Essays in Mortgage Funding and Risk Management

by

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Abstract

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This dissertation consists of three chapters on mortgage funding and risk management. The U.S mortgage market is very concentrated. In 2006, the top 40 lenders were responsible for the origination of 96 percent of all mortgages (Stanton et al. (2014)). These large lenders originated about 60 percent of the mortgages through the wholesale channel, delegating parts of the origination process to third party agents such as mortgage brokers and correspondent lenders. I show that the type of agent selected by the wholesale lender could crowd out local banks, who often act as correspondents and rely on these wholesale lenders for funding. I also show that this crowding out has spillover effects. As local banks decreased their presence in the county, they have also reduced other types of lending. As a result, their local communities showed less growth in small businesses.

The second chapter discusses the perils of warehouse lending. Warehouse lending is an important part of the U.S. mortgage market because a large fraction of mortgage origination, both pre-crisis and currently, is carried out by non-depositories who are reliant on warehouse facilities to fund their mortgage origination activity. After the passage of The Bankruptcy Abuse Prevention Act (BAPCPA), in April 2005, most warehouse facilities were structured as Master Repurchase Agreements (MRAs). BAPCPA re-defined the mortgage loans held as collateral on the warehouse lines (the newly originated mortgages) as repo thus exempting them from automatic stay upon the bankruptcy of the mortgage originator (the repo seller). We consider the effect of the growth of MRAs for funding mortgage originations on the performance of the mortgage originators (repo sellers) and warehouse lenders (repo buyers). We find that mortgage originators (repo sellers), that used MRAs to fund their loans, originated mortgages of lower quality and that these originators were more likely to declare bankruptcy. Symmetrically, we find that the warehouse lenders (repo buyers) experienced a sharper increase in mortgage charge-offs and non-performing mortgages than non-warehouse lenders, even though the quality of the retail and wholesale mortgages that they originated were comparable to the quality of mortgages originated by non warehouse lenders. This negative outcome for warehouse lenders arose from the exemption of the mortgage repo collateral from automatic stay, since under BAPCPA the poor quality assets of bankrupt

counter parties, the mortgage originators, became consolidated on the warehouse lender balance sheets. Thus, the consolidated loans from the bankrupt counter parties generated an important component of the deterioration in the warehouse lenders' mortgage

In the third chapter, we propose an empirical duration measure for the stock of U.S. Agency MBS that appears to be less prone to model risk than measures such as the Barclays Effective Duration measure. We find that this measure does not appear to have a strong effect on the 12-month excess returns of ten-year Treasuries as would be expected if shocks to MBS duration lead to commensurate shocks to the quantity of interest rate risk borne by professional bond investors (see, Hanson, 2014; Malkhozov et al., 2016). Given this negative reduced form result, we then explore the mortgage and treasury hedging activities of the primary MBS investors such as commercial banks, insurance companies, the agencies, the Federal Reserve Bank, Mutual Funds, and foreign investors. We find that the only investors that may follow the models of Hanson (2014) and Malkhozov et al. (2016) are foreign investors in Switzerland and the United Kingdom and life insurance firms. Life insurance firm market share has declined over the period, dropping below 10% since 1996 and reaching 4% in 2016. Furthermore, Switzerland and the United Kingdom are not major participants in the US Treasury market. Of the investors we are not able to study, hedge funds and pensions/retirement funds are the two investor groups that may trade along the Hanson (2014) and Malkhozov et al. (2016) models. However, although these two investor groups held almost 25% of the Agency MBS market (including households and non profit organizations) in the late 1990s, post crisis their share has fallen below 10%

To my family, near and far

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Chapter 1

Mortgage Production Channels and Local Lending

1.1 Introduction

During the housing boom of the early 2000s, the total amount of outstanding mortgage debt more than doubled, from 6.8 trillion dollars in 2000 to 14.7 trillion dollars in 2008 [1]. Almost 60 percent of these mortgages were wholesale originations, that involved third party agents such as mortgage brokers and correspondents (see Figure 1.1). In 2005, 56 percent of prime loans and 78 percent of non-prime loans were originated through the wholesale channel (Apgar et al. (2007)). Wholesale lending facilitates the penetration of non-local lenders to markets previously dominated by local community banks.

In this paper, I inquire how wholesale lending affected the local depositories and the community. I show that the use of third party agents could be beneficial for local lenders if it increases the collaboration between them and the wholesale lenders, but it could also crowd them out of the market when the wholesale lenders substitute local lenders with mortgage brokers.

Local lenders, also known as community banks, are depository institutions (commercial banks, thrifts, and credit unions) that operate locally to provide the credit needs of their communities. They are relatively small in size, geographically concentrated and focus on traditional borrowing and lending activities, such as accepting deposits and issuing loans. The community banks' deep knowledge and close ties with their communities enables them to "go beyond the standardized credit models used by larger banks and consider a range of factors when making credit decisions" [2].

Between 1984 and 2011, the number of community banks declined by almost 60 percent, from 15,663 in 1984 to 6,799 in 2011 (see Figure 1.2), mostly due to mergers and consolida-

[1] Source: Federal Flow of Funds

[2] Ben Bernanke (2012), see http://www.federalreserve.gov/newsevents/speech/bernanke20120216a.htm for the full speech

tions. Although 92 percent of all bank charters are still considered community banks, their market share dropped from 38 percent in 1984 to only 14 percent in 2011 (Federal Deposit Insurance Corporation (2012)). Previous research linked this trend to financial deregulation, such as the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994, that opened the way for interstate branching (DeYoung et al. (2004)) and technological innovations, such as credit scores (Berger (2003) , Berger et al. (1999), Petersen and Rajan (2002)) that made it easier for larger financial institutions to compete in non-local markets. The recent passage of the Dodd-Frank Act, that does not differentiate between large and small banks and imposes an additional burden on community banks, resulted in an even faster decline in community banks' market share (Lux and Greene (2015)). While the observed industry consolidation can improve geographic diversification, eliminate inefficient institutions and lower funding costs Berger et al. (2007a), Berger et al. (1998), Jayaratne and Strahan (1998)), policy makers have expressed their concerns regarding the effect this trend might have on the supply of credit to opaque borrowers, such as small businesses, low-income borrowers and borrowers located in rural areas (Kocherlakota (2014), Yellen (2014), ICBA (2012) and Meyer (1999)). This paper extends the literature by considering the effect innovations in the mortgage production process had on these local lenders.

Wholesale could choose between originating their mortgages through the retail channel or the wholesale channel. The retail channel involves direct communication with the borrowers. The lender's loan officers screen borrowers, make the credit decision and fund the loan. The wholesale channel involves the participation of third party agents in the origination process. There are two types of agents: correspondent lenders and mortgage brokers. Correspondent lenders are community banks and small mortgage companies. They are responsible for originating and funding the loans, often by using warehouse lines of credit provided by the wholesale lender. After origination, they sell the loan to the wholesale lender for a fee. Mortgage brokers are intermediaries that match borrowers with lenders. They have less autonomy than the correspondent lenders, and they are usually not the ones making the credit decision or funding the loans. They receive detailed guidelines from the wholesale lenders regarding the compensation they will receive for each type of loan and their role is limited to the submission of mortgage applications to the wholesale lender (Apgar et al. (2007).

To the best of my knowledge, this is the first paper that considers the effect mortgage production channels had on the local communities. I show that the choice wholesale lenders make between the different production channels has a direct effect on the mortgage volume originated by local lenders.

The US mortgage market is extremely concentrated. In 2006, the top 40 lenders originated more than 96 percent of residential mortgages (Stanton et al. (2014)). These large lenders are the result of the increase in mortgage benefit from having economies of scale and cheaper access to the secondary mortgage market than do smaller lenders. Until 2004, the secondary mortgage market was dominated by the Government Sponsored Enterprises (GSEs) Fannie-Mae and Freddie Mac. Small lenders could sell individual loans directly to the GSEs in exchange for cash or securities backed by these loans. However, in an attempt to limit their counter party risk, the GSEs began to work mainly with larger lenders, also known as aggregators, and it became more expensive for smaller lenders to sell their loans directly to the GSEs. In 2004, the top five sellers were responsible for over 75 percent of mortgages purchased by Fannie Mae and over 55 percent of the loans purchased by Freddie Mac (See Federal Housing Finance Agency Office of Inspector General (2014)). Aggregators verify that the loans they sell meet the GSEs' underwriting guidelines and provide the representations and warranties on the mortgages loans (which means that they will need to buy back defective loans from the GSEs). Due to their high origination volume, the aggregators received guarantee fee discounts from the GSEs. For smaller lenders, the access to the secondary mortgage market was more expensive. A survey conducted by Inside Mortgage Finance in 2005 (Inside Mortgage Finance (2015b)) showed that small lenders preferred to sell GSE qualified mortgages to non-GSE investors (such as the aggregators) because of better pricing and higher service release premium. The access of small lenders to the secondary mortgage market was restricted even more after 2004. Market trends, changes in regulation [3] and accounting irregularities discovered on the balance sheets of Fannie Mae and Freddie Mac in 2003 and 2004 gave rise to the use of private label securitizers (PLS). The PLS' annual mortgage purchase volume more than doubled, from 514 billion dollars in 2003 to over 1,000 billion dollars in 2006 [4]. PLS relied on large pools of mortgages and small lenders had to go through the aggregators in order to access this market. The lack of scale economies made local banks rely on these aggregators to fund and originate the mortgages.

After establishing the crowding out effect of local lenders from the mortgage market, I look at the spillover effect. I show that lenders that were crowded out of the mortgage market decreased other types of lending and bring evidence that funding of local lenders was limited once they did not have the cooperation of the large wholesale lenders.

In the last part of the paper, I inquire whether this substitution between mortgage brokers and correspondents had any aggregate effect on the local communities. Unlike mortgage brokers who focus on a single product, local banks provide multiple services for the communities. Small business lending is a good example of opaque borrowers that rely on bank credit and do not have access to the capital markets. they have a short credit history, do not have a lot of tangible assets they can pledge as collateral and do not have publicly traded securities or audited financial reports. This lack of transparency leads to information-asymmetries that could prevent lenders from providing credit to these institutions. Lenders can overcome this barrier by collecting local soft information on the borrower (Petersen and Rajan (1994), Nakamura (1994)). I show that the crowding out of local lenders from the mortgage market had adverse effect on the growth of small businesses.

Measuring the effect of the production channel on local lending is a challenging task. The Home Mortgage Disclosure Act (HMDA) dataset, which has the best coverage of residential mortgage originations, does not report through which channel the loans were originated. To

[3] Two important regulations that passed in 2005 were the ruling that said that loans kept in Special Purpose Vehicle (SPV) can be removed from the balance sheet and the lowering of the haircut required for the five largest broker-dealers (See, for example, Nadauld and Sherlund (2013))

[4] Source: Inside Mortgage Finance, February 2, 2007

overcome this limitation, I construct a proxy for the volume originated through each channel by looking at the distance between the location of the property and the location of the lenders' branches. I use this measure to show that local lenders decreased mortgage originations more in counties where there was an increase in non-local mortgages originated through the broker channel. While this measure gives us a sense about the correlation between the production channel and local lending, the causality is weak. It is possible that the increase in loans originated through the broker channel is a response to the decline in community bank lending and not the other way around. To alleviate this concern, I use a second approach and utilize the heterogeneity in mortgage state laws and broker occupational licensing requirements to identify states where brokers have an advantage over correspondents. I then run a triple difference-in-difference regression to compare counties located in areas where brokers have an advantage over correspondents to counties where brokers have less of an advantage.

In 2004, the Office of the Comptroller of the Currency (OCC), who is the regulator of national banks in the US, issued a rule preempting national banks from state anti-predatory laws. Under this preemption, national banks do not need to comply with local anti-predatory laws [5]. Di Maggio and Kermani (2015) show that following this preemption, there was an increase in mortgage lending that was more pronounced in subprime regions and Ding et al. (2012) show that loans that were exempted from strong anti-predatory state laws had higher default risk. I expand on their findings and consider the effect the preemption had on the channels through which loans were originated. I show that, when coupled with lenient broker laws, the preempted wholesale lenders substituted correspondents with mortgage brokers and as a result, local retail lenders were crowded out of the mortgage market.

The rest of the paper continues as follows. Section 1.2 provides a background on the different production channels, Section 1.3 gives a review of the literature, in Section 1.4 I provide a brief overview of the data used in the analyses, Section 1.5 goes over the empirical methodology, Section 1.6 goes over the results and Section 1.7 concludes.

1.2 Mortgage Production Channels

The U.S. mortgage origination market is going through vertical disintegration, where there are several agents, each with its own specialization, involved in the process. In the past, mortgages were originated mostly through the retail channel. A loan officer, who is the employee of the institution that also funds the loan, is responsible for all aspects of the underwriting and funding processes. The housing boom of the early 2000s saw a decrease in the market share of mortgages originated through this channel. Instead, lenders began to originate mortgages through the wholesale channel, outsourcing parts of the process to third party agents, such as mortgage brokers and correspondents. Vertical disintegration occurs when there are gains from specialization and trade. Two necessary conditions for vertical disintegration are the ease of coordination between the different agents in the chain

[5] See http://www.occ.gov/static/news-issuances/news-releases/2004/nr-occ-2004-3.pdf for the news release

and standardization of the products (Jacobides (2005b)). These two conditions were met with the proliferation of mortgage securitization.

In the 1970s, the Government Sponsored Enterprises (GSEs) were established, with an objective to increase home ownership by forming a secondary mortgage market. The GSEs purchase loans from lenders, bundle them into pools and securitize them. The forming of the GSEs had a big impact on the mortgage market and securitized lending grew from about 30 percent in the 1980s to almost 70 percent in 2007 [6]. The securitization chain is comprised of numerous agents, including loan officers, trustees, servicers, insurers, securitizers and investors. To facilitate the transmission of information between the different agents, lenders were more likely to base their credit decision on observable and easily quantifiable information ('hard information'), such as borrower credit score, loan-to-value (LTV) ratio and the terms of the loan (Rajan et al. (2015)). Relying on hard information made it easier for the different parties to coordinate their activities. The GSEs standardized the mortgage market by providing clear guidelines to the types of mortgages they would be willing to purchase from the originators. This standardization also improved coordination between the different parts in the securitization pipeline and facilitated the process of vertical disintegration.

Mortgage originators increasingly relied on the wholesale production channel because it enabled them to gain from the agents' local knowledge and ties to consumers, without bearing the costs of opening a local branch. Relying on third party agents made it easy for wholesale lenders to adjust to the business cycle since they did not have to go through the hiring or layoff processes (Apgar et al. (2007)). Because securitization helped standardize the market, The distance between borrowers and lenders became less of an obstacle and has led to an increase in the amount of loans originated by wholesale lenders.

The wholesale origination channel uses two types of agents: correspondent lenders and mortgage brokers. The wholesale lender provides the brokers and correspondents a menu of prices, informing how much it would pay for different types of loans (a combination of interest rate, points, prepayment fees etc.). While they serve similar roles, mortgage brokers and correspondents differ in their funding, autonomy given in the process and regulation.

Correspondents are mortgage companies and depository institutions, such as community banks. They have more autonomy than mortgage brokers in the origination process and are the ones who make the credit decision and fund the loans using either deposits or warehouse lines of credit. Their revenue comes from origination fees, interest payments, servicing fees and proceeds they receive when selling the loan. Depository institutions that serve as correspondents usually offer their borrowers a large variety of products. Their success depends on long term relationships and the prosperity of their communities (Mortgage Bankers Association (2008)). They are regulated by different agencies, depending on their charter. Independent mortgage companies are regulated by the state and depository institutions are regulated by either the Office of the Comptroller of the Currency (OCC) , the Federal Reserve, the Federal Deposit Insurance Corporation (FDIC), or the National Credit Union Administration (NCUA). Prior to the crisis, thrifts were regulated by the Office of

[6] Source: Federal Reserve Statistical Release, schedule L218

Thrift Supervision (OTS) but are now regulated by the OCC.

Mortgage brokers match borrowers with lenders and assist with the application process. They work with a large number of wholesale lenders and reduce the search costs of the borrower by providing a wide menu of options. In 2004, there were about 53,000 mortgage brokers operating in the US. They were responsible for the origination of nearly 70 percent of all mortgages originated on that year (Kleiner and Todd (2009)) and at least 65 percent of all subprime loans originated between 2004 and 2006 (Berndt et al. (2010)). Brokers do not fund the loans or make the final credit decisions. Their revenue comes from direct fees received from the borrower and a yield spread premium (YSP) they receive from the lender [7]. The YSP is known in advance and depends on the term of the loan (i.e higher interest loans with have higher YSP). This form of compensation gives an incentive for mortgage brokers to stir borrowers into higher interest loans. Brokers have no 'skin-in-the-game' and are not affected by the performance of the loans they have helped to originate. Their liability, when it exists, is limited to the broker fees. Mortgage brokers are regulated by the state and are subject to less demanding regulatory oversight, when compared to depository institutions. Most of the mortgage broker regulation focuses on licensing requirements and do not include an ongoing examination. Unlike mortgage bankers (including depository and non-depository institutions), brokers do not need to comply with federal laws such as The Real Estate Settlement Procedures Act (RESPA) and The Truth in Lending Act (TILA) that require the lenders to disclose and clarify all the costs associated with the loan. They are also exempt from the Home Mortgage Disclosure Act (HMDA) that requires the disclosure of information on all of the mortgages originated and purchased during the year. They also do not have safety and soundness reviews (Ernst et al. (2008)), as do depository institutions. State licensing also puts more burden on mortgage bankers than it does on mortgage brokers and anti predatory loans laws are usually directed at mortgage bankers and not mortgage brokers (Mortgage Bankers Association (2008)).

Rating agencies view retail originations as safer than wholesale originations since there is a lower risk of fraud (Inside Mortgage Finance (2015a)) and loans originated by correspondents are considered safer than those originated by brokers. Mortgage brokers are thinly capitalized and do not have the ability to repurchase defective loans. Regulators are more likely to go after mortgage bankers since they have the resources to pay.

1.3 Literature Review

This paper is related to two main strands of literature: wholesale lending and the uniqueness and importance of local lending.

[7] Sometimes they will use table funding, where the broker will originate the loan but will immediately assign it to the purchaser

Wholesale Lending

Most of the literature on wholesale lending focuses on the quality of mortgages originated by mortgage brokers. Mortgage brokers collect fees from the lenders and borrowers at the time of origination and are not affected by the loan performance. Knowing the YSP in advance incentivizes them to steer prime borrowers to subprime or even predatory loans with unfavorable terms (Agarwal et al. (2016), Engel and McCoy (2007)). LaCour-Little and Chun (1999) show that mortgages originated by brokers are more likely to prepay, since prepayment generates more fees for the brokers. Using loan data of a national subprime mortgage lending firm, Alexander et al. (2002) extend Lacour-Litle and Chun's work to show that even for loans that otherwise look the same, those that were originated by third party agents were more expensive and defaulted more frequently than those originated through the retail channel. Jiang et al. (2014) show that loans originated by mortgage brokers have higher delinquency rates. Garmaise (2010) look at the length of the relationship between borrowers and lenders and shows that the quality of the mortgages presented to a lender by the broker decreases over time.

Mortgage brokers originated the majority of subprime loans in the years leading up to the financial crisis. Demyanyk and Van Hemert (2011)) show that the quality of subprime mortgage loans deteriorated in the years leading to the crisis and Ding et al. (2011a) compare subprime loans to loans originated under the Community Advantage Program (CAP), which was targeted at low and medium income borrowers. They show that subprime loans had higher default rates.

The cost of third party origination has also been the topic of several papers. El Anshasy et al. (2006) show that borrowers obtaining loans from brokers do not pay more and generally pay less than borrowers obtaining loans directly from lenders

Most papers do not distinguish between the correspondent and broker channels. In this paper, I contribute to the literature by considering the local effect of wholesale lending. I show that the choice the wholesale lender makes between mortgage correspondents and brokers may have implications on the local community.

Local Lending

There is a large literature that focuses on the importance and uniqueness of community banks and local lending. Community banks are believed to have superior knowledge about the communities they are located in and a better ability to collect and process soft information. This ability enables them to provide credit to opaque borrowers, such as low income borrowers and small businesses, that would otherwise be rationed out of the market. Theory attributes this competitive edge to their organizational structure, ownership, and proximity to their borrowers. Most community banks are privately owned [8], decentralized organizations. These organizational structures mitigate the difficulty involved in the transmission

[8] The community banks that are publicly traded will usually not trade on the major exchanges (Federal Deposit Insurance Corporation (2012))

of soft information (Stein (2002)) and reduce contracting problems between the different management layers (Berger and Udell (2002)). The proximity to the borrowers and concentrated geography further facilitates the collection of soft information and helps to soften the competition with non-local lenders who are more likely to base their credit decisions on hard information (Hauswald and Marquez (2006). Several empirical studies support the hypothesis that physical distance between borrowers and lenders (Berger et al. (2005), Brevoort and Hannan (2004), Agarwal and Hauswald (2010) and organization hierarchy (Liberty and Mian (2009)) have negative effects on the communication of soft information. Other papers show that local lenders invest more in private information than their less geographically concentrated competitors (Loutskina and Strahan (2011), Zarutskie (2013), Ergungor (2010)).

The empirical evidence on the importance of small banks to their local communities is mixed. Several papers find negative correlation between the size of the bank and the percentage of investment in small businesses (Berger and Udell (1995); Keeton (1996); Peek and Rosengren (1997); Strahan and Weston (1996)) and show that relationship lending provided by small banks increases the volume of small business loans (Berger et al. (2005), Berger and Black (2011), Canales and Nanda (2012)) and improves the terms of these loans (Berger and Udell (1995)). Gilje (2012) uses oil and gas shale discoveries as a positive funding shock to local banks and shows that following this shock, the number of establishments dependent on external financing increased, especially in counties with high concentration of small banks, Celerier and Matray (2016) find that bank branch density increases the likelihood of low income households to hold a bank account. Greenstone et al. (2014) and Gozzi and Goetz (2010) show that areas whose local banks suffered more during the 2008 financial crisis also experienced a larger reduction in the number of establishments as well as an increase in unemployment.

The negative effects of local bank closures and mergers has also been the topic of a large number of papers. Ashcraft (2005) found that failure of healthy small banks have a larger effect on the real economy than the failure of large institutions, Nguyen (2015) found that branch closing has long term effect on the supply of credit to small businesses but only temporary effect on mortgage lending, suggesting that non-local banks can substitute the areas of bank lending that depend on hard information, but cannot fully substitute local banks when it comes to soft information. There is also evidence that mergers of local banks with large banks could have negative effect on small business lending (Craig and Hardee (2007), Sapienza (2002), Peek and Rosengren (1997)) that could lead to the underperformance and even bankruptcy of firms who had relationships with the acquired banks (Degryse et al. (2011)).

There are, however, several papers that found limited effects of bank consolidation on small business lending (Strahan and Weston (1998), Strahan and Weston (1996), Keeton (1996)) or show that the effect is only transitory (Di Patti and Gobbi (2007), Francis et al. (2008), Berger et al. (1998) Berger et al. (1998), Jayaratne and Wolken (1999)). Peek and Rosengren (1998) conclude that in roughly half of the mergers, small business loans even increased following the mergers.

A few papers argue that technology advances (Berger et al. (2007b), Berger et al. (2013), DeYoung et al. (2011)) and deregulation (Black and Strahan (2002), Becker (2007), Rice and Strahan (2010)) made it easier for larger institutions to provide loans to opaque borrowers and compete with local lenders. Cetorelli and Strahan (2006) shows that competition and looser state-level restrictions on bank entry reduces the size of the typical establishment and increases the share of establishments.

This paper looks at the importance of local banks to their communities by exploiting a liquidity shock that occurred when they had limited access to the secondary mortgage market. The effect mortgage securitization has on bank lending is an empirical question. On the one hand, Loutskina and Strahan (2009) Show that increased supply of liquid loans increases the supply of jumbo mortgages, which are less liquid. Jimenez et al. (2014) show that Spanish banks that were more involved in mortgage securitization also increased lending to non-real estate firms, Loutskina (2011) shows that lenders with a liquid portfolio of loans (i.e loans that can be easily securitized) extend more C&I loans during times of monetary tightening, when the cost of funding is high. On the other hand, Chakraborty et al. (2014) show that firms that securitize mortgages find it more profitable to channel more funds to mortgage origination, at the expense of other types of lending.

I support the former and show that banks that were more affected by the liquidity shock reduced other types of lending and increased the holdings of liquid securities. After establishing this effect, I go on to show that counties that experienced a more severe liquidity shock also saw a smaller increase in small businesses.

