | 13.330* | | | 16.204* | | |
| | (6.446) | | | (6.884) | | |
| NPL | 5.788 | | | 2.975 | | |
| | (7.183) | | | (7.314) | | |
| MBS | 0.145 | | | 0.064 | | |
| | (0.220) | | | (0.225) | | |
| Deposit Interests | 4.594 | | | 3.652 | | |
| | (3.797) | | | (3.727) | | |
| Interest Income | -11.218*** | | | -9.850*** | | |
| | (2.705) | | | (2.207) | | |
| Observations | 3073 | 3073 | 3063 | 3073 | 3073 | 3063 |
| Adjusted $R^2$ | 0.711 | 0.672 | 0.789 | 0.708 | 0.674 | 0.798 |
| cluster | State | State | State | State | State | State |
| Year FE | Yes | Yes | No | Yes | Yes | No |
| State FE | Yes | No | No | Yes | No | No |
| County FE | No | Yes | Yes | No | Yes | Yes |
| State-Year FE | No | No | Yes | No | No | Yes |