1.4 Data and Summary Statistics

Data on 1-4 residential home mortgages are obtained from the Home Mortgage Disclosure Act (HMDA) dataset. Each year, mortgage lenders are required to disclose information regarding the mortgage applications they have received and the mortgages they have purchased throughout the year. For each application, they indicate whether it was accepted or rejected and whether it was sold in the secondary market. The report also includes loan characteristics such as loan amount, loan purpose (home purchase, refinancing or home improvements), the type of loan (conventional or not), the income, gender and race of the borrower and the location of the property. HMDA covers all mortgage lenders that have a branch located within an MSA and assets above a threshold that is modified annually (for example, in 2016, banks with assets of less than 44 million dollars were exempt). The sample includes all loans originated by depository institutions (commercial banks, thrifts and credit unions) between the years 2000 and 2006. I chose to end the sample in 2006 in order to avoid the impact of the financial crisis that began to unfold in 2007.

The location of the branches of each depository institution is from the Federal Deposit Insurance Corporation (FDIC) Summary of Deposits (SOD) dataset. This data include, for each FDIC insured lender, the location of all branches as well as the volume of deposits on each branch. For credit unions, I obtain the location of the branches from SNL Financial. I remove non-depository institutions from the dataset because there is no information on their branch location.

Data on the balance sheet of commercial banks are obtained from the Reports of Income and Condition (the "Call Reports"). One of the limitations of HMDA is that small lenders and lenders that do not have a branch located within an MSA do not need to report to HMDA. Some of these smaller institutions are likely to be correspondent lenders. Utilizing the Call Report data allows me to analyze the behavior of banks that are not included in the HMDA dataset and observe their balance sheet. Figure 1.10 compares the kernel density of the log assets of the lenders that report to HMDA and those that file the Call reports. We can see that the smaller banks are excluded from HMDA.

Data on the number of small establishments located in each county is obtained from the National Establishment Time Series (NETS) dataset. NETS provides data on the establishments and number of employees located in the U.S.

From Compustat, I obtain data on the capital expenditures and operating cash-flows of non-financial firms in the U.S between 2000 and 2006. These data are used to compute the dependency of different industries on external finances. Compustat only includes public firms that are relatively large in size. Therefore, the firms represented in this dataset probably have good access to external financing. Therefore, their use of external financing is relatively frictionless (Rajan and Zingales (1998)).

Data on state APL laws is from Ding et al. (2012) and the index of mortgage broker licensing requirements is from Pahl (2007).

Lastly, data on poverty rates and household income in each county is obtained from Small Area Income and Poverty Estimates (SAIPE) and unemployment rates are obtained from the U.S Bureau of Labor Statistics (BLS).

Table 1.1 summarizes the main variables used in the analysis. Panel (A) includes summary of county characteristics and panel (B) reports the summary statistics of the commercial banks' balance sheet.

1.5 Empirical Methodology

The paper considers the effect mortgage production channels have on local lending. The main prediction is that when wholesale lenders substitute correspondent lenders with mortgage brokers, the correspondent lenders, who are mostly local lenders, are crowded out of the market. I use two approaches to gauge the importance of the wholesale lenders' decision to local bank lending. In the first approach, I measure the volume of loans originated through each channel directly. The second approach takes advantage of the heterogeneity in state regulation of mortgage brokers and predatory lending laws. I construct a 'broker advantage' index that indicates in which states brokers have an advantage over correspondents in the creation of predatory loans.

Direct Approach

To measure the effect the mortgage production channel has on local lending, I construct a proxy for the volume of mortgages originated through each channel. HMDA does not report the channel through which a loan was originated. Therefore, to construct the measure, I make the following assumptions. First, I assume that loans originated by a correspondent are disclosed in HMDA as purchased loans. According to the HMDA guidelines, loan originations should be reported by the institution that makes the credit decision. since correspondents usually have full control of the credit decisions (as well as the funding of the loan), they need to register the loans as originated under their name. After they forward the loan to the wholesale lender, the wholesale lender reports the same loan as purchased (Scheessele (1998) and Apgar et al. (2007)). Since mortgage brokers are not the ones making the credit decisions, their loans will be disclosed as originated by the wholesale lender. Second, I follow Apgar et al. (2007) and assume that originations made in a county where the lender has a retail branch are done through the retail channel while loans originated in counties with no physical branches are likely to go through the broker channel. I believe this is a reasonable assumption since there is evidence that shows that the competition in the mortgage market is local. For example, In 2004, the median household lived within 4 miles of its primary financial institution and 50 percent of households obtained mortgages from an institution located less than 25 miles away (Scharfstein and Sunderam (2013)).

For each lender, I identify the counties in which it has a physical branch and classify all of the mortgages originated by the lender in these counties as loans originated through the retail channel. Loans that were originated in counties where there is no physical branch are assumed to be originated through the broker channel and loans purchased by the lender are assumed to be originated through the correspondent channel.

Figure 1.4 shows the volume of loans originated through each channel between 2000 and 2008. We can see that, prior to the crisis, there was an increase in the volume of mortgages that were originated through the wholesale channel. When the crisis was in full force, in 2008, the volume of loans originated through these channels decreased more than the volume of loans originated through the retail channel.

Validity Check

To make sure the measure is valid, I conduct several sanity checks. First, Figure 1.5 shows a binned scatter plot of the link between the size of the depository institution and the fraction of loans that were originated through the wholesale channel (brokers and correspondents). As expected, larger lenders originate a higher fraction of their loans through the wholesale channel, and the smaller lenders, such as community banks, focus more on local lending through the retail channel.

Second, In 2005, over 3000 depository institutions reported to HMDA. Table 1.2 lists the top 20 lenders. The tables show the volume of mortgages originated (through all channels) by the institution in 2005, and a breakdown of the channels through which they originated their loans. The last four columns show the market share of the lender (out of all depositories). The table illustrates the concentration in the mortgage market; The top 20 lenders originated 74 percent of the loans. If we look at their market share in each production channel, while in the retail channel they are responsible for 60 percent of the origination, their market share is substantially higher in the broker and correspondent channels (74 and 87 percent respectively). This supports the idea that larger lenders were the ones that were the most active in these channels. We can also see that, as expected, most of these large lenders originated most of their loans through the wholesale channels.

Lastly, in Table 1.3, I compare the characteristics of loans originated through the different channels in 2005. One drawback of this measurement is that some mortgages might appear twice in the sample. For example, if a loan was originated through a correspondent that reports to HMDA, it will first be recorded as originated and then as purchased. Therefore, there is an overestimation of the mortgages that were originated through the retail channel. I consider the differences in loan characteristics using two samples. In the first three columns, the retail channel includes all loans that were originated locally. In the last three columns, the retail channel only includes loans that were originated locally and kept on the balance sheet. While this measure will not include correspondent loans, it also won't include loans originated in the retail channel and sold directly to the GSEs, so this is an underestimation of the retail channel.

Table 1.3 illustrates the differences between the loans that were originated through each channel. Borrowers that originated their mortgages through the retail channel had higher incomes, lower loan-to-income ratios (LTI) and were more likely to be of a white origin. The loans originated through that channel were more likely to remain on balance sheet and less likely to be high-cost loans. A high-cost loan is defined as a loan with an annual percentage rate (APR) that is at least 3 percent higher than the treasury rate of a bond with a similar maturity. HMDA does not require to report the spread for purchased loans. Therefore, I can only compare the fraction of high-cost loans originated through the retail and broker channels. These observed differences support the view that retail loans are considered safer than loans originated through the wholesale channels.

Measuring the Substitution between the Production Channels

To gauge the impact of the different wholesale channels, I define the fraction of non-local lending done through the broker channel in county i at time t ($BRFRAC_{it}$) to be:

$$BRFRAC_{it} = \frac{BR_{it}}{BR_{it} + CORR_{it}} \tag{1.1}$$

Where BR_{it} is the volume of mortgages originated through the broker channel in county i at time t and $CORR_{it}$ is the volume of mortgages originated through the correspondence channel. Figure 1.6 shows the distribution of this measure. I use the heterogeneity of $BRFRAC_{it}$ to analyze the effect the substitution between correspondent lenders and mortgage brokers had on the retail channel and the local economy.

Measuring the effect of the production channel on local lending directly could be misleading due to endogeneity and reverse causality. For example, it is possible that non-local banks increased the use of brokers because local lenders decreased mortgage lending and not the other way around. To alleviate these concerns, I will turn to a second approach and take advantage of two state laws, anti-predatory lending laws and mortgage broker licensing, to construct a 'broker advantage index'. The index will indicate in which states wholesale lenders are more likely to choose brokers over correspondents.

'Broker Advantage' Index

In this section, I introduce the broker advantage index. The purpose of the index is to identify states in which wholesale lenders are more likely to choose brokers over correspondent lenders. The measure is constructed by taking advantage of two sets of state laws: anti-predatory lending laws (APL) and mortgage broker licensing requirements.

Anti Predatory Laws and the OCC Preemption

Predatory lending refers to loans that are structured to benefit mortgage brokers, lenders, and securitizers at the expense of the borrower. These include mortgages that the borrower cannot afford, rent seeking (steering prime borrowers to subprime loans or having high prepayment penalties), direct fraud (such as making false promises to refinance the loan to better terms in the future) and the withholding of information (such as the rate sheets) (Engel and McCoy (2007)). Concerned about the increase in predatory and abusive lending, Congress enacted the Home Ownership and Equity Protection Act (HOEPA) in 1994. The act imposed additional disclosure requirements on a subset of mortgages defined as 'high-cost loans' [9]. These high-cost loans are prohibited from having prepayment and default, balloon payments, and negative amortization features. While all lenders must comply with HOEPA, its coverage is very limited and less than five percent of subprime mortgages fall under HOEPA's 'high-cost loan' definition (Bostic et al. (2008)). As a response to the weakness of HOEPA, states began passing local anti-predatory lending laws that were more restrictive than HOEPA and covered a higher fraction of the market. North Carolina was the first to pass such a law in 1999 and by 2007, 29 states and the District of Columbia had their own local APL laws. The passing of stronger APL reduced the volume of subprime applications (Ho and Pennington-Cross (2006)) and high-cost loans (Elliehausen et al. (2006)) and lowered the mortgage default rates (Ding et al. (2011b)). Bostic et al. (2012) show that the market responded to these laws by substituting the types of loans originated in order to circumvent the limitations imposed by the APL. State APL laws vary in their restriction, coverage, and enforcement provisions. For example, New Mexico enacted a law in 2004 that was one of the most restrictive laws. It increased the coverage of high-cost loans by lowering the trigger

[9] HOEPA's definition of high-cost loan includes first lien mortgages that have either an annual percentage rate (APR) that exceeds Treasury securities by at least eight percent (or ten percent for second liens) or total fees and points that exceed eight percent of the total loan amount

set by HOEPA. It also prohibited prepayment penalty and balloon payments provision and added an assignee liability clause. Other states, such as Florida, enacted laws that were relatively similar to HOEPA.

In the U.S, there are numerous institutions charged with regulating and supervising depositories. In the pre-crisis period, National banks were regulated by the Office of the Comptroller of Currency (OCC), state banks were regulated by state authorities and either the Federal Reserve System (FRS) or the Federal Deposit Insurance Corporation (FDIC), thrifts were regulated by the Office of Thrift Supervision (OTS) and credit unions were regulated by the National Credit Union Administration (NCUA) [10]. Becoming a state bank lowered the supervisory costs but national banks enjoyed the preemption of several state laws (Blaire and Kushmeider (2006)). Independent mortgage companies are regulated by the state.

Until 2004, all lenders, except those regulated by the OTS, had to comply with HOEPA as well as with state APL laws. In January of 2004, the OCC preempted national banks and their subsidiaries from several state laws, including APL laws. According to the OCC, the inability of national banks to operate under "uniform, consistent and predictable standards ... interferes with their ability to plan and manage their business, as well as their ability to serve the people, the communities and the economy of the United States" [11].

The OCC claimed that they have preventive measures that are "aimed at keeping abuses out of the national bank". However, the preemption increased the share of high- cost loans originated by national banks from 16 percent in 2004 to 26 percent in 2006 (Ding et al. (2012)). The terms of the loans were also affected and there was an increase in the volume of loans with prepayment penalties and negative amortization features made by national banks in states with APL laws (Di Maggio and Kermani (2015)). The increase in these types of mortgages resulted in an increase in delinquency and foreclosure rates during the crisis (Di Maggio and Kermani (2015) and Ding et al. (2012)).

Figure 1.7 shows the volume of mortgages originated between 2000 and 2008 by OCC lenders and breaks it down according to its production channel. On the right axis, we see the market share of OCC regulated lenders. At its peak, almost 60 percent of the loans were originated by OCC lenders. The figure suggests that lenders regulated by the OCC had an important role in the mortgage origination process in the years prior to the crisis and that a significant fraction of these loans, especially prior to 2007, were done through the wholesale channel.

Mortgage Brokers Licensing Requirements

78 percent of non-prime loans originated in 2005 were originated by wholesale lenders. Guttentag (2000), Jr. (2006) and Hansen (2005) suggest that, in order to attack the source of

[10] in 2009, the OTS was canceled and the OCC became the regulator of thrifts

[11] See OCC's News Release from January 7th, 2004 https://www.occ.gov/static/news-issuances/news-releases/2004/nr-occ-2004-3.pdf

the problem and not merely the outcome, state anti-predatory laws should be complimented with strong mortgage broker regulation.

Mortgage brokers are regulated by the state. Unlike depository institutions, most of their supervision is limited to licensing requirements and not to ongoing activities. Almost all states require brokers to register, but the occupational licensing requirements vary from state to state. Pahl (2007) compiled a mortgage broker licensing requirements index for all states between 1996 and 2006. During this period, more states enacted stringent broker licensing and registration requirements. In 1996, only three states had restrictive broker regulation in place. By 2006, all states, except for Alaska, had some level of broker regulation in place and 18 states enacted highly restrictive regulations (Pahl (2007)). The state statutes differ in their coverage as well as restrictions. Some states only restrict the firm, or the person in control, others restrict all of the employees in the firm yet other states also cover all control persons within the firm. The type of requirements also differs between the states. As of 2006, only two states do not have any registration requirements (Alaska and Colorado). fourteen states require the firm to have a branch in the state where it operates and forty-two states have net wealth or surety bonds requirements. The amount of required net worth or surety bond is relatively low and ranges from 10,000 dollars in Arizona to 250 thousand dollars in New Jersey. Florida has the strictest requirements, spanning the education of principals, branch managers, and employees.

Several papers used the index compiled by Pahl to look at the effect of broker licensing requirements on the quality of the loans. Dagher and Fu (2011) show that states with stricter broker laws experienced fewer defaults during the 2008 financial crisis, Keys et al. (2009) exploit a rule of thumb in the borrower's FICO score that distinguishes between mortgages that can be easily securitized by selling them to the GSEs. Fannie Mae and Freddie Mac would not purchase loans to borrowers with a FICO score of less than 620. Using this as a threshold, they compared the performance of loans just above and just below the threshold and found that in states where there were weak broker laws, easily securitized loans were of lower quality, Kleiner and Todd (2009) find that the requirement to hold a surety bond or maintain minimum net worth is associated with fewer brokers, lower loan volume, fewer subprime mortgages, higher foreclosure rates on subprime mortgages and a higher percentage of mortgages carrying high interest rates

Constructing the Broker Advantage Index

I take advantage of the broker licensing requirements and the 2004 OCC preemption of state APL laws to construct a 'broker advantage' index that will indicate in which states preempted wholesale lenders are more likely to choose to go through the broker channel and not the correspondent channel. Previous research showed that the preemption lead OCC regulated lenders to increase the origination of loans in states with APL laws. The assumption is that in states with strong APL laws and weak broker licensing requirements, the OCC regulated lenders preferred to go through the broker channel and not the correspondent channel. There are several reasons why brokers have an advantage over correspondents in these states. First, many local banks (and all mortgage companies) are not regulated by the OCC and could therefore not originate predatory loans under their names. In 2004, S & P announced that it will not rate deals with high-cost loans made by non-OCC or OTS lenders. The implication is that loans with predatory characteristics originated by non-preempted lenders could not have been sold in the secondary market [12]. The GSEs did not purchase any high-cost loans, regardless of who the originator was [13]. Brokers, on the other hand, only match between borrowers and lenders and are usually not the creditors. National banks could, therefore, sell high-cost broker originated loans in the private label market. Second, even OCC community banks were probably less willing to make these predatory loans. Under the Community Reinvestment Act (CRA), their communities belonged to their assessment areas and loans originated in these areas were more closely monitored (Apgar et al. (2007), Laderman and Reid (2008)) . Third, well-capitalized banks are more risk averse because they have the capacity to purchase back defective loans (Inside Mortgage Finance (2015b)). Brokers, on the other hand, do not have any 'skin-in-the-game'. As a result, they are more willing to originate these risky loans on behalf of the OCC lender. Lastly, Local lenders cultivate long-term relationships and the state of the local banks is tightly linked to the state of the community it is located in (ICBA (2013)). It is, therefore, less likely for them to issue loans with predatory terms.

To identify the states with strong APL laws, I use Ding et al. (2012) *ineffect* flag. This flag is set to 1 when a state has APL laws that are stronger than HOEPA (either because of coverage, amount of restrictions or level of enforcements). For the strength of broker regulation, I use the index constructed by Pahl (2007). I rank the states according to the strength of the licensing requirements and define the bottom quartile as a "weak broker law" states. I then interact the APL flag with the weak broker flag to construct a 'broker advantage' flag. Figure 1.8 shows a map of the states included in the sample and Table 1.4 lists the states and indicates the level of regulation in the state as of 2005. I remove states that had changes in either their APL laws or broker licensing requirements after 2004.

Overall, there are 30 states in our sample. four have both strong APL laws and weak broker laws (Colorado, Minnesota, Michigan and New Mexico) and five states have weak broker regulation and no APL laws (Alaska, South Dakota, Delaware North Dakota and Virginia).

Identification

I use the broker advantage flag to identify states where OCC wholesale lenders are more likely to prefer brokers over correspondents. To account for the possibility that counties within the same state could experience different shocks, I improve the identification and pursue a similar approach to Di Maggio and Kermani (2015). I identify counties that are more

[12]See "Standard & Poor's Implements Credit Enhancement Criteria and Revises Representation and Warranty Criteria for Including Anti-Predatory Lending Law Loans in U.S. Rated Structured Finance Transactions" from May 13th 2004

[13]See `http://www.freddiemac.com/learn/pdfs/uw/Pred_requirements.pdf`

likely to be affected by the shock as those who had a high fraction of OCC non-local lending that was done through the correspondent channel in 2003, before the preemption. These counties are likely to experience a greater shock when the OCCs will substitute correspondent lenders with mortgage brokers. Using this specification, I run a triple difference-in-difference regression. This specification allows me to control for changes between states as well as changes between the counties within each state. I expect counties located in states with a broker advantage that had a high fraction of wholesale OCC lending that was done through the correspondent channel to be more affected by the OCC preemption.

1.6 Results

The Crowding Out Effect

This section tests the hypothesis that when wholesale lenders substitute correspondent lenders with mortgage brokers, correspondent lenders are crowded out of the mortgage market. Figure 1.9 shows a binned scatter plot of the correlation between changes in the fraction of wholesale loans originated through the broker channel and the fraction of local lending. There is a clear negative correlation between these two variables, indicating that counties who were exposed to substitution between correspondents and brokers also experienced a loss of local bank market share.

I use two approaches to test this hypothesis. In the direct approach, I construct a measure of the fraction of wholesale lending that was done through the broker channel. The second measure takes advantage of the heterogeneity of anti-predatory lending laws and mortgage broker requirements. The treatment group includes counties in states that have strong APL laws and weak broker licensing requirements. The control group includes counties in states with either no APL laws or strong broker licensing requirements.

Direct Approach

I run the following regression:

$$Y_{it} = \nu_i + \kappa_t + \beta \times BRFRAC_{it} + \gamma \times X_{it} + \epsilon_{it} \tag{1.2}$$

Where Y_{it} is a set of dependent variables and $BRFRAC_{it}$ is the log of the fraction of wholesale lending originated through the broker channel, as defined in Equation 1.1. The unit of observation is county-year. ν_i κ_t are county and year fixed effects respectively. X_{it} is a set of time-varying county controls. The controls include lags of the unemployment rate, poverty rate, and household income. To control for the type of mortgage applicants in the county, I add the lag of the applications' median income, median loan amount, and percent of black, Hispanic and female applicants. I also add the Herfindahl index (HHI) as an additional control. HHI measures the competition in the county, where higher numbers indicate a more concentrated market. It is constructed using all mortgage originations (including those made by independent mortgage companies).

Our coefficient of interest is β. A negative number indicates a negative effect of the growth in broker lending on local mortgage originations.

Table 1.5 shows the results of the regression specified in Equation 1.2. Columns 1-2 look at the effect on the log of mortgages originated through the retail channel. A 10% increase in the fraction of wholesale loans originated through the broker channel decreases local lending by 6.7 %. In columns 3-4 I repeat the same regression but instead of the log of the volume, the dependent variable is the fraction of mortgages originated through the retail channel in the county. Normalizing the volume of retail lending by the total volume of originated mortgages alleviates concerns that the results are driven by local demand shocks. The coefficient is statistically and economically significant, suggesting that a 10 % increase in $BRFRAC_{it}$ decreases the market share of local lenders by over 9 percent.

Columns 5-6 look at the fraction of loans that were originated in the retail channel and were kept on the balance sheet and not sold in the secondary market. A 10 % increase in broker lending increases the fraction of retail loans that were not sold to the secondary market by 3 percent. This could suggest that local lenders rely on wholesale lenders to access the secondary mortgage market. When wholesale lenders substitute correspondent lenders with mortgage brokers, it becomes more expensive for correspondents to access the secondary mortgage market and therefore, they keep the loans they originate on their balance sheet.

Lastly, in columns 7-8 I look at the number of local branches located in the county. Again, we see a negative and statistically significant relationship. A 10 % increase in broker market share decreases the number of local bank branches by 1.8 percent. Ashcraft (2005) and Nguyen (2015) show that branch closures have large effects on the real economy and on small business lending and Celerier and Matray (2016) find that bank branch density increases the likelihood of low-income households to hold a bank account. Therefore, the crowding out of the local lenders from the mortgage market might have had spillover effects. One concern could be that the results are driven by bank competition and not the composition of wholesale lending. To control for the competition in a county, I add the HHI measure as a control. The HHI measures the concentration of lenders (local and non-local) in a county. A larger number indicates a more concentrated market. We see that less competition (higher HHI) increases the fraction of loans originated through the retail channel as well as the number of local branches. We can also see that adding the HHI measure does not affect our results. Therefore, the results are not driven by market competition.

Mortgage Broker Advantage Index

To improve the identification, I now turn to the broker advantage index described in Section 1.5. This identification divides the counties into two groups. The treatment group includes counties located in states with high APL laws and weak broker laws. In the control group, we have counties located in states with either no APL laws or strong broker licensing requirements. Similar to Di Maggio and Kermani (2015), I take advantage of the heterogeneity in the use of correspondents by OCC lenders prior to the OCC APL laws preemption. I define the following triple diff-in-diff specification:

$$
\begin{aligned}
Y_{ct} = {} & \delta \times OCC_c \times I_{2004} \times Broker_c + \beta_1 \times OCC_c \times I_{2004} + \beta_2 \times Broker_c \times I_{2004} \\
& + \beta_3 \times OCC_c \times Broker_c + \beta_4 \times OCC_c + \beta_5 \times I_{2004} + \beta_6 \times Broker_c \\
& + \Gamma \times X_{c(t-1)} + \nu_c + \gamma_t + \epsilon_{ct}
\end{aligned} \tag{1.3}
$$

The unit of observation is county-year. Y_{ct} is a set of dependent variables, OCC_c is the fraction of mortgages that were originated by OCC lenders through the correspondent channel in 2003 in county c, $Broker_c$ is the broker advantage flag, I_{2004} is a dummy that is set to 1 for the years after 2004 and X_{ct} is a set of time varying county characteristics. The identification includes county and year fixed effects. Errors are clustered at the county level. The coefficient of interest is δ. This coefficient measures the effect of the OCC preemption law. The prediction is that we will see a stronger effect for counties located in states with a broker advantage that used to rely on OCC lenders to originate loans through the correspondent channel.

Using this specification enables us to measure the local effects the substitution between brokers and correspondents had by using two control groups, county characteristics, and state regulation.

Table 1.6 establishes the relationship between the OCC preemption and lending activities in the counties. Columns 1-2 measure the effect the preemption law had on the fraction of wholesale originations and purchases done by OCC lenders. The positive coefficient indicates that, following the 2004 OCC preemption, their market share grew more in states that had APL and weak broker licensing requirements. This result is similar to previous papers that showed that the preemption resulted in a higher volume of mortgages originated by OCC lenders. Columns 3-4 shows the fraction of retail originations that were kept on the balance sheet. The positive coefficient means that in states with a broker advantage, local investors kept a larger fraction of the loans they originated on the balance sheet. That supports the idea that it was more difficult for them to access the secondary mortgage market. Lastly, columns 4-5 look at the fraction of wholesale lending done through the broker channel. As expected, we see that their market share increased in states with strong APL laws and weak Broker laws.

Table 1.7 summarizes the local effect of the substitution between correspondents and mortgage brokers. Similar to Table 1.5, columns 1-2 and 3-4 show that depositories located in counties that experienced a larger shock after the preemption, decreased their mortgage originations more (both in volume and market share). In columns 5-6, I consider retail lending done by OCC lenders. One could argue that local OCC lenders should not be affected because they were also preempted from local APL laws, and therefore were not at a disadvantage when compared to mortgage brokers. A possible explanation is that, although they were exempt from state APL laws, local lenders regulated by the OCC were not originating loans with predatory characteristics. Loans that are originated locally are monitored more closely by the regulator. Moreover, local lenders rely on long-term relationships with their communities. Therefore, they could have had less of an incentive to originate loans with predatory terms. Lastly, in columns 7-8, we see that the number of local branches also dropped in this counties. This could suggest that the substitution from correspondents to mortgage brokers had local effects that went beyond the volume of mortgages originated by the local lenders.

Local lenders' Balance Sheet

In this section, I consider the impact the crowding out of local lenders from the mortgage market had on the balance sheet of the lenders. Losing access to the secondary mortgage market can affect lenders in two opposing ways. On the one hand, mortgages become less profitable and local lenders could shift their resources and invest more in other types of lending. On the other hand, having a less liquid balance sheet could force lenders to invest more in liquid assets, instead of loan origination. One of the limitations of HMDA is that small institutions and institutions that do not have a branch office in an MSA are exempt from reporting to HMDA. These small lenders are likely to rely on wholesale lenders for funding. In order to get a better picture of who the local lenders are, I use the Consolidated Reports of Condition and Income ("Call Reports"). All commercial banks, regardless of size and location, are required to submit quarterly reports. Comparing the coverage of the call reports to that of HMDA gives an idea of the number of commercial banks that do not report to HMDA. As of the end of 2005, 4,148 community banks reported to HMDA and 3,820 only filed call reports. The median size of commercial banks reporting to HMDA was about 205 million dollars compared to a median of 63 million dollars for the banks that only filed call reports. I limit the sample to include commercial banks who operate in a single state. Since large lenders usually operate nationally, the sample is restricted to smaller banks. Including banks that are not located in MSAs is also important since in these areas the part played by these small lenders is even more important. The Call Reports are aggregated at the entity level and do not provide a breakdown of lending by county. Since most banks operate in more than a single county, I create, for each lender, a weighted average of the presence of OCC correspondence activity in 2003. The weights are according to the share of deposits in each county:

$$WOCC_i = \frac{Deposits_{ic}}{TotDeposits_i} \times OCC_c \tag{1.4}$$

$Deposits_{ic}$ is the volume of deposits at bank i in county c, $TotDeposits_i$ are the total deposits at bank i and OCC_c is the faction of correspondent lending done by OCC lenders in 2003 in county c. I then use this measure and run a variation of Equation 1.3:

$$
\begin{aligned}
Y_{it} = {} & \delta \times WOCC_i \times I_{2004} \times Broker_s + \beta_1 \times WOCC_i \times I_{2004} + \beta_2 \times Broker_s \times I_{2004} \\
& + \beta_3 \times WOCC_i \times Broker_s + \beta_4 \times WOCC_i + \beta_5 \times I_{2004} + \beta_6 \times Broker_s \\
& + \Gamma \times L_{i(t-1)} + \nu_i + \gamma_t + \epsilon_{cst}
\end{aligned} \tag{1.5}
$$

Since the Call reports are submitted quarterly, the unit of observation is lender-quarter. Y_{it} is the dependent variable and L_{it} is a set of lender characteristics (log of total assets, the fraction of deposits and capital ratio) and $WOCC_i$ is defined in Equation 1.4. All regressions include quarter and lender fixed effects. Standard errors clustered at the lender level. Our coefficient of interest is δ. The results of the regression defined in Equation 1.5 are shown in Table 1.8. Column 1 shows a decrease in loan sales for banks in the control group. This strengthens the hypothesis that switching from correspondents to brokers limits the access local lenders had to the secondary mortgage market. Columns 2 and 3 look at the volume and fraction of loans kept on the balance sheet. We can see that both the volume of loans, as well as their relative percentage of the balance sheet, decreased for lenders in the control group. Columns 4-8 break the loans into residential mortgages and non-residential mortgages. In columns 5 and 6 we see that the volume and fraction of non-residential mortgages decreased in the control group. We do not see this effect for the residential mortgages. This could be because the Call Report includes only mortgages that were kept on the balance sheet and does not capture the volume of mortgages sold in the secondary market. Lastly, in column 8, we see that banks that belonged to the control group decreased their Federal Home Loan Bank (FHLB) advances. The FHLB provides collateralized advances at low-interest rates. It is a popular form of financing where a bank uses its originated mortgages as collateral to receive loans from the FHLB. The decrease in these advances could be the result of these banks having fewer mortgages to post as collateral. Overall, this table shows that banks located in states with strong APL laws and weak broker laws and were located in counties that were reliant on correspondent lending with OCC lenders experienced a decline in their loan portfolio.

Small Businesses

In the previous sections, I showed that substitution between correspondents and mortgage brokers crowded local banks out of the mortgage market. I then showed that lenders react to this crowding out effect by reducing other types of lending In this section, I consider the aggregate effect of this crowding out of local banks. Adding to the literature that looks at the links between local banks and small business lending, I turn to examine the effect the OCC preemption had on small businesses.

Firms vary in their dependence on external financing. I follow Rajan and Zingales (1998) and Gilje (2012), and construct a proxy for firm dependence for the different industries. The proxy is based on the assumption that different industries use different technologies, and these, in turn, determine the industries' reliance on external finance. For each firm in

Compustat, I sum the difference between its capital expenditure and operating cash flows between 2000 and 2006. I then divide it by the total capital expenditure during that time period:

$$Dep_i = \frac{\sum_{2000}^{2006}(CAPX_{it} - OCF_{it})}{\sum_{2000}^{2008} CAPX_{it}} \tag{1.6}$$

Where $CAPX_{it}$ is firm i's capital expenditure in year t and OCF_{it} is the operating cash-flow of firm i in year t. Firms that generate enough cash flow to pay for their expenditures, need less outside capital to keep their operations in place.

I take the average of this measure for all firms with the same 3 digit Standard Industrial Classification (SIC) code. Industries that depend on external financing are those with a Dep_i that is greater than the median of this proxy.

Using this measure, I divide the establishments in each county into those that are highly dependent on external finance and those that are not. I drop out of the sample depository institutions, non-depository credit institutions, security and commodity brokers, insurance carriers, insurance agents and brokers, real estate and holding and other investments offices. I also remove from the sample firms with more than 100 employees, since the focus is on small businesses.

Direct Approach

I run the regression specified in Equation 1.2. Table 1.9 shows the results of this regression. Columns 1-4 include firms that are dependent on external financing and columns 4-8 include firms that are less dependent on external financing. In columns 1-2, the dependent variable is the log of the number of establishments in the county. The negative coefficient suggests that a 10 % decrease in the fraction of correspondent lending leads to a 2.4% decrease in the number of new establishments. In columns 3-4 I repeat the regression but this time I normalize the number of new establishments by the total number of establishments in a county. The results remain qualitatively similar. Columns 5-6 and 7-8 repeat the same regressions as the ones in columns 1-2 and 3-4 respectively, but this time for firms that are less dependent on external financing. We still see a negative effect but the magnitude is smaller and not as statistically significant. Adding the HHI measure does not alter our results and the coefficients remain negative and statistically significant.

Mortgage Broker Advantage Index

I run the regression defined in Equation 1.3. The results are shown in Table 1.10. Columns 1-4 include the financially dependent firms and columns 5-8 include those that are less dependent. Similar to Table 1.9, we can see that the number of new establishments in counties that experienced a stronger shock following the 2004 OCC preemption saw a decline in the number (columns 1-2) and market share (columns 3-4) of new establishments. For the non-dependent firms, the results are not statistically significant.

1.7 Conclusion

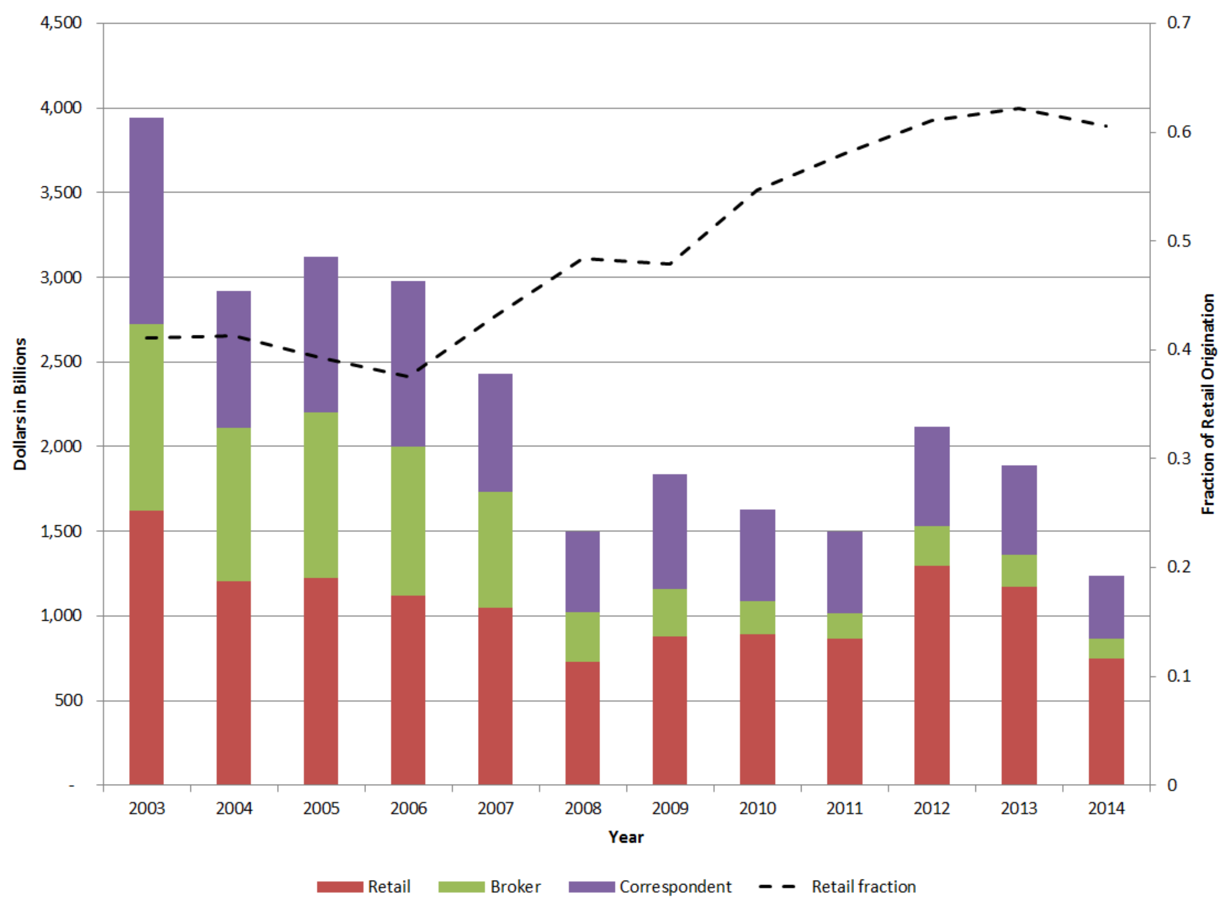
The U.S. mortgage market is concentrated. Small lenders rely on large wholesale lenders to fund and purchase their mortgages. In this paper, I consider the importance of wholesale lenders to the local communities. I show that the choice wholesale lenders make between mortgage brokers and correspondent lenders could impact the local economy and establish a negative relationship between the fraction of wholesale lending that was done through the broker channel and the volume and market share of mortgages originated through the retail channel.

I then show that this crowding out has spillover effects. Local lenders who were crowded out of the mortgage market, lost an important source of funding. I find that these local lenders also reduced other types of lending and increased their share of liquid assets.

Most of the post-crisis discussion focuses on finding ways to mitigate systemic risk and the too-big-to-fail problems associated with large intertwined financial institutions. Very little attention is given to the effect the new regulation will have on the smaller lenders. The 2010 Dodd-Frank Act imposes higher regulation costs (Kocherlakota (2014)) and suggestions to replace the Government Sponsored Entities (GSEs) by private label securitizers may further limit the access smaller lenders have to the secondary market (ICBA (2013)). These suggestions might increase industry consolidation and reduce the number of operating local lenders. I show that the demise of local lenders could have an adverse effect on the growth of small businesses and that community banks still have an important and unique role in the U.S. economy.

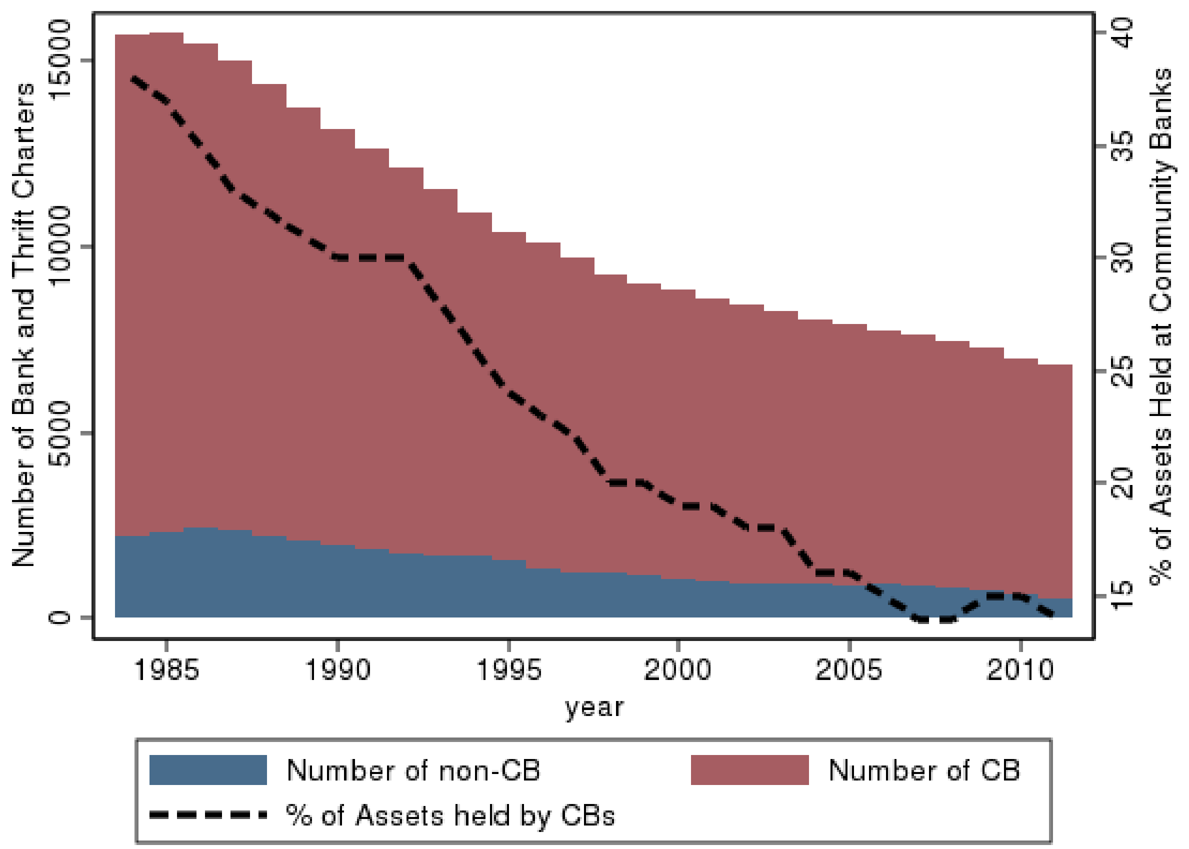
1.8 Figures

Figure 1.1: Mortgage Production Channels



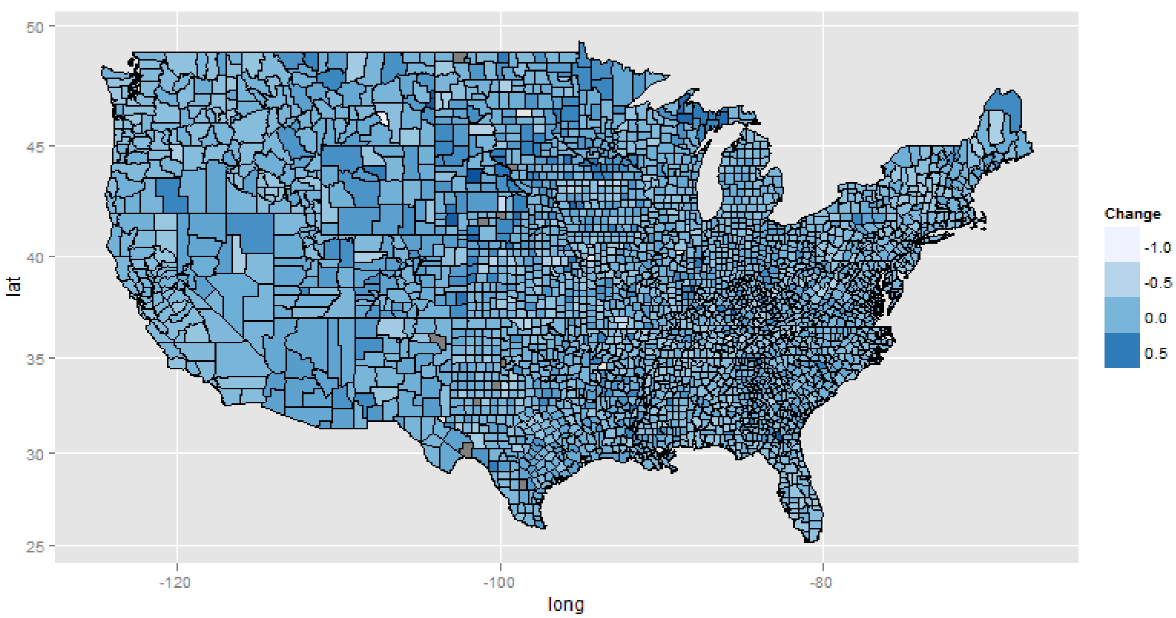
The figure shows the annual volume of mortgage originations done through the retail, broker and correspondent production channels between 2003 and 2014. On the left axis we see the volume of mortgage originations in millions of dollars and on the right axis we see the fraction of mortgages originated through the retail channel (defined as the fraction of retail originations to total originations). Source: Inside Mortgage Finance, Guide to Mortgage Origination Channel Strategies, 2015

Figure 1.2: Community Banks Market Share



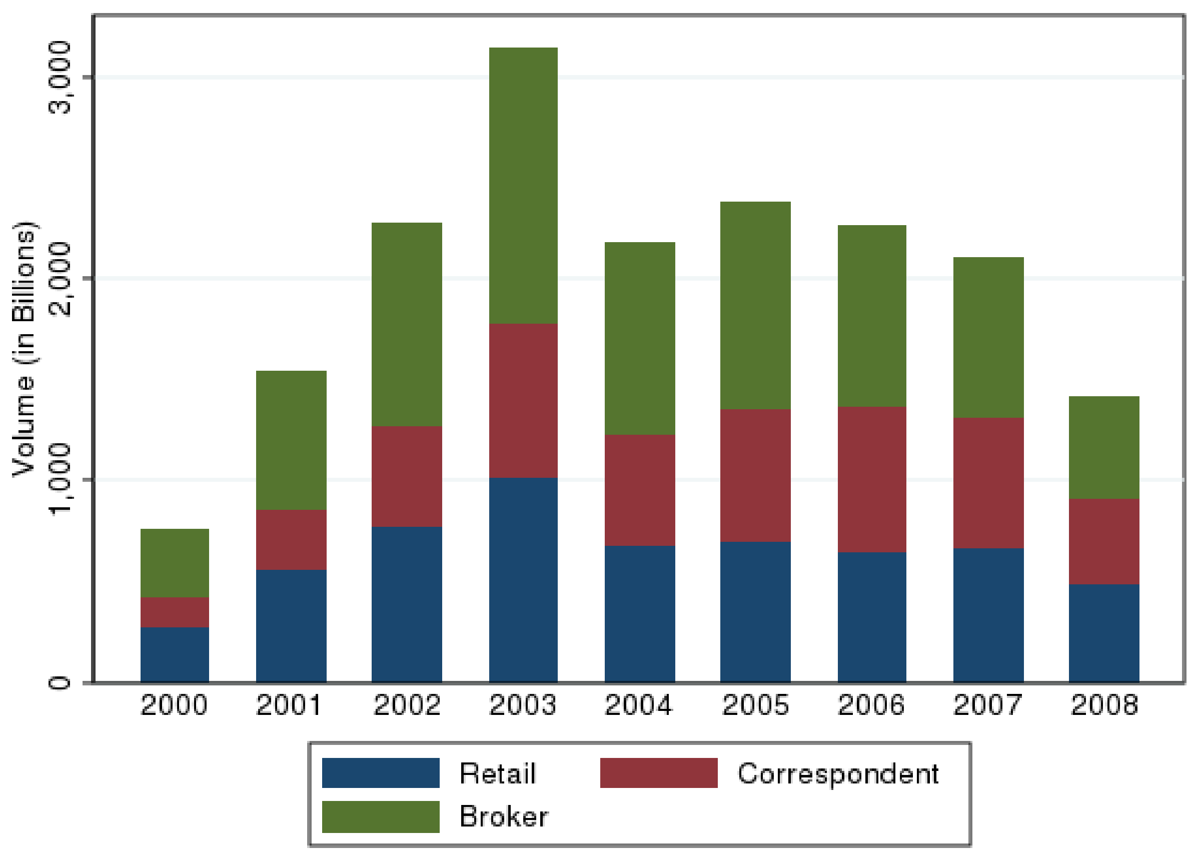
The figure shows the number of charters controlled by community banks and non-community banks as well as their fraction of total assets between 1984 and 2011. On the left axis we see the number of charters and on the right axes we have the percentage of assets held by the community banks. Source: FDIC (2012)

Figure 1.3: Changes in Local Lending Between 2000 and 2006



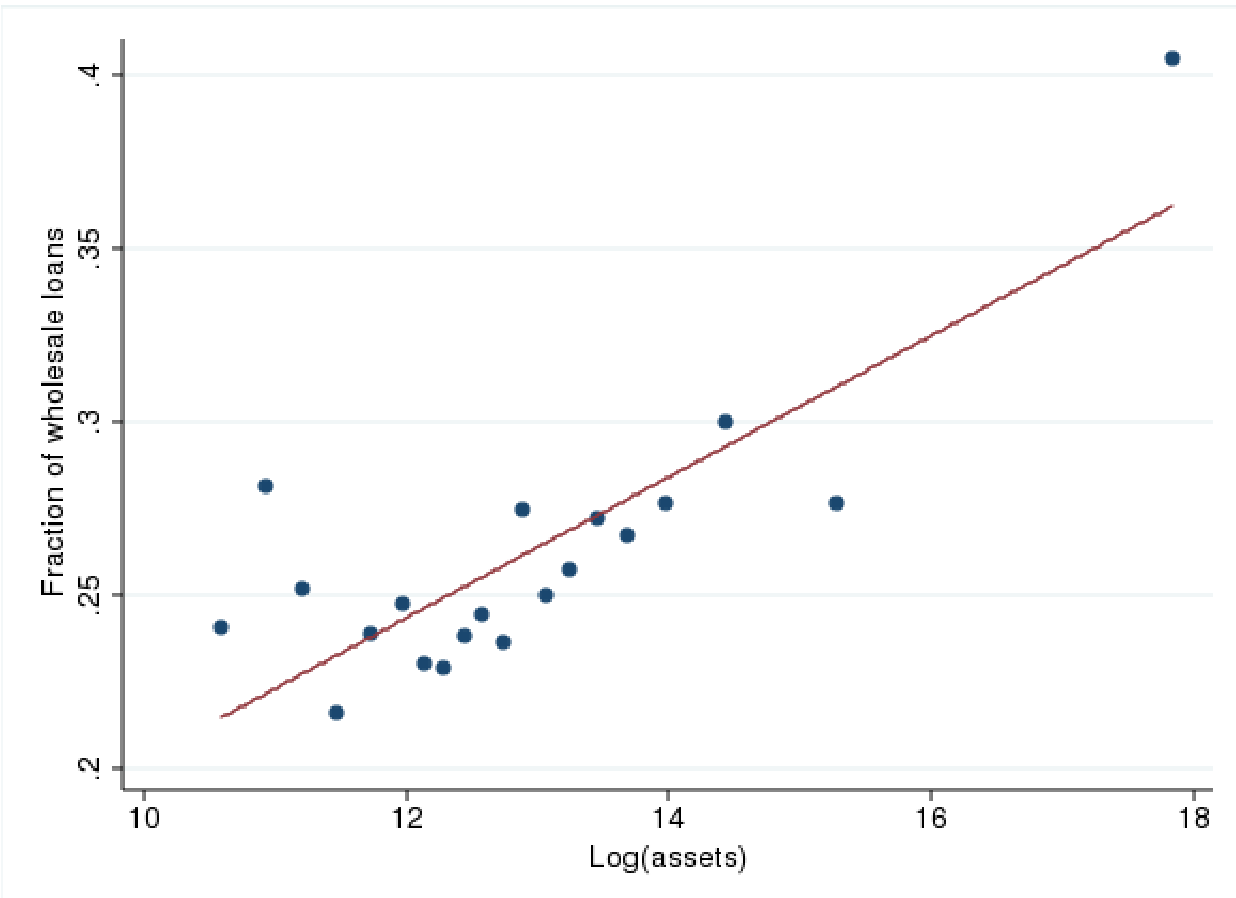
The map shows changes in the fraction of mortgage originations that were done through the retail channel between 2000 and 2006. A loan is assumed to be originated through the retail channel id the lender that originated the loan has a branch in the same county as the property for which the mortgage was obtained. Negative values indicate a shift from retail to wholesale originations.

Figure 1.4: Mortgage Production Channels Estimate



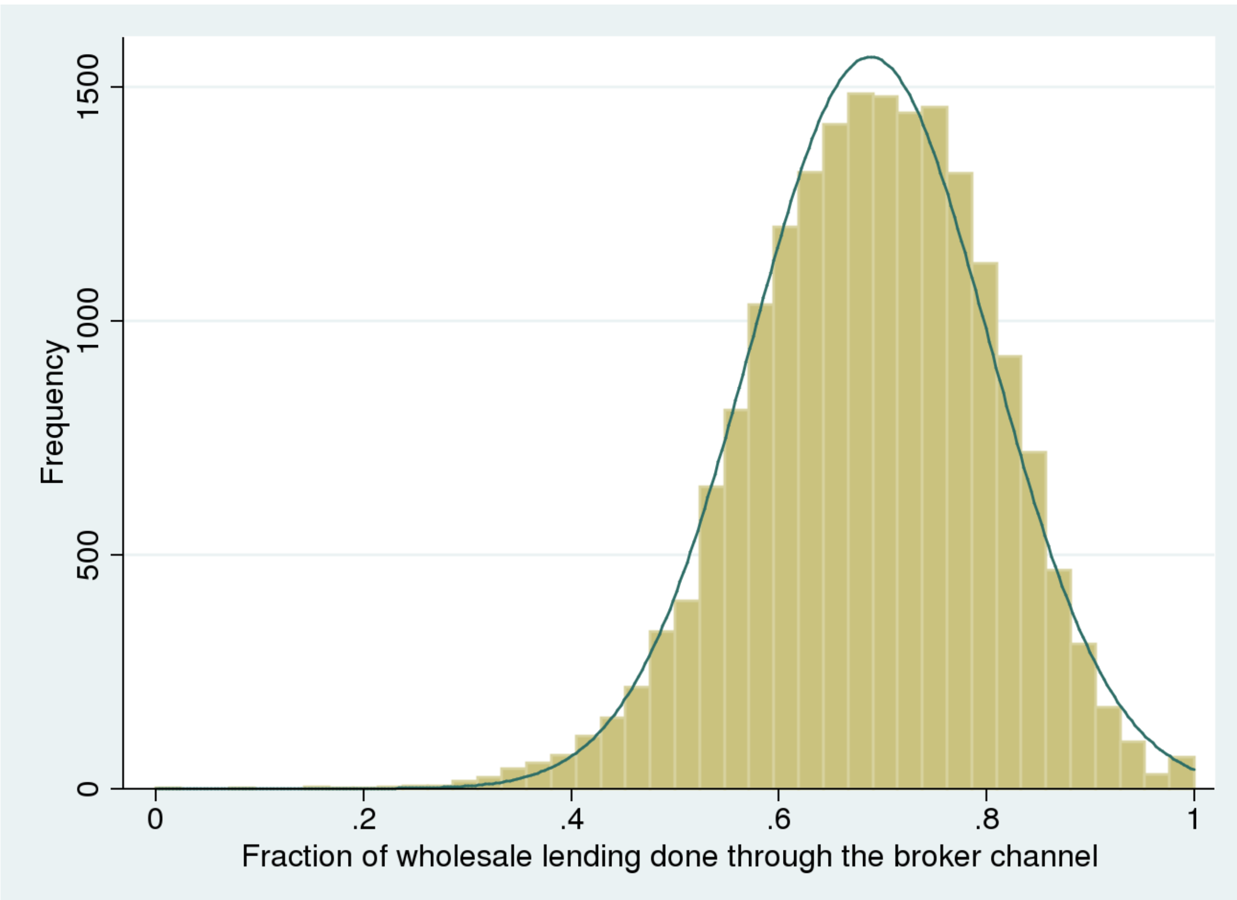
The figure shows the estimation of the volume of mortgages originated through the retail, broker and correspondent channels between 2000 and 2008. Retail mortgages are defined as loans made by lenders that have branches in the same county as the property, brokered mortgages are defined as mortgages originated by lenders who do not have a branch in the same county as the property and loans originated through the correspondence channel are defined as loans purchased by the lenders

Figure 1.5: Wholesale Lending and Lender Size



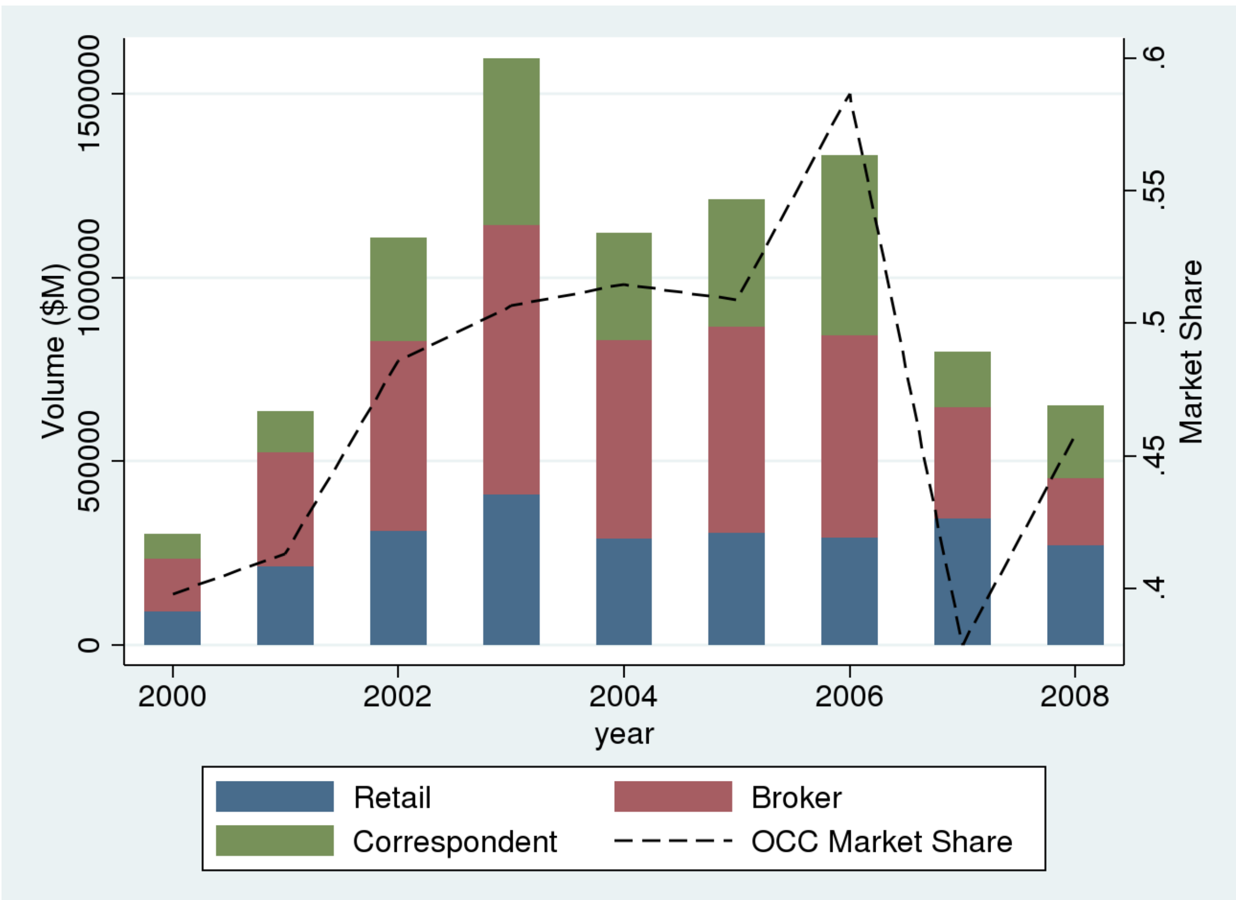
The graph is a scattered bin plot that shows the correlation between the size of the lender and the fraction of loans done through the wholesale channel (either broker or correspondent). The correlation is strong, indicating that the wholesale channel is an important mortgage origination channel for the larger lenders

Figure 1.6: Wholesale Loans: Brokers Market Share



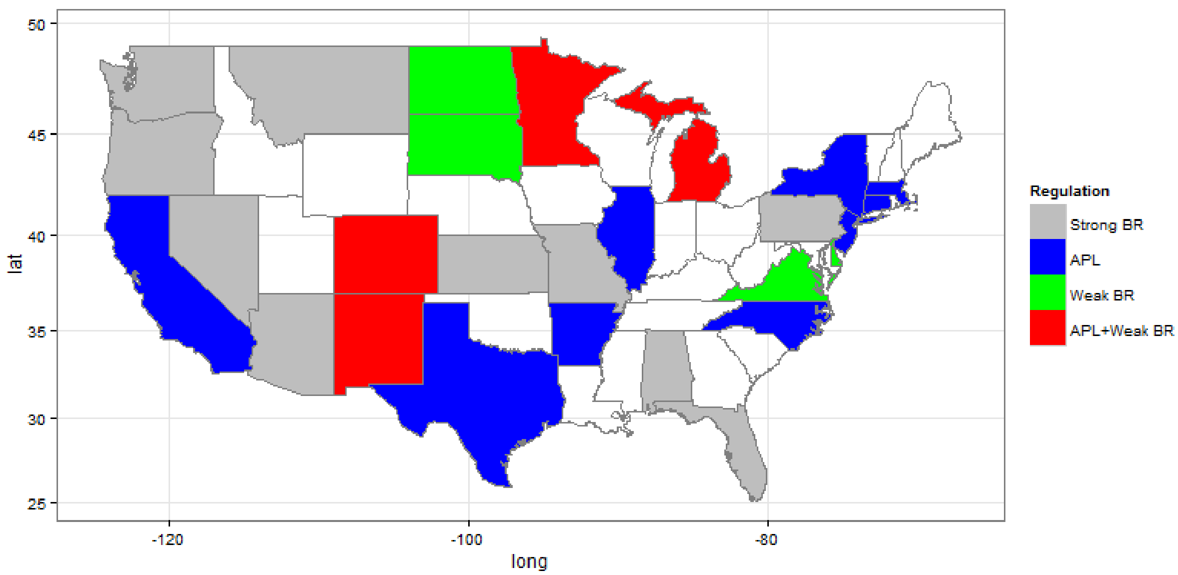
The figure shows the distribution of the fraction of wholesale loans that were originated through the broker channel in each county during the sample period (2000-2006), as defined in Equation 1.1. The histogram is compared to the normal distribution for reference

Figure 1.7: Mortgage Originations by OCC Lenders



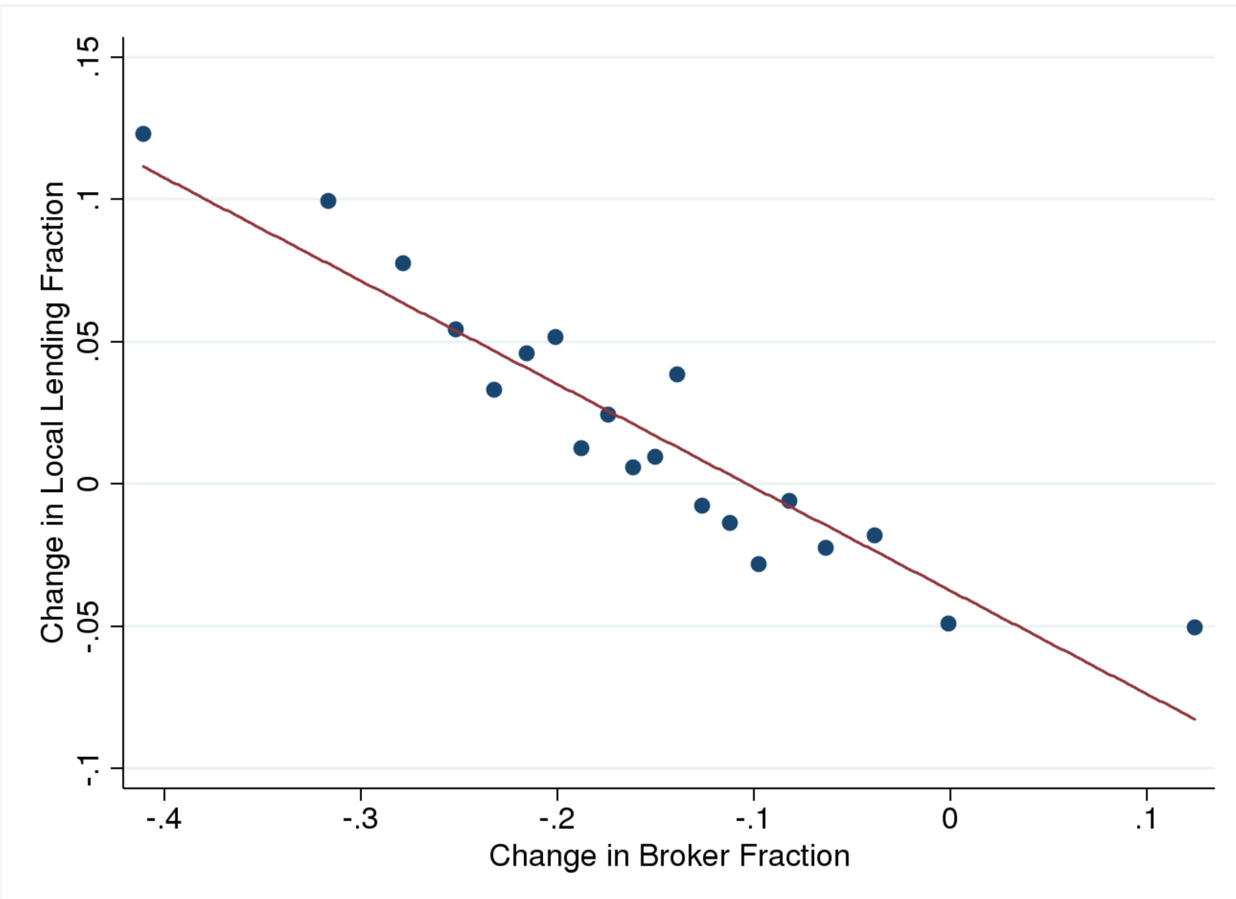
The figure shows the break down of mortgage production channels for national banks regulated by the OCC from 2000 to 2008. The left axis shows the volume of originated loans in millions and on the right axis we see the OCC lenders' market share over time.

Figure 1.8: APL Laws and Broker Licensing Requirements by State



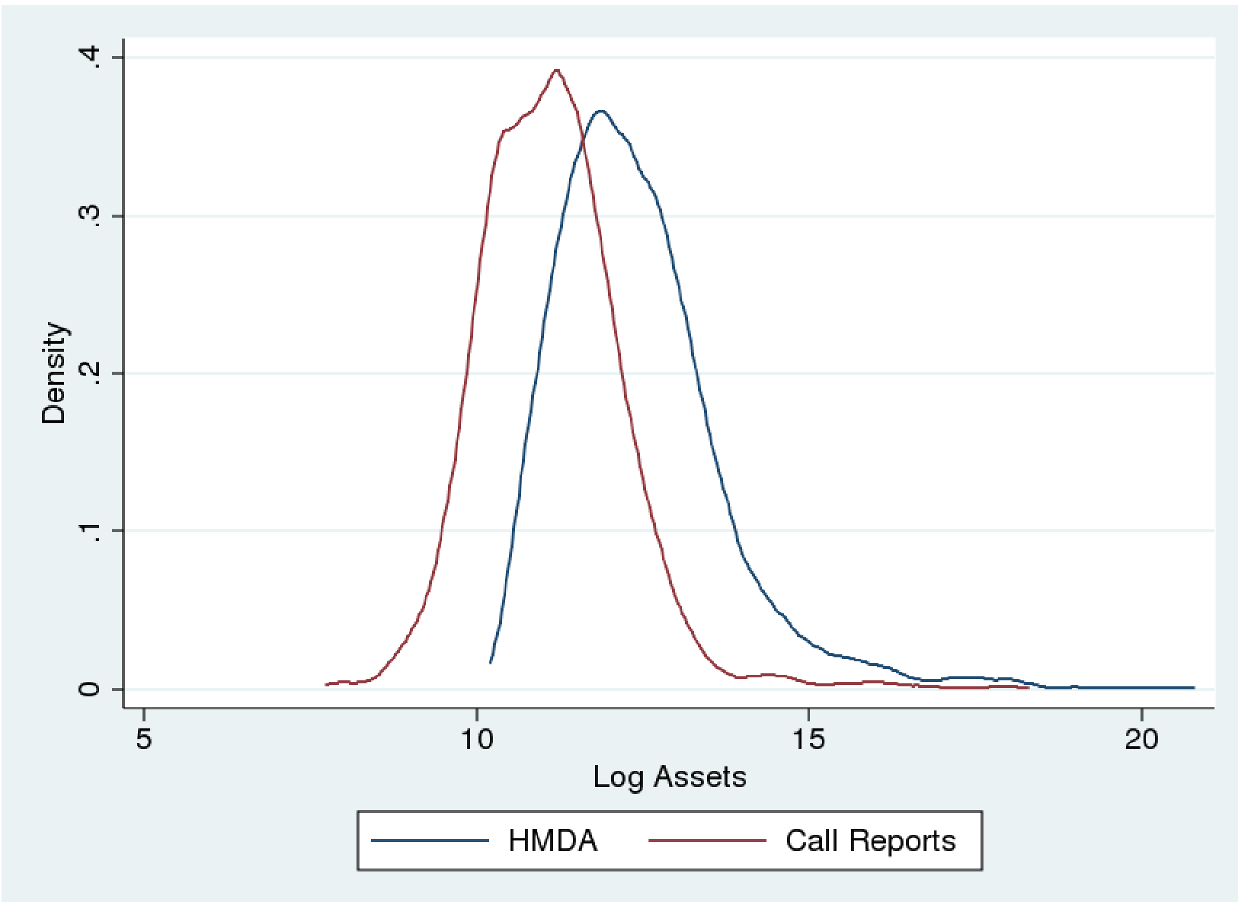
The map shows the strength of broker and state APL regulation as of 2004. The red states are those with string APL laws and weak broker requirements laws, the gray states are those with strong broker licensing requirements, the blue states are those with APL laws and the green states are those with weak broker licensing requirements. White states are not included in the sample.

Figure 1.9: Brokers and Retail Lending



This is a binned scatter plot that shows how substitution between correspondents and brokers is negatively correlated to lending through the retail channel. The x axis shows the change in the fraction of wholesale originations that were done through the broker channel and the y axis shows the change in the fraction of loans that were originated through the retail channel.

Figure 1.10: Comparing HMDA Coverage to the Call Reports



The figure shows the kernel density of the log of the assets for commercial banks that appear in HMDA and those that only appear in the call reports.

1.9 Tables

Table 1.1: Summary Statistics.

Panel A: County Summary Statistics

	N	Mean	SD	Min	Max
Mortgage originations	21,160	512,628	2,597,046	0	123,870,323
Mortgage purchases	21,160	217,382	1,226,969	0	54,719,132
HHI	21,160	.077	.074	0	1
Mortgage Applications					
Median borrower income	21,138	54	19	11	600
Median loan amount	21,140	86	48	1	720
Total applications	21,140	4,869	19,090	1	624,852
Black (%)	21,140	4.4	8.4	0	100
Hispanic (%)	21,140	3.7	7.9	0	100
Female (%)	21,140	21	6.7	0	100
Rejected (%)	21,140	15	11	0	100
County Characteristics					
Population	21,160	91,935	295,016	147	9,519,338
Poverty (%)	21,159	14	5.7	0	48
Household Income	21,157	37,679	9,744	15,231	100,772
Unemployment (%)	21,143	5.3	1.9	1.3	21
Number of branches	21,160	27	72	0	1,734
Establishments	21,157	5,186	16,793	11	622,356

Panel B: Lender Summary Statistics

	N	Mean	SD	Min	Max
Assets	131,775	333,065	1,875,191	1,945	88,311,750
Loans/Assets	131,775	.62	.16	.1	1.2
Mortgage/Assets	131,457	.16	.13	0	.95
Loan Sales/Loans	124,832	.00059	.0047	-.47	.43
Advances/Asstes	131,775	.013	.041	0	.97
Capital Ratio	131,457	.11	.045	-.074	1
Deposits/Assets	131,457	.93	.092	0	1

The table reports the summary statistics of the main variables used in the regressions. Panel A includes county level characteristics and panel B includes the lender level characteristics. The sample period is 2000-2006. *Mortgage originations* and *Mortgage purchases* are the volume of originated and purchased mortgages in thousands, respectively, *HHI* is the Herfindahl Index, measuring lender concentration in the county. The mortgage applications characteristics are from HMDA and include borrower income, median loan amount and total applications. They also include the percentage of loan applications made by Black and Hispanic borrowers and the percentage of applications made by females. *Rejected* is the percentage of applications that were rejected. *Population* is from the 2000 census *Poverty* is the percentage of population living in poverty as obtained from SAIPE, *Household Income* is also from SAIPE, *Unemployment* is from the BLS data and *Establishments* are from NETS.

.

Table 1.2: Top 20 Mortgage Lenders in 2005

Name	**Volume ($M)**	**Retail**	**Broker**	**Correspondent**	**Total**	**Retail**	**Broker**	**Correspondent**
COUNTRYWIDE BK NA	432,039	0.0	0.5	0.5	0.18	0.00	0.21	0.33
WELLS FARGO BK NA	230,166	0.4	0.4	0.2	0.10	0.15	0.09	0.06
WASHINGTON MUT BK	153,842	0.6	0.1	0.3	0.06	0.13	0.02	0.06
LEHMAN BROTHERS BK FSB	145,142	0.0	0.3	0.7	0.06	0.00	0.04	0.16
JPMORGAN CHASE BK NA	87,375	0.3	0.5	0.2	0.04	0.04	0.04	0.03
BANK OF AMER NA	83,939	0.8	0.1	0.1	0.04	0.10	0.01	0.01
CITIBANK WEST FSB	77,736	0.1	0.3	0.6	0.03	0.01	0.02	0.07
NATIONAL CITY BK IN	71,057	0.0	1.0	0.0	0.03	0.00	0.07	0.00
HSBC BK USA NA	68,413	0.1	0.4	0.4	0.03	0.01	0.03	0.05
SUNTRUST BK	47,193	0.4	0.4	0.2	0.02	0.03	0.02	0.01
INDYMAC BK FSB	46,367	0.1	0.5	0.4	0.02	0.01	0.02	0.03
WORLD SVG BK FSB	45,643	0.8	0.2	0.0	0.02	0.05	0.01	0.00
WACHOVIA BK NA	41,025	0.6	0.1	0.3	0.02	0.03	0.01	0.02
LASALLE BK MIDWEST NA	39,642	0.1	0.7	0.2	0.02	0.00	0.03	0.01
NORTH FORK BK	37,864	0.1	0.8	0.1	0.02	0.01	0.03	0.01
FIRST TN BK NA	37,067	0.1	0.8	0.1	0.02	0.01	0.03	0.00
FREMONT INV & LOAN	35,382	0.1	0.9	0.0	0.01	0.01	0.03	0.00
FLAGSTAR BK FSB	27,864	0.1	0.8	0.1	0.01	0.00	0.02	0.00
GMAC BK	27,716	0.0	0.6	0.4	0.01	0.00	0.02	0.02
OHIO SVB BK	23,994	0.1	0.8	0.1	0.01	0.00	0.02	0.00
					74%	**60%**	**74%**	**87%**

The table shows the top 20 depository institutions that reported to HMDA in 2005. Columns 1-4 show, for each lender, the volume of mortgage originations and purchases and the fraction of these mortgages that were originated through the retail, broker and correspondent channels respectively. Columns 5-8 look at the market share of each lender. Column 5 shows its total market share and columns 6-8 show the market share in the retail, broker and correspondent channels respectively. Overall, the top 20 lenders originated 75 percent of all mortgages, 60 percent of mortgages originated through the retail channel, 74 percent of mortgages originated through the broker channel and 87 percent of mortgages originated through the correspondent channel.

Table 1.3: Loan Characteristics

	Full Sample			Only loans kept on balance sheet		
	Retail	Broker	Correspondent	Retail	Broker	Correspondent
	Mean	Mean	Mean	Mean	Mean	Mean/t
Loan Amount	194.4	191.2***	187.5***	183.0	191.2***	187.5***
		(24.0)	(48.5)		(-47.2)	(-25.0)
Income	105.2	98.9***	96.4***	112.4	98.9***	96.4***
		(60.6)	(65.9)		(97.2)	(93.9)
LTI	2.22	2.30***	2.44***	1.94	2.30***	2.44***
		(-52.5)	(-103.8)		(-188.3)	(-180.6)
Black	0.055	0.085***	0.048***	0.056	0.085***	0.048***
		(-171.7)	(44.6)		(-125.5)	(42.1)
Hispanic	0.10	0.10***	0.067***	0.100	0.10***	0.067***
		(-17.4)	(166.2)		(-17.6)	(135.2)
White	0.78	0.75***	0.47***	0.77	0.75***	0.47***
		(120.8)	(915.4)		(66.4)	(692.7)
Sold to GSEs	0.27	0.26***	0.33***			
		(18.4)	(-184.2)			
Not sold	0.49	0.23***	0.29***			
		(816.6)	(562.7)			
High cost loan	0.067	0.25***		0.092	0.25***	
		(-721.0)			(-449.9)	

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The Table compares the characteristics of loans originated through the retail channel to those originated through the broker and correspondent channels for loans originated in 2005. The first three columns include the whole sample, columns 4-6 exclude retail originated loans that were not kept on the balance sheet. The full sample is an overestimation of the retail channel, since several loans that were originated through the retail channel were originated by correspondents. Columns 4-6 underestimate the retail channel because they exclude loans originated by the retail channel and sold directly to the secondary market. $LoanAmount$ reports the average loan amount (in thousands), $Income$ is the average income of the borrower (in thousands), LTI is the loan-to-income ratio, *Black* is the fraction of loans given to black borrowers, *Hispanic* is the fraction of loans given to Hispanic borrowers and $White$ is the fraction of loans given to white borrowers. *Sold to GSEs* is the fraction of loans that were reported as sold to one of the GSEs (Fannie Mae or Freddie Mac), *Not Sold* is the fraction of loans that were not sold after origination and *High cost loan* is the fraction of mortgages that are defined as high cost (according to HMDA guidelines, a high cost loan is a loan whose spread between the annual percentage rate (APR) and a treasury bond with similar maturity is 3 percent for first liens and 5 percent for second liens. Data are obtained from HMDA.)

Table 1.4: APL Laws and Broker Licensing Requirements.

State	Broker Index	Weak BR	APL	Broker Advantage
COLORADO	0	1	1	1
MINNESOTA	1	1	1	1
MICHIGAN	3	1	1	1
NEW MEXICO	3	1	1	1
ALASKA	0	1	0	0
SOUTH DAKOTA	1	1	0	0
DELAWARE	3	1	0	0
NORTH DAKOTA	3	1	0	0
VIRGINIA	3	1	0	0
DISTRICT OF COLUMBIA	4	0	1	0
MASSACHUSETTS	4	0	1	0
NEW YORK	4	0	1	0
MISSOURI	4	0	0	0
ALABAMA	6	0	0	0
ARIZONA	6	0	0	0
KANSAS	6	0	0	0
PENNSYLVANIA	7	0	0	0
WASHINGTON	7	0	0	0
ARKANSAS	8	0	1	0
HAWAII	8	0	0	0
OREGON	9	0	0	0
CALIFORNIA	10	0	1	0
ILLINOIS	10	0	1	0
CONNECTICUT	11	0	1	0
NORTH CAROLINA	12	0	1	0
TEXAS	12	0	1	0
NEVADA	12	0	0	0
NEW JERSEY	13	0	1	0
MONTANA	14	0	0	0
FLORIDA	16	0	0	0

The table reports the level of broker licensing requirements and whether the state had anti-predatory laws that were stronger than HOEPA as of 2004. Column 1 shows Pahl (2007) broker licensing requirements index. The higher the number, the stricter is the requirement. Column 2 identifies states with weak broker licensing requirements. I define weak licensing requirements as the bottom 25 percent of the broker index. Column 3 uses the index compiled by Ding et al. (2012) to identify states with APL laws that are stricter than HOEPA. Column 4 is the broker advantage flag, which is an interaction of columns 2 and 3. I removed from the sample states who had law changes after 2004.

Table 1.5: County Effects: Direct Approach

	Retail Volume		Retail Fraction		Fraction Kept on Balance Sheet		Local Branches	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(Broker Fraction)	-0.46***	-0.67***	-0.91***	-0.92***	0.21***	0.30***	-0.18***	-0.17***
	(-5.32)	(-10.22)	(-20.83)	(-20.30)	(5.63)	(8.19)	(-5.84)	(-6.35)
HHI		0.91		0.47**		-0.063		0.13***
		(1.54)		(2.23)		(-0.51)		(2.69)
Observations	18726	15835	18726	15835	18597	15751	18979	15988
R2	0.63	0.37	0.092	0.11	0.28	0.19	0.20	0.19
Year FE	X	X	X	X	X	X	X	X
FIPS FE	X	X	X	X	X	X	X	X
County Controls		X		X		X		X

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table reports the coefficients of the weighted least squares regression defined in Equation 1.2. The dependent variables are the log of mortgage originations done through the retail channel, the log of the fraction of retail loans originated through the retail channel, the log of the fraction of retail originated loans that were kept on the balance sheet and the log of the number of branches of depository institutions located in the county. The volume of mortgages is based on HMDA, data on the number of branches are from SOD and SNL. The sample period is 2000-2006. All regressions are weighted by county population and standard errors are clustered at the county level. *Log(Broker)* is the log of the fraction of wholesale lending that was done through the broker channel and HHI is the Herfindahl index, measuring the concentration of lenders in the county.

Table 1.6: County Effects: Link Between the Direct Measure and The Broker Advantage Index

	OCC Fraction		Not Sold		Broker Fraction	
	(1)	(2)	(3)	(4)	(5)	(6)
$I04 \times OCC \times BrokerAdvantage$	0.28***	0.42***	0.59***	0.39**	0.57***	0.58***
	(3.01)	(4.34)	(3.21)	(2.03)	(8.13)	(8.77)
$OCC \times BrokerAdvantage$	0.13*	0.16**	0.14	0.17	-0.53***	-0.38***
	(1.74)	(2.25)	(0.76)	(0.91)	(-7.55)	(-6.30)
$I04 \times BrokerAdvantage$	-0.085*	-0.14***	-0.24***	-0.18**	-0.25***	-0.23***
	(-1.95)	(-3.35)	(-3.09)	(-2.25)	(-7.72)	(-7.75)
$I04 \times OCC$	-0.079	-0.14***	-0.095	0.024	0.053	0.045
	(-1.28)	(-3.04)	(-1.47)	(0.40)	(1.39)	(1.28)
Broker Advantage	-0.12***	-0.14***	-0.081	-0.050	0.14***	0.089***
	(-3.50)	(-3.97)	(-1.31)	(-0.79)	(5.17)	(4.16)
$I04 \times APL$	-0.058***	-0.045***	-0.012	-0.0043	0.022**	0.016*
	(-3.33)	(-2.64)	(-0.61)	(-0.19)	(2.13)	(1.70)
$I04 \times WeakBrokerReq$	-0.045***	-0.035**	0.044	0.030	-0.025**	-0.020*
	(-3.22)	(-2.36)	(1.26)	(0.77)	(-2.07)	(-1.74)
I04	0.24***	0.17***	-0.17***	0.21***	-0.24***	-0.20***
	(11.69)	(9.30)	(-6.50)	(7.57)	(-19.58)	(-15.02)
APL	0.090***	0.10***	0.022	0.011	0.0041	0.0017
	(4.28)	(4.27)	(0.88)	(0.37)	(0.49)	(0.19)
Weak Broker Req	0.11***	0.15***	0.018	0.0094	-0.023	-0.021**
	(4.08)	(6.48)	(0.72)	(0.40)	(-1.54)	(-2.12)
Observations	10852	9136	10621	8988	10851	9135
R2	0.49	0.49	0.30	0.21	0.58	0.63
Year FE	X	X	X	X	X	X
FIPS FE	X	X	X	X	X	X
County Controls		X		X		X

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table reports the coefficients of the weighted least squares regression defined in Equation 1.3. The dependent variables are the fraction of mortgages originated by OCC lenders, the fraction of mortgages that were not sold after origination and the fraction of wholesale mortgages originated by brokers. The volume of origination is based on HMDA. The sample period is 2000-2006. All regressions are weighted by county population and standard errors are clustered at the county level. $I04$ is a dummy that is set to 1 for years after 2004, *Broker Advantage* is a flag that is equal to 1 for states where brokers have an advantage over correspondents, OCC is the fraction of wholesale mortgage originations that were done by OCC lenders through the correspondent channel in 2003, APL is 1 for states with APL, $WeakBrokerReq$ is equal to 1 in states with weak broker licensing requirements.

Table 1.7: County Effects: Broker Advantage Index

	Retail Volume		Retail MS		OCC Retail		Local Branches	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I04 \times OCC \times BrokerAdvantage$	-3.53***	-2.90***	-2.15***	-2.12***	-4.36***	-4.49***	-0.39***	-0.35***
	(-8.55)	(-8.13)	(-6.64)	(-7.60)	(-5.57)	(-5.33)	(-2.84)	(-2.80)
$OCC \times BrokerAdvantage$	0.56**	0.62*	0.73***	0.63**	3.12***	3.11***	-0.058	0.10*
	(1.98)	(1.76)	(3.03)	(2.05)	(2.92)	(3.03)	(-1.03)	(1.79)
$I04 \times BrokerAdvantage$	1.00***	0.85***	0.88***	0.81***	1.31***	1.40***	0.076	0.036
	(6.24)	(5.94)	(7.04)	(7.11)	(4.36)	(4.61)	(1.18)	(0.63)
$I04 \times OCC$	0.50***	0.16	-0.11	-0.11	0.82***	0.59**	0.095	0.12**
	(2.99)	(1.10)	(-1.16)	(-1.24)	(3.28)	(2.44)	(1.27)	(2.16)
Broker Advantage	-0.092	-0.089	-0.12*	-0.064	-0.56	-0.69**	0.050**	0.0021
	(-0.99)	(-0.83)	(-1.76)	(-0.74)	(-1.64)	(-2.12)	(2.16)	(0.09)
$I04 \times APL$	-0.031	-0.011	0.10***	0.11***	-0.075	-0.042	0.025	0.031**
	(-0.66)	(-0.24)	(3.27)	(3.49)	(-0.79)	(-0.50)	(1.42)	(2.08)
$I04 \times WeakBrokerReq$	0.19***	0.19***	0.13***	0.14***	0.25**	0.28***	0.041	0.064***
	(3.48)	(3.76)	(4.44)	(5.13)	(2.32)	(2.60)	(1.63)	(2.74)
	(1.46)	(0.47)	(3.68)	(2.52)	(-5.97)	(-7.68)	(1.88)	(0.64)
Observations	10703	9040	10703	9040	8799	7499	10854	9137
R2	0.69	0.43	0.12	0.14	0.58	0.33	0.26	0.25
Year FE	X	X	X	X	X	X	X	X
FIPS FE	X	X	X	X	X	X	X	X
County Controls		X		X		X		X

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table reports the coefficients of the weighted least squares regression defined in Equation 1.3. The dependent variables are the log and fraction of mortgages originated through the retail channel, log of the loans originated by OCC lenders through the retail channel and log of the number of local branches in the county. The volume of originations is based on HMDA and the number of local branches are from the SOD and SNL Financial datasets. The sample period is 2000-2006. All regressions are weighted by county population and standard errors are clustered at the county level. $I04$ is a dummy that is set to 1 for years after 2004, *Broker Advantage* is a flag that is equal to 1 for states where brokers have an advantage over correspondents, OCC is the fraction of wholesale mortgage originations that were done by OCC lenders through the correspondent channel in 2003, APL is 1 for states with APL, $WeakBrokerReq$ is equal to 1 in states with weak broker licensing requirements.

Table 1.8: Lender Balance Sheet

	Loan Sales	Loans		Non-Res Loans		Res Loans		Advances
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I04 \times WOCC \times BrokerAdvantage$	-0.0018**	-0.091**	-0.059***	-0.098**	-0.070***	0.14	0.011	-0.022**
	(-2.24)	(-2.44)	(-3.15)	(-2.04)	(-3.87)	(1.45)	(1.08)	(-2.28)
$OCC \times BrokerAdvantage$	0.0015***	-0.040	-0.0066	0.027	0.033**	-0.20**	-0.039***	0.0092
	(2.80)	(-1.31)	(-0.44)	(0.72)	(2.27)	(-2.57)	(-4.24)	(1.45)
$I04 \times WOCC$	-0.00088**	0.035*	0.015	0.13***	0.045***	-0.29***	-0.030***	0.0079**
	(-2.14)	(1.86)	(1.56)	(5.10)	(5.11)	(-5.48)	(-5.52)	(2.28)
$I04 \times BrokerAdvantage$	-0.000060	0.018	0.016**	0.052***	0.034***	-0.11***	-0.018***	0.0049
	(-0.17)	(1.30)	(2.22)	(2.97)	(4.84)	(-3.02)	(-4.52)	(1.64)
$BrokerAdvantage$	-0.00014	-0.0048	-0.0063	-0.054***	-0.022***	0.066***	0.016***	-0.0047***
	(-0.84)	(-0.50)	(-1.28)	(-4.51)	(-4.77)	(2.80)	(5.38)	(-2.85)
$I04 \times APL$	0.00018*	-0.0060	-0.0047*	-0.021***	-0.0097***	0.049***	0.0049***	-0.00086
	(1.70)	(-1.04)	(-1.69)	(-2.88)	(-3.72)	(3.10)	(3.11)	(-0.91)
$I04 \times WeakBrokerReq$	0.00017	0.028***	0.016***	0.013	0.0088**	0.024	0.0076***	0.00098
	(0.60)	(3.36)	(3.68)	(1.25)	(2.04)	(0.89)	(2.82)	(0.59)
Observations	124831	125399	125399	125373	125399	124143	125399	125399
R2	0.017	0.84	0.083	0.78	0.13	0.35	0.072	0.15

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.
The table reports the coefficients of the weighted least squares regression defined in Equation 1.5. The dependent variables are the log of loan sales, log and fraction of loans, log and fraction of non-residential loans, log and fraction of residential loans, and the fraction of FHLB advances. The data are based on the Call Reports. The sample period is 2000-2006. Standard errors are clustered at the lender level. $I04$ is a dummy that is set to 1 for years after 2004, *Broker Advantage* is a flag that is equal to 1 for states where brokers have an advantage over correspondents, $WOCC$ is the weighted fraction of wholesale mortgage originations that were done by OCC lenders through the correspondent channel in 2003 (as defined in Equation 1.4), APL is 1 for states with APL, $WeakBrokerReq$ is equal to 1 in states with weak broker licensing requirements.

Table 1.9: New Establishments: Direct Approach

	Dependent				Non-dependent			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(Broker Fraction)	-0.22***	-0.19***	-0.25***	-0.18***	-0.039	-0.10**	-0.10*	-0.066
	(-3.66)	(-3.02)	(-3.41)	(-2.72)	(-0.87)	(-2.04)	(-1.88)	(-1.28)
HHI		0.76***		0.70**		0.76***		0.68***
		(2.62)		(2.48)		(3.33)		(2.88)
Observations	21094	17951	18147	17951	20667	17601	17766	17601
R2	0.70	0.69	0.65	0.68	0.58	0.62	0.68	0.69
Year FE	X	X	X	X	X	X	X	X
FIPS FE	X	X	X	X	X	X	X	X
County Controls		X		X		X		X

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table reports the coefficients of the weighted least squares regression defined in Equation 1.2. The dependent variables are the log of the number of new establishments in the county (*Volume*) and the number of new establishments as a fraction of all establishments in the county (*Fraction*). The number of establishments is based on NETS. The sample period is 2000-2006. All regressions are weighted by county population and standard errors are clustered at the county level. *Log(Broke)* is the log of the fraction of wholesale lending that was done through the broker channel and HHI is the Herfindahl index, measuring the concentration of lenders in the county. Columns 1-4 include establishments that are dependent on external financing (See definition in Equation 1.6) and columns 5-8 include establishments that rely less on outside funding.

Table 1.10: New Establishments: Broker Advantage Index

	Dependent				Non-dependent			
	Volume		Fraction		Volume		Fraction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I04 \times OCC \times BrokerAdvantage$	-0.52**	-0.68***	-0.61**	-0.69***	0.078	-0.029	0.064	-0.032
	(-1.99)	(-2.60)	(-2.34)	(-2.92)	(0.35)	(-0.14)	(0.29)	(-0.16)
$OCC \times BrokerAdvantage$	0.27	0.47*	0.43	0.44	0.29*	0.44*	0.45*	0.44
	(1.63)	(1.74)	(1.37)	(1.41)	(1.83)	(1.77)	(1.68)	(1.59)
$I04 \times BrokerAdvantage$	0.34***	0.35***	0.36***	0.34***	0.046	0.061	0.039	0.034
	(2.90)	(2.97)	(3.02)	(3.06)	(0.54)	(0.71)	(0.43)	(0.40)
$I04 \times OCC$	-0.49***	-0.21	-0.50***	-0.26	0.16	0.25**	0.060	0.19*
	(-3.13)	(-1.25)	(-2.95)	(-1.57)	(1.54)	(2.16)	(0.54)	(1.67)
Broker Advantage	-0.21***	-0.40***	-0.40***	-0.43***	-0.24***	-0.38***	-0.39***	-0.39***
	(-3.56)	(-4.42)	(-3.71)	(-3.94)	(-4.58)	(-4.99)	(-4.57)	(-4.51)
$I04 \times APL$	-0.053	-0.0098	-0.021	0.013	-0.044	-0.022	-0.015	0.0060
	(-1.20)	(-0.23)	(-0.52)	(0.35)	(-1.41)	(-0.67)	(-0.50)	(0.21)
$I04 \times WeakBrokerReq$	0.092*	0.12**	0.15***	0.13***	0.080**	0.10**	0.10***	0.095***
	(1.85)	(2.38)	(3.04)	(2.89)	(2.10)	(2.52)	(2.78)	(2.59)
Observations	12108	10288	10428	10288	11832	10063	10185	10063
R2	0.72	0.70	0.69	0.70	0.61	0.65	0.71	0.72
Year FE	X	X	X	X	X	X	X	X
FIPS FE	X	X	X	X	X	X	X	X
County Controls		X		X		X		X

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table reports the coefficients of the weighted least squares regression defined in Equation 1.3. The dependent variables are the log of the number of new establishments in the county (*Volume*) and the number of new establishments as a fraction of all establishments in the county (*Fraction*). The number of establishments is based on NETS. The sample period is 2000-2006. All regressions are weighted by county population and standard errors are clustered at the county level. $I04$ is a dummy that is set to 1 for years after 2004, *Broker Advantage* is a flag that is equal to 1 for states where brokers have an advantage over correspondents, OCC is the fraction of wholesale mortgage originations that were done by OCC lenders through the correspondent channel in 2003, APL is 1 for states with APL, $WeakBrokerReq$ is equal to 1 in states with weak broker licensing requirements. Columns 1-4 include establishments that are dependent on external financing (See definition in Equation 1.6) and columns 5-8 include establishments that rely less on outside funding.

Chapter 2

The Perils of Exemption from Automatic Stay

Co-Authored with Richard Stanton [1] and Nancy Wallace [2]

2.1 Introduction

A growing literature addresses the theoretical merits of the exemption of derivatives and repurchase agreements from automatic stay in bankruptcy.[3] Surprisingly, despite the importance of the repurchase-agreement market to mortgage origination and the instability introduced by this market in the run-up to the financial crisis, few papers consider the possible role of the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) of 2005 on the development and pre-crisis collapse of the short-term markets that funded — and continue to fund — mortgage origination in the U.S. (see Echeverry et al., 2016; Stanton et al., 2014).[4] Of particular interest for this paper, is the importance of the post-

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[3]See, for example, Hoenig and Morris (2013); Infante (2013); Duffie and Skeel (2012); Schwarcz and Sharon (2015); Simkovic (2009); Roe (2011); Bolton and Oehmke (2014); Pozsar et al. (2012); Morrison and Riegel (2005).

[4]Ganduri (2016) recognizes the importance of independent mortgage companies (IMCs) in pre-crisis mortgage markets, however, he assumes that being an IMC is synonymous with the use of funding structures that afforded exemption under BAPCPA. We find that not all IMCs used these structures, whereas other mortgage originators did use them including depositories. Srinivasan (2016) also recognizes the importance of BAPCPA in driving increased demand for mortgage backed security products and finds that underwriters of securitized products increased the use of mortgage derivative repo in the months following the adoption of BAPCPA. He does not, however, focus on the mortgage origination channel as we do in this paper. Instead, he focuses on the hold for sale (HFS) portfolios of large bank holding companies and assumes that these HFS mortgage backed security holdings are synonymous with all mortgage repo collateral positions. We find that this assumption is inconsistent with both the call report and GAAP accounting requirements for recognizing the asset and liability structure of BHC mortgage warehouse positions – the specialized repo structures that are used to fund new mortgage originations on the part of the repo counterparties of the BHCs (the third

BAPCPA 2005 exemption provisions found in the Master Repurchase Agreements (MRAs) for mortgage warehouse lines as well as the accounting requirements found in the performance covenants of these counterparty agreements. The accounting covenants gave the warehouse lender well defined criteria to shut off the lines to the mortgage originators, often leading to the bankruptcy of the mortgage originator, and the exemption provisions of BAPCPA guaranteed that the repo collateral, the whole mortgages that were the collateral on the lines, remained on the books of the BHC warehouse lender rather than being consolidated into the bankruptcy estate of the mortgage warehouse borrower, the mortgage originator. These and other provisions of the post BAPCPA MRAs led to runs on the mortgage origination funding markets and to widespread bankruptcies. Interestingly, these funding structures have not changed post crisis and remain a very significant feature of the current funding used to originate mortgages for securitization by the Government National Mortgage Association (GNMA), Freddie Mac, and Fannie Mae.[5]

An important contribution of our paper is that it provides a more nuanced understanding of what has been termed the "originate-to-distribute" model of mortgage origination (see Keys et al., 2010; Rosen, 2010; Purnanandam, 2011; Bord and Santos, 2012; Keys et al., 2012). We argue that although it is true that prior to the mid 1970s banks used deposits to fund loans that they then kept on their balance sheets until maturity, this model of banking started to change at least two decades prior to the financial crisis. Over this two decade period, the industrial organization of the U.S. mortgage market evolved to include a large segment of non-depository and small-depository lenders who relied on warehouse lines from large international intermediaries to fund their mortgage origination activity (i.e. the dollars needed to fund borrowers' loan demand) (see Stanton et al., 2014). These non-depository lenders were, in turn, reliant on sales of their newly originated mortgages as a means to pay-off their warehouse lines. The securitization sales were to GNMA and the GSEs or in 2005 through 2007 to large private aggregators.

The non-depository loan origination activity is an "originate-to-distribute" model, however, the large bank holding companies, investment banks, and insurance companies functioned primarily to provide capital to non-depository and small depository originators and exercised little oversight on the underwriting quality of the loans. For this reason, often cited theoretical foundations concerning the monitoring functions of banks who engage in loan sales,[6] do not directly pertain to this form of mortgage origination, since legally the warehouse lenders are rarely liable for the quality of the loans that they fund. Instead, as warehouse lenders, the banks focused on monitoring the overall credit quality of the counterparties on their warehouse lines leaving the oversight of the loan underwriting quality to monitoring by GNMA and the GSEs or pre-crisis to private securitizers.[7] Starting in about

party or subsidiary mortgage originators).

[5]As of this writing, Q3:2016, 80% of GNMA and about 60% of Freddie Mac and Fannie Mae mortgage origination counterparties were funded through MRAs (see *Inside Mortgage Finance, 2016*).

[6](See, for example, Pennacchi, 1988; Gorton and Pennacchi, 1995; Petersen and Rajan, 1994; Holmström and Tirole, 1997; Parlour and Plantin, 2008).

[7]The agencies monitored through their scoring models, LoanUnderwriter and LoanProspector, and

2000s, the warehouse lending function expanded to include bond and commercial paper financing. The passage of the BAPCPA 2005 led to important changes in the incentives of warehouse lenders via a vis their warehouse counterparties because the mortgage collateral on warehouse lines became redefined as repurchase agreements (repo) and therefore eligible for exemption from automatic stay upon the bankruptcy of counterparties.[8]

We empirically analyze the functioning of the warehouse mortgage lending model after the passage of BAPCPA. Our analysis considers the firm performance of mortgage originators who relied on repo eligible warehouse lines and the performance of the warehouse lenders who provided the lines of credit. We also consider the relative quality and ex post performance of the underwriting standards for mortgages underwritten on warehouse lines eligible for repo status and those originated by lenders who were also repo lenders but did not originate their loans on warehouse lines. Finally, we consider the effect of repo status on the pricing of mortgage backed securities where the pool collateral was primarily mortgages that were underwritten on warehouse lines with repo status. We find that mortgage underwriting on warehouse lines with repo status was of systematically poorer quality and that firms that relied on this source of funding for their mortgage origination were more likely to go bankrupt. Warehouse lenders significantly increased their warehouse lending activities post BAPCPA and were significantly more exposed to elevated charge offs on their hold to investment book of mortgages. These charge offs were associated with post bankruptcy consolidation of the mortgage repo collateral, the loans originated by their repo counterparties, onto their balance sheets. Overall, the origination quality of the mortgages originated by warehouse lenders, whether for sale or hold to maturity, were of higher quality than those mortgage that were originated by the warehouse counterparties. Finally, the liquidity provided by BAPCPA appeared to be priced into mortgage backed securities collateralized mortgages originated through repo eligible warehouse lines. These results suggest the potential for significant peril associated with mortgage origination carried out on repo eligible warehouse lines of credit.

The paper is organized as follows. In Section 2.2, we compare the four warehouse lending contract structures and explain why the master repurchase agreements post BAPCPA became the dominant contract. In Section 2.3, we provide empirical evidence concerning the quality of mortgage underwriting under the post-BAPCPA master purchase agreements and the firm performance of mortgage originators whose warehouse lines were structured as master repurchase agreements. Section 2.4 reports on the magnitude of the warehouse lending positions of the bank holding companies and the effect of these positions on the warehouse lenders' (repo buyers) firm performance. We also provide empirical evidence concerning the quality of the mortgage underwriting for loans originated directly by the BHC's, who were also warehouse lenders, and compare the BHC loans to the loans originated by repo sellers using warehouse lines. In Section 2.5, we report the pricing effects of BAPCPA on private label mortgage backed securities where the collateral was largely funded under

GNMA and the GSEs has the right to exclude originators from the secondary mortgage market who were found ex post to consistently originate poor quality loans.

[8]See, the 2005 Amendments, Bankruptcy Code §101 (47).

master repurchase agreements. Section 2.6 concludes.

2.2 U.S. mortgage funding and warehouse lending

As shown in Figure 2.1, between 1997 and 2008 a significant share of mortgage origination in the U.S. was funded outside of the depository structure of the commercial banks, Savings and Loan Institutions and Credit Unions. An important outstanding issue in our understanding of the operation of the U.S. mortgage market both pre-crisis and currently concerns the causes of the fragility of the "pipeline" phase of mortgage origination. The pipeline phase of mortgage origination is structured to last, on average, between thirty to sixty days depending on whether the securitization channel is, or was, the Government Sponsored Enterprise (GSEs) or private label securitization entities.[9] The pipeline involves institutions (warehouse lenders, or repo buyers) that provide funding through lines of credit to mortgage originators (repo sellers) who in turn redeploy these funding dollars to borrowers (the principal on their mortgages) in exchange for a promissory note and a mortgage/deed-of-trust on the borrower's property. The mortgage originator (repo seller) transfers the mortgage and the note to the warehouse lender (repo buyer) as surety collateral for its borrowing on the warehouse line. Since the transfer takes place under Article 9 of the Universal Commercial Code, the interest is usually also perfected – a strong ownership position. Once the mortgage originator successfully sells the newly originated mortgage to a GSEs or, pre-crisis, to non-GSE securitization entity, the dollars received from the sale transaction are used by the mortgage originator (repo seller) to repay the warehouse lender (repo buyer) thus releasing capacity on the outstanding line of credit and allowing the transfer of the perfected interest in the note to the trustee of the Real Estate Mortgage Investment Conduit in the case of private-label securitization or to the trustee of the Pass Through pool in the case of GSE securitization.

A significant problem with identifying the non-depository sources and uses of funds for the mortgage pipeline is that these arrangements are structured as bespoke agreements between repurchase agreement Buyers and Sellers. As shown in right-hand side of Figure 2.2, pre-crisis one important class of repurchase agreement warehouse lenders (repo buyers) were off-balance sheet entities, called Structured Investment Vehicles (SIVs), that were associated with the same holding company as the repurchase agreement Buyer (i.e. these companies were borrowing from bankruptcy remote entities (SIVs) funded by commercial paper (called Extendable Asset Backed Commercial Paper (ABCP)) in part collateralized by their own holding company).

[9] Based upon calculation from the authors, the pipeline period typically averages between 30 to 45 days for mortgages that are securitized by the GSEs (using the time between the mortgage origination date and the first RMBS payment date for about 39 million mortgages securitized by Fannie Mae and Freddie Mac). The pipeline period typically averages between 45 to 55 days for mortgage that were securitized via the private-label mortgage market (using the time between the mortgage origination date and the first RMBS payment date for about 22 million mortgages securitized through 5,500 private-label RMBS deals using data provided by ABSNet) (see, Echeverry et al., 2016).

As shown in the left-hand side of Figure 2.2, the far larger class of warehouse lenders (repo buyers) were commercial banks, savings and loan institutions, finance companies, and investment banks all with highly variable (or non-existent) regulatory capital requirements and considerable discretion in the GAAP and regulatory accounting treatment of their positions. As shown in the bottom left-hand segment of Figure 2.2, a final difficulty in tracking the sources and uses of funds in the pipeline phase of mortgage origination arises because the perfected interests that were held by the warehouse lenders (repo buyers) were often eligible for rehypothecation (i.e. the notes could be pledged as collateral for borrowing through repurchase agreements with other counter-parties) either with the Federal Home Loan Bank using Federal Home Loan Bank Advances or on the bilateral repo market. Thus, determining the mortgage pipeline leverage ratios per dollar of originated principal requires a nearly impossible tally of the Federal Home Loan Advances, the derivative positions due to the rehypothecation (recorded for accounting purposes as assets receivables and interest rate forward contracts or as derivative positions), the reverse repurchase positions of the repo buyer (recorded for accounting purposes as loans held for investment with a 100% risk weight), and the outstanding drawdowns on the lines of credit to the mortgage repo Seller from multiple repo buyers and from their SIVs.

As is evident in Figure 2.1 and Figure 2.2, a large share of U.S. mortgage origination is funded through sources other than deposits and the current organizational structure of the mortgage origination market is surprisingly disintegrated (see Stanton et al., 2014). Three important institutional changes led to the disintegration of the highly vertically integrated within the depository banking sector U.S. mortgage origination and funding market that existed prior to 1970 (see Jacobides, 2005a; Chen, 2005; Bresnahan and Levin, 2013). First, the federal government introduced standardized securitization systems through the GSEs and the Government National Mortgage Association (GNMA) and allowed non-depository mortgage banks to issue and service loans under GSE criteria. With this change, non-depository mortgage banks could use lines of credit obtained from commercial banks (see Fabozzi and Modigliani, 1992) to fund loans temporarily before sales to the GSE securitizers. The second major change occurred as the result of the recession of 1979–81, when banks and S&Ls laid off their loan origination staff and then re-established long-term relationships, often with the same staff, as independent loan brokers. The loan brokerage vertical disintegration was funded with lines of credit from mortgage banks, commercial banks or S&Ls or by an alternative model whereby the brokers merely served as agents that matched borrowers with loan products without making the underwriting or funding decisions. The third major change was the vertical disintegration of loan servicing from loan origination through the creation of a market for mortgage servicing rights.

Each of these stages of vertical disintegration in the mortgage market led to the creation of highly specialized entities: mortgage brokers with highly specialized local market knowledge; mortgage bankers with specialized knowledge concerning capital market funding and managing pre-securitization pipeline risk; depository institutions who did some origination but increasing specialized in funding downstream originators through short-term lines of credit and repurchase agreements that require the management of liquidity and roll-over risks; mortgage servicers specialized in the management of interest rate and prepayment risk; and mortgage securitizers with specialized capital market knowledge associated with accessing the mortgage investors needed to purchase the mortgage backed securities.

The warehouse lending facilities used to provide the short-term funding to the mortgage origination pipeline are among the largest lending facilities at commercial banks and they often involve counter parties that have the highest leverage in the loan portfolio. As shown in Table 2.1, these credit facilities can be structured as traditional lines of credit (LOC), as master repurchase agreements (MRA) or as true sale agreements.[10] As discussed above, in the pre-crisis period SIVs funded by extendable ABCP were another common pipeline funding structure. The most common pipeline funding structure is the master repurchase agreement because, as shown in Table 2.1, it has a number of features that are potentially highly advantageous to the warehouse lender (the repo buyer) and, thus, reduce the cost of capital to the mortgage originator (the repo seller).

Master Repurchase Agreements (MRAs)

Currently, the MRA funding structure is widely used for conventional conforming mortgage origination that is intended for GSE securitization. It was also widely used in the pre-crisis period for the private-label origination pipeline. The mortgage originator uses the revolving lines to fund the mortgages that it originates in its own name. The warehouse lender then simultaneously retains an interest in the mortgage, which is subject to a commitment by the mortgage originator to repurchase the loan from the warehouse lender within thirty days. The warehouse lender "perfects" its interest in the collateral (the note), usually through assignment or through UCC-1.[11] The originator pays a haircut for each dollar of loan balance originated,[12] as well as an interest payment, typically priced at LIBOR plus a spread. The lines are structured such that the newly originated loan collateral held in the facility must be sold within the next 30 to 45 days. Unsold loans held for more than 45 days are subject to further margin calls and mark-to-market charges. These fees can rapidly increase the cost of the MRA to the mortgage originator by five to six hundred basis points. Once the mortgage originator sells the loan into the securitized market, either through private-label or GSE securitization, the proceeds from the sale are repaid to the warehouse lender, releasing the capacity of the facility for future lending.

Another reason for the prevalence of MRAs in structuring mortgage warehouse facilities (both currently and in 2006) involves the treatment of these days under the Bankruptcy

[10] All three of these arrangements can be documented so as not to involve table funding. What separates a bona fide warehouse line from a table funding transaction is that with a bone fide warehouse line, the mortgage banker originates the mortgage loan in its own name with "at risk" funds and remains responsible for the loan performance pending sale in the secondary market.

[11] A perfected security interest in the mortgage note automatically perfects a security interest in the underlying mortgage (see UCC §§9-203(g), 9-308(e)).

[12] The haircut is charged as a percentage of balance, such that less than 100% of the loan would be funded, or owned, by the warehouse lender. In 2006, these haircuts ranged between 95% and 100%.

Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA).[13] As shown in Figure 2.3, the use of MRA's increased dramatically upon the passage of BAPCPA and the prevalence of MRAs to fund mortgage originations surpassed that of lines of credit among mortgage originators. Under BAPCPA, MRAs qualify as "repurchase agreements," so the collateral can be safe harbored upon bankruptcy of the counterparty. Since the warehouse lender usually has a perfected interest in the unsold mortgage collateral within the facility, the exemption from automatic stay enables them to take over the collateral upon the default of the mortgage originator. The warehouse lender can then immediately sell its interests in the mortgage loans to repay the related advances, repurchases, and other obligations of the mortgage originator.[14]

The MRAs continue to be treated as collateralized lending by many lenders, despite the recent insistence by the OCC that they do not qualify as true sales under GAAP. Their treatment as repurchase agreements under BAPCPA and their eligibility for exemption from automatic stay guarantees the warehouse lender significant speed and freedom to liquidate collateral and close down the facilities. The MRA covenants also allow the warehouse lender the right to close down the facility and take over the collateral due to triggers tied to the economic performance of the originator or due to the inability of the originator to make margin calls associated with holding loans seasoned for more than 45 days. Given the contractual features of the MRAs, the warehouse lender typically has an incentive to focus on counterparty risk and the liquidity of the mortgage collateral, rather than on the underwriting quality of any given loan.[15] As a result, these facilities are vulnerable to systemic slowdowns in the liquidity of whole loan sales into the secondary mortgage market, the aggressive margining requirements on seasoned loans that are intended to guarantee that these funding sources are short term (usually less than 30 days), and even short-term performance weakness of the counterparties. Without reliable demand for whole loans in the secondary mortgage market, whether from the GSEs or (in 2006) from private-label securitization, the MRA funding structure for mortgage origination is quite vulnerable to runs.

The demise of lines of credit, true sales, and SIVs

As shown in Table 2.1, the three other contracting structures that can be used for warehouse lending are lines of credit, true sales, and structured investment vehicles (SIVs). Lines of credit are used to provide funding to the mortgage origination pipeline, however, they are not commonly used. Under a LOC, the loan originator receives an advance from the warehouse lender that is generally less than the amount required to fund the mortgage loan and the advance is repaid once the mortgage originator sells the loan in the secondary market. The

[13] See Pub.L. 109-8, 119 Stat. 23, enacted April 20, 2005, `http://www.gpo.gov/fdsys/granule/STATUTE-119/STATUTE-119-Pg23/content-detail.html` and `http://www.gpo.gov/fdsys/pkg/PLAW-109publ8/html/PLAW-109publ8.html`

[14] See Schweitzer et al. (2008).

[15] A further reason for this focus is that the put-back options for all loans that are sold out of the facility remain with the originator since the originator underwrote and funded the loan in its own name.

mortgage originator pays some form of interest on the advance from the warehouse lender, but that interest does not vary based on any gain or loss experienced by the originator upon the sale of the loan in the secondary market. The mortgage originator must contribute to the funding of each mortgage loan, called the "Hair-Cut." The collateral of the LOC underlying mortgage loans, but the content of the required collateral packages can vary. Although the sale of the mortgage loan collateral is the primary source of repayment on LOCs, the warehouse lenders usually underwrite the mortgage originator's credit as a secondary source of repayment. A disadvantage of this contracting structure is that the collateral on the LOC is not eligible for repo status.

The demise of LOCs was largely driven by policy changes at the Office of the Comptroller of the Currency (OCC). In a 2012 supervisory memorandum,[16] the OCC reiterated its position that MRAs should be accounted for by warehouse lenders as loans to a mortgage originator rather than as a true-sale purchase of individual mortgage loans.[17] Warehouse LOcs have the additional restriction that there are legally binding limits for these programs by counterparty exposure.

True sale agreements completely remove the mortgage collateral from the bankruptcy of mortgage originator (except for servicing) and may have other legal advantages for warehouse lenders. The primary disadvantage of these contracts is that they limit recourse to the mortgage originator and potentially pass underwriting liability to the warehouse lender since they "own" the loans. One important advantage of this contract structure is the mortgage collateral is recognized as loans held for sale with either a 20% or 50% risk weight as opposed to the 100% risk weight for MRA collateral. The three ASC 860-10-40-5 conditions that are required to be met to achieve true sales treatment are:[18]

1. The assets are isolated from the originator and placed beyond the reach of the originator even in bankruptcy or other receivership (often referred to as "legal isolation."
2. The transferee has the right to pledge or exchange the assets it received, and no condition constrains the bank from taking advantage of its right to pledge or exchange the asset or provides more than a trivial benefit to the originator.
3. The originator does not maintain effective control over the transferred assets.

The final pre-crisis warehouse lending contracts were called structured investment vehicles (SIVs). SIVs were bankruptcy remote entities created by mortgage originators, such as Countrywide and many real estate investment trusts (REITs) engaged in mortgage origination, to provide warehouse lines to the parent mortgage originator. The SIVs were funded by the issuance and sale of asset backed commercial paper (ABCP) by the parent holding

[16]See Supervisory Memorandum, the Comptroller of the Currency, December 18, 2012.

[17]The OCC Memorandum criticized warehouse lenders that incorrectly accounted for their MRAs as purchased loans with a 50% risk-weight allowed for qualifying mortgages, and argued, instead, that the MRA should be recognized as a financing transaction (i.e., a warehouse line of credit) with a 100% risk weight.

[18]See Supervisory Memorandum, Comptroller of the Current, Administrator of National Banks, SM 2012-7, To: All Examining Personnel, From: John C. Lyons Jr. Senior Deputy Comptroller and Chief Nation Bank Examiner, Date: December 18, 2012, Subject: Mortgage Purchase Programs.

company and the assets of the SIV were the mortgage liens that were the collateral on the lines of credit provided to the parent originator. The contracting structure was similar to MRAs and the draws on the lines were priced using haircuts and margins. The SIV market completely collapsed by November 2007 with the collapse of the ABCP market (see, Echeverry et al., 2016).

2.3 Mortgage originators and firm performance

In this section, we consider the loan underwriting and firm performance of mortgage originators who did and did not rely on master repurchase agreements to fund their mortgage origination. We restrict our sample to include the top 40 lenders (as compiled by Inside Mortgage Finance) and all of their affiliated subsidiaries. For each lender, we searched the 8-K and 10-K for evidence of MRA financing. We also added several smaller REITs and mortgage brokers that were known to use MRAs to finance their mortgage origination.

Underwriting quality, MRA funding and BAPCPA

From the Home Mortgage Disclosure Act (HMDA), we obtain loan-level data on loans originated in 2005 and 2006. We limit our sample to these two years because in this period there was an increase in the use of repo agreements (after the passage of BAPCPA and before the market dried up in 2007). HMDA includes annual reports for the majority of mortgage applications received by the lenders. The disclosure includes the location of the property, whether the application was accepted, rejected or withdrawn by the borrower, whether the loan was originated or purchased by the lender, whether the loan was sold during the year, the income of the borrower, the purpose of the loan (home purchase, refinance or home improvement), occupancy, rate spread over treasuries [19] and the race and gender of the borrower. We remove loans with missing loan amounts, borrower income, borrower gender or borrower race. We also remove loans with loan amount or borrower income that are above the 99 percent of their distributions.

We augment the dataset to the "HMDA Lender File" compiled by Robert Avery. The lender file provides information on the type of lender — whether it is a commercial bank, savings bank, credit union, affiliated mortgage company (AMC) or an independent mortgage company (IMC). Data on loan characteristics are obtained from The Home Mortgage Disclosure Act (HMDA).

Overall, our sample includes 46 independent mortgage companies, 307 affiliated mortgage companies and 44 depository institutions. The sample represents about 55 percent of all mortgage originations and 75 percent of all purchased loans in HMDA.

[19] the spread is reported only for originated mortgages. It is computed by taking the difference between the annual percentage rate (APR) and the yield of treasury bonds with similar maturities. Lenders are required to disclose the spread only if it is higher than 3 percentage points (for first liens) or five percentage points (for junior liens)

To obtain performance data, we merge these data with transaction level data from CoreLogic DataQuick dataset. DataQuick provides information on the status of the loan. We define a loan to be in distress if it went through foreclosure, REO liquidation, short sale or an ownership transfer. From DataQuick, we also obtain the value of the property.

Table 2.2 shows summary statistics of the main variables used in the analysis. *Purchased* is equal to 1 if the loan was purchased by the lender, *LTI* is the loan-to-income ratio, *LTV* is the loan-to-value ratio, *Income* is the borrower's reported income, *Conforming* is equal to one if the loan amount is smaller than the GSE's conforming loan limit, *High Cost* is equal to one if the loan is a high-cost loan, *Rejected* is equal to one if the application was rejected by the lender, *Withdrawn* is equal to one if the application was withdrawn by the applicant, *Sold* is equal to one if the loan was sold and *Distress* is equal to one if the loan ended in distress.

We run the following loan-level ordinary least squares regression:

$$Y_{lct} = \alpha_{ct} + \beta \times \text{RepoSeller}_l + \Gamma \times X_l + \epsilon_{lct} \tag{2.1}$$

Where Y_{lct} is a set of outputs, RepoSeller_l is 1 if the lender is identified as a mortgage originator funded by warehouse lines with MRA contracting structures and 0 otherwise [20], X_l is a set of loan controls. The controls include the type of lender (independent mortgage company (IMC), affiliated mortgage company (AMC) or a depository), the type of loan (conventional, FHA, VA or FSA/RHS), the purpose of the loan (home purchase, refinancing or home improvement), occupancy, borrower gender, borrower race and whether the loan was purchased by the originator. All mortgages include county-year fixed effects and the errors are clustered at the county level. The coefficient of interest, β, captures the difference in output between the treatment group (repo sellers) and the control group (non-repo sellers).

Table 2.3 shows the results of the regression defined in Equation 2.1 for all applications and mortgage purchases [21].

Columns 1-7 look at a set of underwriting characteristics. We find that repo sellers had loan-to-income (LTI) ratios that were 0.12 higher and loan-to-value (LTV) that were 0.01 higher than the LTI and LTV of mortgages originated by non-repo sellers. Demyanyk and Van Hemert (2011) found that loans with high LTV, especially in this time period, experienced higher delinquency rates. These results support the prediction that repo sellers originated riskier loans. Interestingly, we do not find differences in the probability of originating a high-cost loan. This could be because the high cost flag only identifies loans with high interest rates but does not take into account other risky characteristics (such as prepayment penalties, balloon payments etc.)

Next, we consider whether the loan was conforming or not. Every year, the GSEs' regulator, The Office of Federal Housing Enterprise Oversight (OFHEO), announces what would be the conforming loan limit (CLL) for that year. The GSEs are prohibited from purchasing loans with principal higher than the CLL. We define conforming mortgages to

[20] We identify the use of MRA contracting structure using the 8Ks and 10Qs of each firm.

[21] We get similar results when we exclude purchased loans.

be those smaller than the CLL of that year [22]. We find that repo sellers were 1 percent less likely to be conforming (column 3). non-conforming loans were considered to be riskier than conforming loans, since they could only be sold to non-GSE securitizers. Therefore, this finding also suggests that repo sellers originated riskier mortgages.

In columns 5 and 6, we find that applications submitted to repo sellers were 5 percent less likely to be rejected by the or withdrawn by the borrower. The lower rejection rates could be the result of lax screening. In column 7 we see that loans originated by repo sellers were 23 percent more likely to be sold in the secondary market, which could also indicate fewer incentives to screen the borrowers (see, for example, Keys et al. (2010) and Purnanandam (2011))

Lastly, in column 8 we look at the ex-post performance of the loans. We find that loans originated by repo sellers were 4 percent more likely to end up in distress.

Overall, Table 2.3 suggests that repo sellers originated lower quality mortgages than those not involved in the repo market.

Mortgage originator bankruptcy and MRA warehouse funding

The previous section established that repo sellers originated mortgages of lower quality. In this section, we consider the fragility of repo funding by looking at the survival rate of repo sellers during the 2007 financial crisis, when the repo market dried up. We show that repo sellers were more likely to go bankrupt during that period, since they lost their main source of capital.

From Compustat, we obtain quarterly data on commercial banks (SIC 6020), federal savings institutions (SIC 6035), mortgage bankers and correspondents (SIC 6162) and real estate investment trusts (REIT, SIC 6798) operating in the U.S. The sample period is 2000Q1–2012Q4. We remove observations that occur after the bankruptcy date, observations with missing total assets, observations where the total amount of liabilities is greater than the total amount of assets and observations where the long term debt is greater than the total liabilities. We also remove firms who first appear in the dataset after 2007Q1. Compustat only includes public firms that are relatively large in size.

Similar to the previous subsection, we identify mortgage originators funded by MRAs by looking at the firms' 8-K and 10-K reports. Overall, there are 1,201 firms included in the sample. 53 of which were identified as MRA sellers and 31 went bankrupt during this period. Table 2.4 summarizes the number of firms by category, Table 2.5 shows the summary statistics of the main variables and Table 2.6 lists the firms that went bankrupt during the sample period. Table 2.4 shows that repo sellers had higher bankruptcy rates than non-repo sellers.

To establish the link between repo sellers and bankruptcy rates, we run the following diff-in-diff Linear Probability Model:

[22] The CLL was set to \$359,650 in 2005 and \$417,000 in 2006. In Alaska, Hawaii, The U.S Virgin Islands and Guam the limit was 150 % higher

$$Y_{it} = \alpha_i + \nu_t + \beta \times \text{Crisis}_t \times \text{RepoSeller}_i + \gamma_1 \times \text{Crisis}_t + \gamma_2 \times \text{RepoSeller}_i + \Gamma \times X_{i(t-1)} + \epsilon_{it} \quad (2.2)$$

Where Y_{it} is set to 1 if firm i declared bankruptcy (or was liquidated) on quarter t, Crisis_t is a dummy variable that is equal to 1 during the crisis period (after 2007Q2),RepoSeller_i is set to 1 for firms that were identified as MRA sellers and X_{it} is a set of time varying controls (log assets, fraction of cash holdings, leverage, fraction of short term debt and book-to-market). All regressions include lender and quarter fixed effects and the errors are clustered at the lender level. Our coefficient of interest, β measures the difference in bankruptcy probability after the 2007 crisis between repo sellers and non-repo sellers.

The results of this regression are shown in Table 2.7. We repeat the regression for four sample periods ending in 2008Q4, 2009Q4, 2010Q4 and 2012Q4. As expected, firms that were using MRAs to fund their mortgages defaulted more often than those that were not using this form of funding. The use of MRAs increased the probability of filing for bankruptcy by between 3 to almost 5 percent.

2.4 Warehouse lenders

As previously discussed, warehouse lenders (repo buyers), who provide lines of credit to mortgage originators on MRAs, own the mortgage assets, used as collateral on the lines of credit, of the mortgage originators (the repo seller) for a short period of time, before mortgage originator (repo seller) buys the collateral back after successfully securitizing the loans. In this section we consider the effect this source of funding had on the warehouse lenders (the repo buyers). We show that during the crisis, banks that served as warehouse lenders (repo buyers) experienced high chargeoffs, high Non Performing Asset (NPA) ratios and increases in Allowances for Loan and Lease Losses (ALLLs). They also had an increase in the volume of trading assets and sold more loans than originated. We suggest that these findings were due to their increased exposure to mortgage originator (repo sell counterparties) bankruptcies.

There is an empirical literature that focuses on the mortgage originate-to-distribute model. For example, Purnanandam (2011) showed that lenders that were more involved in OTD lending prior to the crisis had more mortgage chargeoffs and non-performing mortgages. As previously discussed, the preponderance of OTD in the U.S. was on the part of nondepository and small depository mortgage originators who were funded on warehouse lines provided by bank holding companies. These warehouse lines are recognized on the warehouse lender balance sheet as loans held for investment with 100% risk weights whereas they are recognized on the warehouse borrower (mortgage originator/repo seller) balance sheet as loans held for sale. Purnanandam (2011) claims to be analyzing OTD lending, however, he limits his analysis to loans held for sale (or loans originated for sale) on the balance sheets of commercial banks even though bank accounting rules do not recognize the MRAs in this way in the Reports of Condition and Income (Call Reports). For this reason, his analysis misses the key role of bank holding companies in providing funding to true OTD lending on the part of non-depository and small depository lenders that comprise more that 60% of U.S. mortgage origination pre-crisis. In addition, Purnanandam (2011) assumes that "it can take about two to three quarters from the origination to the sale of these loans in the secondary market" whereas Echeverry et al. (2016) show, using loan-level securitization timing data, that it takes substantially less time for both GSE and private-label loans to be securitized. Finally, because Purnanandam (2011) ends his sample period in 2008Q1, he misses a later period of mortgage originator (repo seller) bankruptcies and, as shown in Figure 2.4, a high-level of chargeoffs that occurred later in the crisis.

Bank Holding Companies Treatment of Resale Agreements

All bank holding companies are required to submit quarterly financial reports (FR Y-9C reports). The FR Y-9c reporting requirements distinguish between secured borrowing and true sales. Warehouse lines using MRAs should be recognized as secured borrowing on the part of the warehouse lender (repo buyer). As secured borrowing, the warehouse lender (repo buyer) needs to record the loan under "Loans and Leases, Net of Unearned Income" (loans held-to-maturity). FASB 140 requires the warehouse lender (repo buyer) to record the loan only if it was sold. In that case, it will need to account for the proceeds from the sale and add a liability to return a similar asset. If the mortgage originator (the repo seller/counterparty on the line of credit) declares bankruptcy and the loan hasn't been sold, the warehouse lender (repo buyer) will record the asset on its balance sheet. If the loan has been sold, the warehouse lender (repo buyer) will simply remove the liability. In all other cases, the collateral won't appear on the warehouse lender's (repo buyer's) balance sheet.

Since the collateral is not disclosed on the balance sheet of the warehouse lender (repo buyer), we need to find an instrument that would be correlated with the volume of repos that were backed by mortgages. We assume that the technology involved in the repo buying process is similar for all collaterals, because the lender considered the quality of the counterparty and not the quality of the collateral. Therefore, we assume that lenders that were important repo buyers in the securities market, were also important repo buyers of other assets, such as mortgages. The FR Y-9C reports disclose the volume of securities bought with a promise to re-sell. We assume that bank holding companies that were active as security repo buyers were also the ones acting as mortgage repo buyers.

According to the FR Y-9C reports, only 10% of the lenders were repo buyers in the pre-crisis period. Table 2.8 lists the bank holding companies who had the largest fraction of repos bought (as a fraction of their assets). The largest repo buyers include JP Morgan Chase, Citigroup Inc. and Bank of America, which we know, from 8-K reports, were important warehouse lenders (repo buyers) to nondepository and small depository mortgage originators. Therefore, we believe this is a valid measure. Figure 2.5 shows the increase in repo buying and selling post BAPCPA 2005 on the part of these largest firms.

We obtain data on bank holding companies from the FR Y-9C reports. Our sample period is 2006Q1-2009Q4. We remove quarters where the firm had an increase in assets of more than 50 percent or an increase in the volume of loans of over a 100 percent. We include only firms that submitted the reports every quarter during the sample. We divide the sample into pre-crisis period (2006Q1–2007Q2) and post-crisis period (2007Q3–2009Q4). We follow an approach similar to Purnanandam (2011) and define a new measure , *prerepobuy*. The measure is the average fraction of repo buying contracts held by each holding company in the pre-crisis period. We define warehouse lenders to be those with a positive value of *prerepobuy*. Summary statistics of the main variables are shown in Table 2.9.

MRAs and warehouse lender performance

Figure **??** shows the volume of mortgages (in billions) held on balance sheet and the percentage of non-performing mortgages for warehouse lenders and non-warehouse lenders. For the warehouse lenders, we see that the percentage of non-performing mortgages started to increase in 2008Q3, when the volume of mortgages kept on the balance sheet increased. This result suggests that the increase in the non-performing mortgages was due to mortgages that were consolidated on the warehouse lenders balance sheet due to the bankruptcies of its MRA borrowers (repo sellers). In Figure 2.7, we compare the percentage of non-performing mortgages for warehouse lenders and non-warehouse lenders. We see that they begin to diverge only towards the end of 2008.

We run the following diff-in-diff regression:

$$Y_{it} = \alpha \times \text{Crisis}_t + \beta \times \text{Crisis}_t \times \text{Warehouse}_i + \Gamma \times X_{it} + \nu_t + \eta_i + \epsilon_{it} \tag{2.3}$$

Where Y_{lt} is the outcome, Crisis_t is equal to 1 after 2007Q2 and zero otherwise, Warehouse_i is set to 1 if we identified the BHC to be a warehouse lender, X_{it} is a set of lender controls (lags of log assets, fraction of commercial and industrial loans, deposit to asset ratio, mortgage to asset ratio, tier1 capital ratio, liquidity and return on equity (ROE)). All regressions include lender and quarter fixed effects and the errors are clustered at the lender level. The coefficient of interest is β, which measures the difference between the balance sheet of warehouse lenders and non-warehouse lenders before and after the crisis.

The results of these regressions are reported in Tables 2.10–2.13. We run the regressions for two sample periods. Columns 1-3 report the results for the early stage of the financial crisis (2006Q1-2008Q1) and columns 4-6 include the later part (2006Q1-2009Q4).

We begin by looking at the quality of the 1-4 residential mortgages held on the BHCs' balance sheet. Table 2.10 considers the net chargeoffs (net of recoveries). These include mortgages charged off and write-downs to fair value on held-for-sale mortgages. Table 2.11 looks at the volume non-performing mortgages. We define non-performing mortgages to be those that are at least 30 days delinquent. Both measures are scaled by the volume of mortgages held on the BHCs' balance sheet. In both tables, our coefficient of interest is positive and statistically significant. These results indicate that warehouse lenders experienced a larger increase in both chargeoffs and non performing mortgages during the crisis. Moreover, in the early phase of the crisis, warehouse lenders did not experience more mortgage delinquencies than non warehouse lenders. It is only in the later phase of the crisis that the warehouse lenders saw an increase in the volume of non performing mortgages, which was greater than that experienced by non warehouse lenders. The fact that the two groups were comparable in the early part of the crises suggests that something occurred on the later part of the crisis that deteriorated the warehouse lenders mortgage portfolio. Table 2.10 tells a similar story. Tha magnitude of the diff-in-diff coefficient quadruples when we add the later phase of the crisis into the sample.

One concern is that the warehouse lenders also participated in the OTD market and that what we are picking up is the results of their OTD activities. In columns 2 5 of Table 2.10 and Table 2.11, we add a control, *OTD*. This is a dummy variable that is set to one if the lender originated mortgages for the purpose of selling them in the secondary mortgage market. We obtain the data from the HC-P schedule of the FR Y-9C reports and define OTD participants to be those that originated mortgages for sale in at least one of the quarters prior to the crisis. Table 2.10 shows that the *OTD* dummy is not statistically significant in both time periods. We do find some significance in the increase in mortgage NPA (Table 2.11), however, the magnitude is less than half than that of the *Warhouse* dummy, suggesting that the increase in non performing assets was more sensitive to whether the BHC was a warehouse lender.

Lastly, it was common for warehouse lenders to rehypothecate the collateral pledged by the repo seller. As a result, many of the warehouse lenders were also repo sellers. To control for that, we define *RepoSell* to be a dummy variable equal to 1 if the BHC acted as a repo seller in at least one quarter prior to the crisis. As shown in the tables, Controlling for repo selling activities does not change the significance and magnitude of β, and it remains positive and statistically significant.

In Table 2.12, we look at the effect of warehouse lending on the allowance for loan and lease losses (ALLL). These are reserves kept on the BHCs balance sheet in order to absorb future write downs on loans and, as previously discussed in Table 2.1, ALLL's must be computed for the MRA positions. Higher values of ALLL suggest that the BHCs expected to see an increase in the write down of loans in the future. We scale the ALLL by the total volume of loans held on balance sheet. Table 2.12 shows the results of the regression defined in Equation 2.3 using ALLL as the output. We can see that in the early stage of the crisis (columns 1-3), warehouse lenders were comparable to non warehouse lenders with regards to their ALLL. It is only in the later period (columns 4-6) that they increased their ALLL more than non warehouse lenders did. The results remain qualitatively the same after controlling for OTD and repo selling activities. It is interesting to see that those participating in the OTD market increased their ALLL in the early part of the crisis, anticipating their portfolio to deteriorate immediately after the first signs of the crisis. However, when we look at the full sample (columns 4-6), we see that the magnitude of the warehouse coefficient is double that of the OTD.

Lastly, Table 2.13 measures whether warehouse lenders sold more mortgages than they had originated for sale during the crisis period. For each lender, we compute the difference between mortgages originated for sale and the volume of mortgages actually sold during the quarter. If the latter is greater than the former, we set the offloading dummy to be one.

Under normal conditions, lenders securitize newly originated mortgages in the same quarter as they were originated. As the table shows, in the early period, those involved in the OTD market were more likely to offload their mortgages. It is not until the later part of the crisis that warehouse lenders began to offload their mortgage portfolio. The fact that some bank holding companies sold more mortgages than they originated could suggest that there were loans put on their balance sheet from other sources. While we cannot pin down the source of the additional mortgages that were sold, we believe this is likely to be the consolidated mortgage collateral from their bankrupt mortgage originator counter parties or from the consolidated of whole loan collateral from assets from their SIVs.

Overall, Tables 2.10–2.13 show that warehouse lenders saw an increase in chargeoffs, non-performing mortgages and ALLL. We also see that they offloaded more mortgages than they had originated in the later period. The results are stronger if we include the later part of the crisis. While the results are only suggestive, a reasonable explanation for this finding is that most bankruptcies of independent mortgage companies occurred during the later period. The results remain statistically significant even after controlling for OTD participation and repo selling. This supports our prediction that warehouse lenders were not originating lower quality mortgages and that the deterioration in the quality of their balance sheet was the result of their consolidation of lower quality mortgages that were originated by their warehouse lending counterparties (repo sellers) who defaulted. Due to the exemption from automatic stay this collateral was immediately recognized on the repo buyers balance sheet consistent with our findings.

To further alleviate concerns about the quality of mortgages originated by warehouse lenders, we compare the loan characteristics of mortgages originated by warehouse lenders and non warehouse lenders. Similar to the regression defined in Equation 2.1:

$$Y_{lct} = \alpha_{ct} + \beta \times \text{Warehouse}_l + \Gamma \times X_l + \epsilon_{lct} \tag{2.4}$$

Our coefficient of interest is β. It measures the difference in output between warehouse and non-warehouse lenders. We obtain data from HMDA and DataQuick on the characteristics of the mortgages and whether they ended up in distress. Table 2.14 compares the underwriting characteristics of mortgages originated by bank holding companies that were warehouse lenders and those that were not. Loans originated by warehouse lenders had lower LTI and higher borrower income. We do not find differences between the probability of a loan being conforming. applications made to warehouse lenders were more likely to be rejected or withdrawn by the borrower, which also suggest that they were screening borrowers more carefully than non-warehouse lenders. Our results indicate the warehouse lenders were more likely to originate high cost mortgages and sell mortgages into the secondary market but the percentage of distressed loans is comparable to bank holding companies who were not warehouse lenders. Therefore, we conclude that the quality of the mortgages originated by warehouse lenders could not have explained the increase in charge-offs and non performing mortgages of the warehouse lenders. Instead, these loans arrived on the balance sheet of warehouse lenders due to the exemption from automatic stay allowed under BAPCPA 2005 and that through exemption the warehouse lenders became exposed to the poor underwriting quality of their mortgage originator (repo seller) counterparties.

2.5 BAPCPA and private-label MBS pricing

There is an empirical literature on the impact the passage of BAPCPA 2005 had on the balance sheet of mortgage originators (repo sellers). Ganduri (2016) found that independent mortgage companies increased originations of risky mortgages following the passage of BAPCPA 2005 and Srinivasan (2016) showed that, following the passage of BAPCPA 2005, there was an increase in securitized products that could have been used as collateral in the repo agreement. We contribute to the literature by showing that the passage of BAPCPA 2005 induced the increase in the price of collateralized mortgage obligations (CMOs) largely collateralized by mortgages originated under MRAs. These price effects suggest that despite the increases in the supply of these bonds, demand pressures were even greater due to the widespread use of these securities in the bilateral repo market.

ABS.Net provides transaction data and ratings for a set of private label CMO tranches. We create a panel of monthly observations for each tranche. We limit our sample to include only AAA rated tranches. The sample period begins in November 2004 (6 months before the passage of BAPCPA), and ends 6 months after the passage of BAPCPA, in October 2005. We run the following ordinary least squares regression:

$$Y_{it} = \alpha_i + \nu_t + \beta \times \text{BAPCPA}_t + \Gamma \times X_{t-1} + \epsilon_{it} \tag{2.5}$$

Where Y_{it} is the log price or changes in prices for cusip i at month t, α_i are CMO tranche fixed effects, ν_t are monthly fixed effects and X_t includes time varying controls. From the Federal Reserve Economic Data (FRED) we obtain data on 1, 10 and 30 year treasury yields (*y1*, *y10* and *y30* respectively). We also include the 30 year mortgage interest rate, provided by Freddie Mac and the Federal Housing Finance Agency (FHFA) house price index and the lag of the price. BAPCPA_t is equal to one for the six months after the passage of BAPCPA 2005. Standard errors are clustered at the CMO tranche level.

Tables 2.15 and 2.16 show the results of the regression defined in Equation 2.5 using monthly mid and bid prices respectively. Our coefficient of interest is β. This coefficient captures the difference in prices attributed to the passage of BAPCPA 2005.

In columns 1-3, we use the log of the prices as the dependent variable. Column 1 includes the whole sample and columns 2 and 3 include prime and non-prime (subprime and Alt-A) respectively. Following the passage of BAPCPA, the prices increased by almost 1.4 percent. CMO tranches backed by prime loans saw a greater increase (1.7 percent) than the price of tranches collateralized by non-prime mortgages (1 percent). In columns 4-6 we repeat the same regression but instead of using the log of the price we use the changes in prices as the dependent variable. We receive similar results.

Overall, the results supplement previous findings by showing that the impact of BAPCPA was not limited to mortgage originations. Following BAPCPA, the prices of private label

CMOs, many of which were collateralized by MRA funded mortgages, also increased. These results suggest that the repo driven demand for these securities in the bi-lateral repo market far outweighed the overall increases in the supply of these securities in the run-up to the crisis.

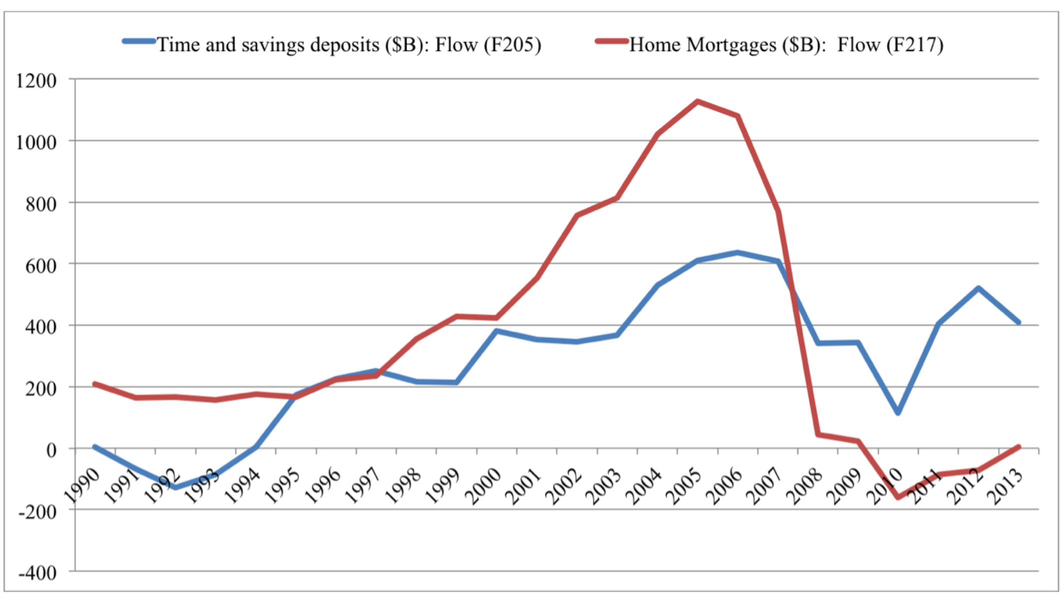
2.6 Conclusions

The financial crisis that began to unfold in 2007 was characterized by a sharp increase in mortgage delinquency and foreclosure rates throughout the U.S. Previous papers attributed the crisis to the OTD model of lending, where lenders originate mortgages only to sell them to the GSEs or private label securitizers shortly after origination. The popular narrative is that those involved in the OTD markets did not screen the borrowers because they had no 'skin-in-the-game' and were not exposed to losses once the mortgage was sold in the secondary market. This, in turn, has led to lax screening and the origination of low quality mortgages. In this paper, we bring a different perspective on the reasons that have led to the crisis. While it is true that smaller non-depository and depository institutions used the OTD market to sell the mortgages they had originated, they would first need to get capital in order to fund their loans. Many of them used MRAs as a source of short term funding. They would use the mortgage as collateral and buy it back from the warehouse lender once it has been sold in the secondary market. BAPCPA 2005 increased the popularity of these MRAs because it exempted the collateral from automatic stay. If the counterparty went bankrupt, the repo buyer would get a hold of the collateral immediately without waiting for the bankruptcy proceedings to end. We provide evidence that it is this method of financing that has contributed to the deterioration in the quality of originated mortgages. Repo buyers provided credit to the repo sellers based on their credit risk, and not the riskiness of their collateral. They had little oversight over the quality of the originated mortgages and were not liable for the mortgages funded by them. When the repo market froze and non-depositories lost their source of funding, many of them went bankrupt. Their loans, that were used as collateral, were then added to the balance sheet of the warehouse lenders. We show evidence that supports the OTD paradigm that repo sellers, who were more likely to sell their mortgages in the secondary mortgage market after origination, originated mortgages of lower quality. However, we complement these findings by considering the deterioration in the mortgage portfolio of the warehouse lenders. We show that warehouse lenders originated mortgages of similar quality to those originated by non warehouse lenders. We also show that the warehouse lenders experienced higher chargeoffs and non-performing mortgages. They have also increased their allowance for loan and lease losses more than non warehouse lenders, suggesting they have anticipated more defaults along the way. This deterioration in the quality of balance sheet held mortgages didn't occur at the beginning of the crisis, but later, at the end of 2008, when many of the non depository institutions filed for bankruptcy. We claim that the deterioration in the quality of mortgages held by BHCs was not the result of lax screening but of the collateral being put back on their balance sheets.

Lastly, we also show that BAPCPA induced the increase in private label CMO tranches. This finding complements previous research that linked the passage of BAPCPA to the increase in the volume of risky mortgages and securitization. At first glance, the distinction between the OTD paradigm and the repo funding mechanism seems small. If there were no secondary mortgage market, originators wouldn't use this type of short funding to begin with. However, the distinction is important when we think about possible remedies to the crisis and ways to prevent future crises of such large magnitude to occur in the future. Following the crisis, researchers and policy makers began to think of mechanisms that could replace the securitization market. One such proposal was the use of covered bonds. Covered bonds are also backed by mortgages but, unlike mortgage backed securities, they are kept on the balance sheet of the mortgage originator. We claim that the root of the problem is not the OTD market but the way the mortgages that were used as collateral were funded. Therefore, substituting mortgage backed securities with other instruments will not protect the market from future crises as long as the mortgages used as collateral are financed using MRAs. The repo market froze during the crisis but has since gained momentum. We need to gain a good understanding of how this funding channel operates in order to create a more stable environment.

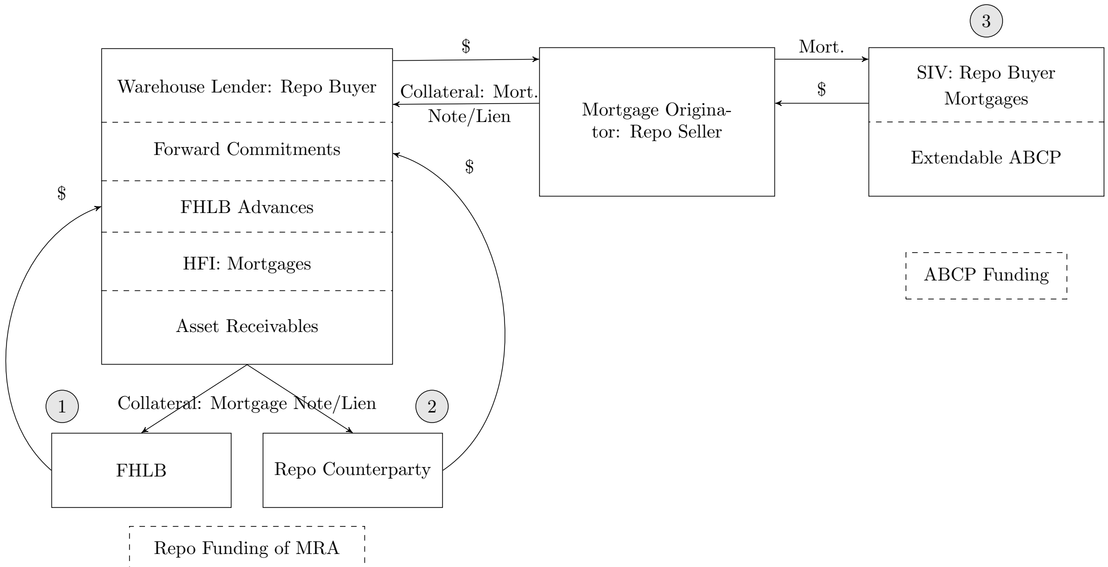
2.7 Figures

Figure 2.1: Deposits and Mortgage Originations



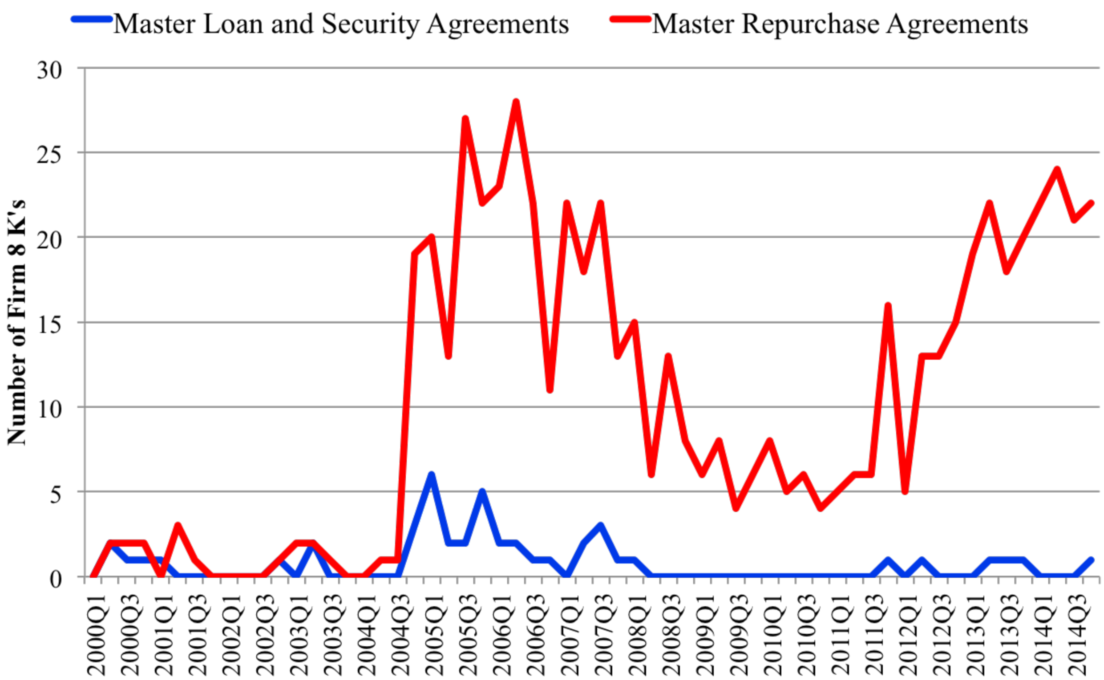
The figure shows the relationship between the flow of time and savings deposits ($ Billions), F205, Flow of Funds, and home mortgage originations ($ Billions), F217, Flow of Funds from 1990 through 2013.

Figure 2.2: Schematic for the pre-crisis pipeline funding structure of the U.S. mortgage market.



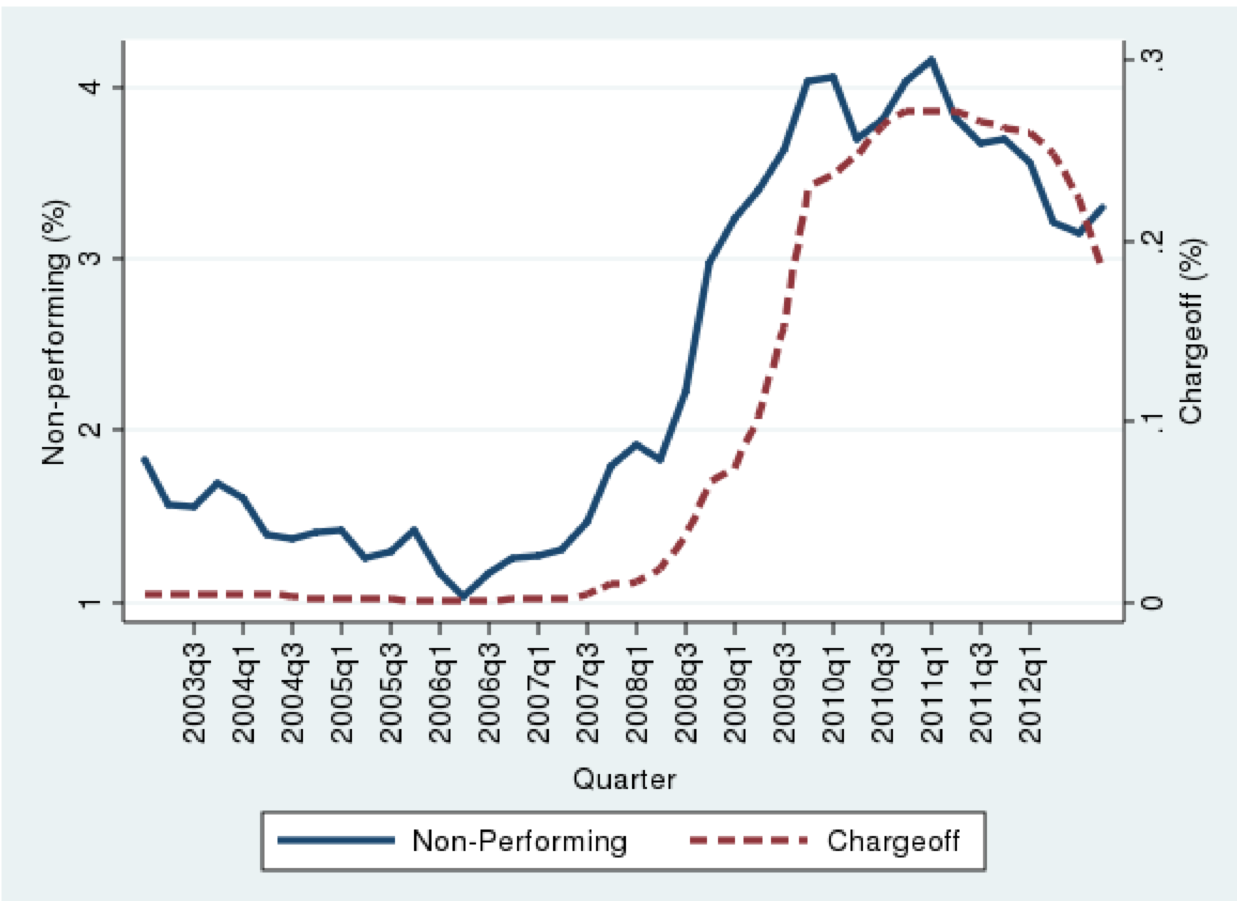
The righthand side of the Figure presents the overall position of the mortgage warehouse lender who recognizes the perfected interest in the mortgage collateral as a short term loan with a 100% risk weight. If the warehouse lender chooses to do so he can 1) rehypothecate the warehouse collateral using a Federal Home Loan Bank Advance or 2) rehypothecate the warehouse collateral on the bi-lateral repo market, as shown in the lower segment of the graph. A third pre-crisis funding structure for warehouse funding lines were Structured Investment Vehicles funded with Asset backed commercial paper as shown in the left-hand side of the graphic. Although not shown in the graphic, the w

Figure 2.3: 8Ks MRA Disclosures



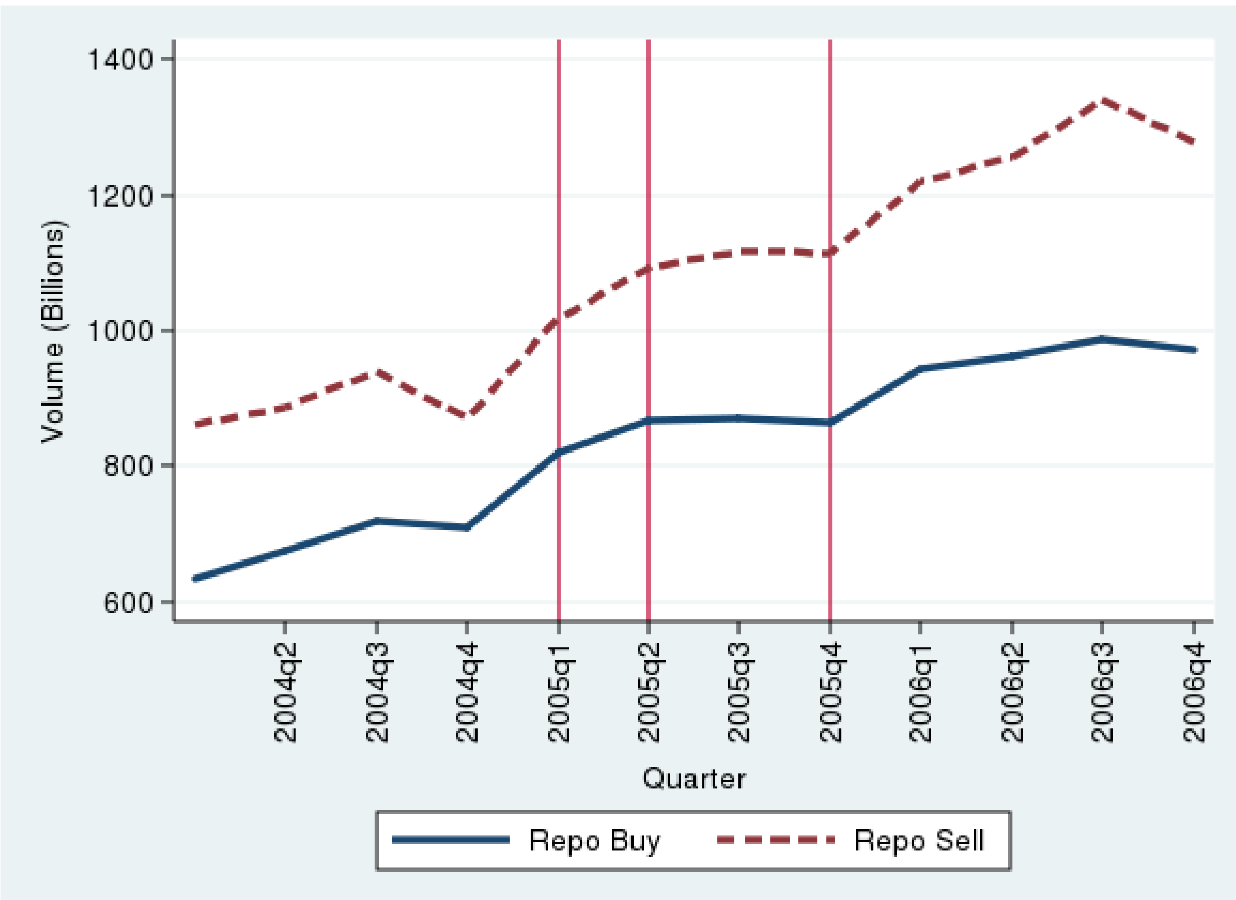
Number of Financial Service Co. 8Ks Disclosing MRAs by Quarter (Firms with SICs 6162, 6163 and 6798).

Figure 2.4: Non-performing mortgages and net charge-offs on mortgages.



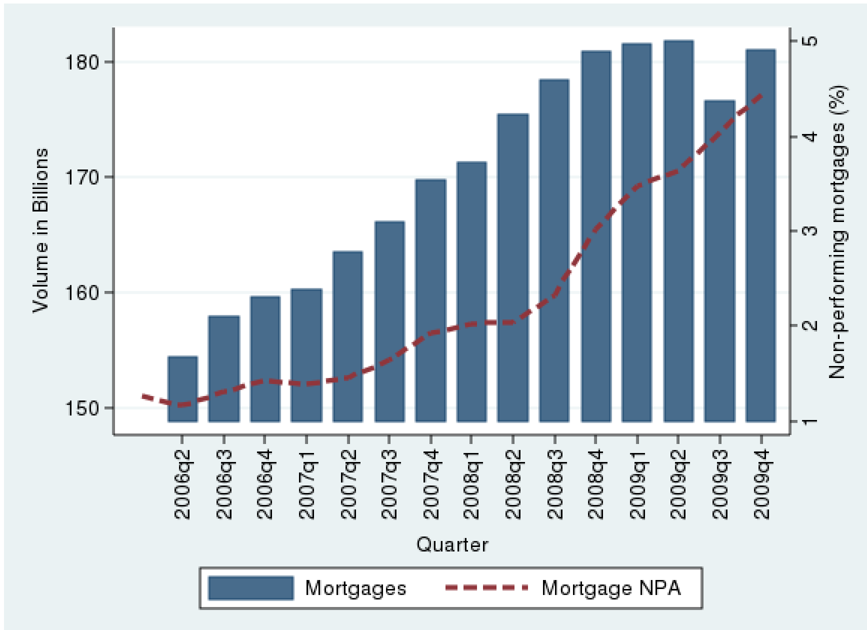
The figure shows the increase in the percentage of non performing mortgages and charge-offs between 2003 and 2013. The charge-off is the average of net charge-off during the past four quarters. Data are obtained from FR Y-9C reports

Figure 2.5: Repo Volume Before and After BAPCPA.

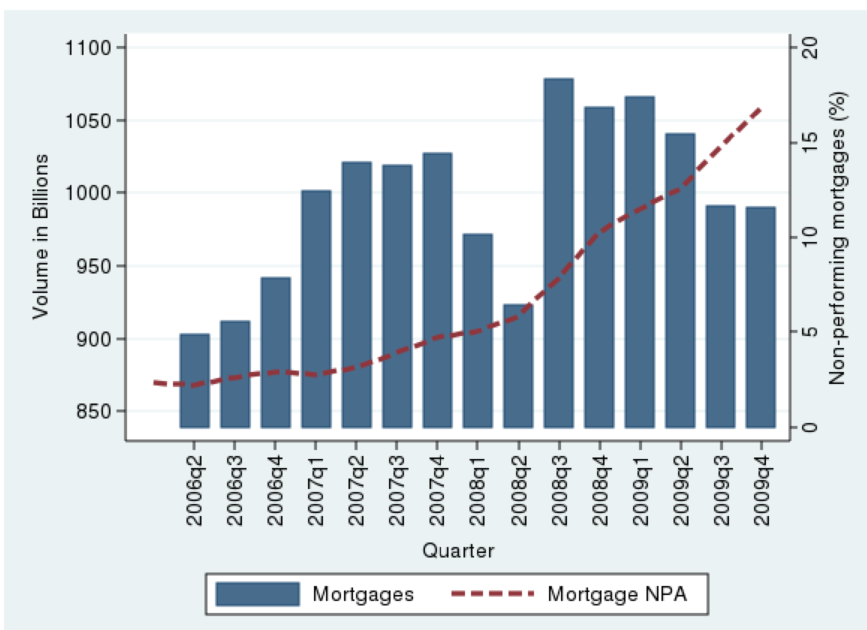


The figure shows the volume of repo buying and repo selling between 2004Q1 and 2006Q4. It includes all BHCs that disclosed their repo holdings for each quarter in the sample. The horizontal lines represent stages in the passage of BAPCPA. The law was presented on February 2005 (2005Q1), signed into law in April of that year (2005Q2), and its effective date was October 2005 (2005Q4)

Figure 2.6: Non-performing mortgages



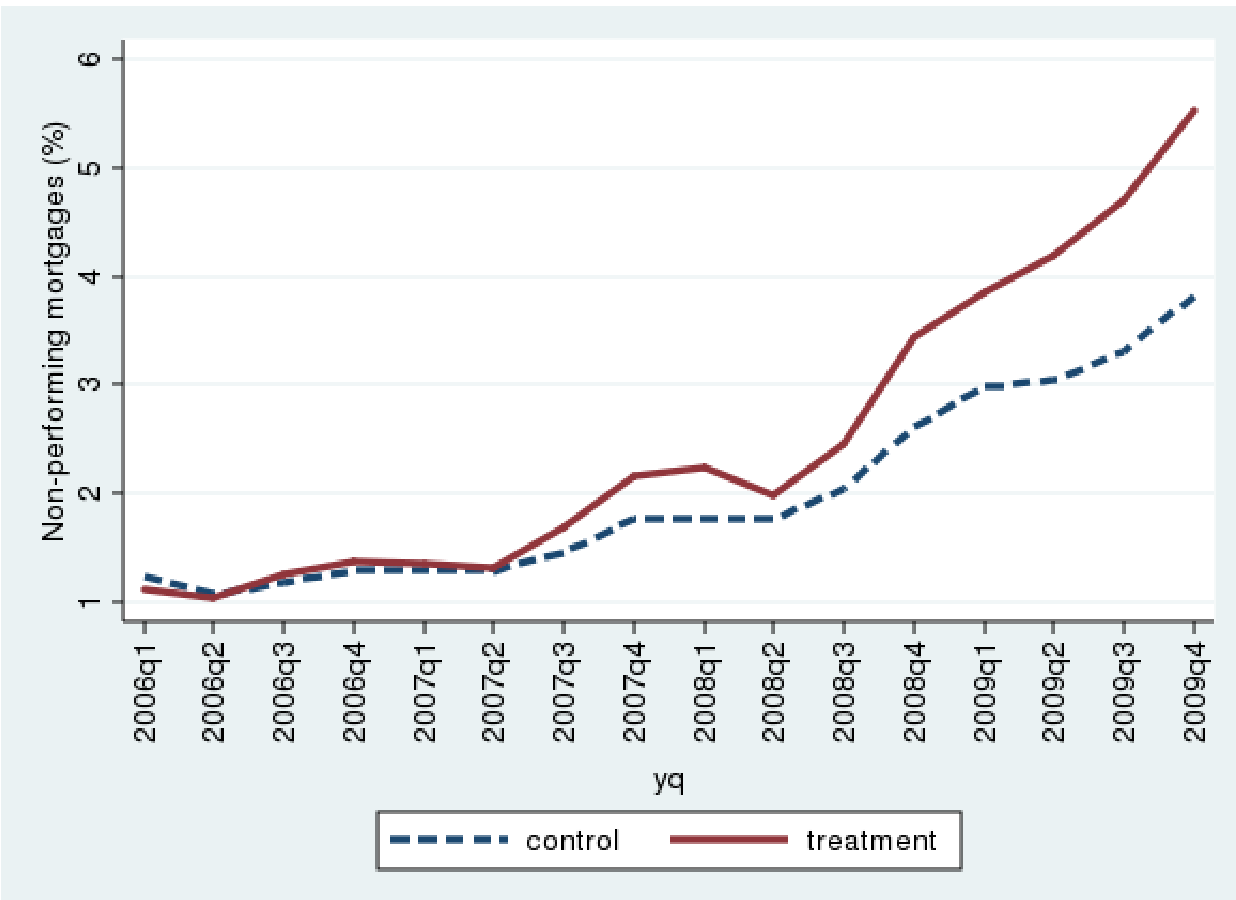
(a) Non warehouse lenders



(b) Warehouse lenders

The figure compares non-performing mortgages held by non-warehouse lenders (panel a) and warehouse lenders (panel b). The blue bars are the volume of mortgages held on balance sheet and the red dotted line shows the percentage of non performing mortgages.

Figure 2.7: Non-Performing Mortgages



The figure compares the percentage of non-performing mortgages held by non-repo buyers (control) and repo buyers (treatment)

2.8 Tables

Table 2.1: Comparison of Pipeline Funding Structures

	Warehouse Lender					
	Economic Ownership of Mortgage Collateral	Accounting Treatment	Stress Tests	RESPA Treatment	Treatment under Counterparty Bankruptcy	Collateral Rehypo-thecation
Pre-crisis and Current Line of Credit	UCC Article 9 Transfer Note perfected	HFI: Counterparty Loan, Allowances for Loan Losses (ALLLs)	ALLLs Counterparty	Allowed	Consolidated	Yes
Mortgage Repurchase Agreement	UCC Article 9 Transfer Note perfected	HFI: Counterparty Loan, Allowances for Loan Losses (ALLLs)	ALLLs Counterparty	Allowed	BAPCA: Exempt Automatic Stay	Yes
True Sale Agreement	UCC Article 9 Transfer Note perfected	HFS: Indiv. Mort. Mark-to-Market	HFS: Indiv. Mort. Mark-to-Market	Restrictions	No Consolidation (true sale)	Yes
Pre-crisis SIV (Extendable ABCP)	UCC Article 9 Transfer Note perfected	Assets: Mortgages Liability: ABCP	N.A.	Allowed	BAPCA: Exempt Automatic Stay	No
	Mortgage Originator					
	Economic Ownership of Mortgage Collateral	Accounting Treatment	Mortgage Collateral	Recourse to Secondary Market	Repurchase Agreement Timing	Cancellation Covenant Triggers
Pre-crisis and Current Line of Credit	No Note	Debt HFS: Loans	HFS: Loans	Putback Risk	30 days, 45 day lender option to sell loans	Margin calls, net worth req., fin. Ratio req.
Mortgage Repurchase Agreement	No Note	Debt HFS: Loans	HFS: Loans	Putback Risk	30 days, 45 day lender option to sell loans	Margin calls, net worth req., fin. Ratio req.
True Sale Agreement	No Note	Forward Commitment Asset receivables	None	Putback Risk	30 days, 45 day lender option to sell loans	Margin calls, net worth req., fin. Ratio req.
Pre-crisis SIV (Extendable ABCP)	No Note	Off Balance Sheet	Forward committment	Putback Risk	30 days, Total Return Swap, ABCP rollover	Net worth req.

Table 2.2: Summary Statistics.

	N	*Mean*	*SD*	*Min*	*Max*
Loan Amount (000s)	30,267,267	179·67	139·08	1·00	847·00
Purchased	30,267,267	0·11	0·31	0·00	1·00
LTI	16,113,171	2·37	3·20	0·00	845·00
LTV	2,395,089	0·71	0·38	0·00	2·98
Income (000s)	30,267,267	85·15	58·77	1·00	444·00
Conforming	16,165,264	0·91	0·29	0·00	1·00
High Cost	16,113,171	0·27	0·44	0·00	1·00
Rejected	27,000,105	0·26	0·44	0·00	1·00
Withdrawn	30,267,267	0·23	0·42	0·00	1·00
Sold	16,113,171	0·76	0·43	0·00	1·00
Distressed	6,155,454	0·25	0·43	0·00	1·00

The table shows the summary statistics of the main variables included in our analysis. Data are from HMDA and DataQuick and include mortgage applications and purchases made in 2005 and 2006. *Purchased* is equal to 1 if the loan was purchased by the lender, *LTI* is the loan-to-income ratio, *LTV* is the loan-to-value ratio, *Income* is the borrower's reported income, *Conforming* is equal to one if the loan amount is smaller than the GSE's conforming loan limit, *High Cost* is equal to one if the loan is a high-cost loan, *Rejected* is equa; to one if the application was rejected by the lender, *Withdrawn* is equal to one if the application was withdrawn by the applicant, *Sold* is equal to one if the loan was sold and *Distress* is equal to one if the loan ended in distress

Table 2.3: Originated and Purchased Mortgage Characteristics.

	LTI	LTV	*Conforming*	*HighCost*	*Rejected*	*Withdrawn*	*Sold*	*Distressed*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RepoSeller	0·12***	0·01***	−0·01***	0·01	−0·05***	−0·05***	0·23***	0·04***
	(21·32)	(5·00)	(−6·61)	(0·86)	(−12·73)	(−23·26)	(76·99)	(20·07)
AMC	−0·03***	0·02***	0·01***	0·15***	0·10***	0·10***	0·06***	0·03***
	(−3·90)	(10·68)	(13·84)	(27·47)	(24·03)	(40·74)	(18·57)	(15·53)
IMC	0·04***	−0·03***	0·01***	0·35***	0·13***	0·30***	−0·03***	0·07***
	(3·88)	(−7·42)	(8·17)	(54·94)	(18·92)	(83·72)	(−6·45)	(21·44)
Home Improvement	−0·67***		0·03***	−0·02*	0·29***	0·19***	−0·27***	
	(−30·59)		(7·57)	(−1·89)	(32·01)	(34·70)	(−23·09)	
Refinance	0·21***	1·19***	−0·00***	−0·01*	0·17***	0·15***	−0·04***	−0·09***
	(15·42)	(21·47)	(−3·45)	(−1·78)	(20·81)	(30·52)	(−13·89)	(−15·44)
Not Owner Occupied	−0·16***	0·08***	0·09***	−0·00	0·01***	−0·03***	0·02***	0·00
	(−6·93)	(36·95)	(14·99)	(−0·21)	(2·71)	(−15·71)	(8·71)	(0·67)
Purchased	0·18***		0·01***				0·05***	
	(38·89)		(4·86)				(15·72)	
Log(income)	−0·05***	−0·08***	−0·03***	−0·03***	0·03***			
	(−34·18)	(−14·14)	(−13·83)	(−12·78)	(−46·51)	(−27·24)	(−22·78)	(4·64)
Constant	8·92***	0·76***	1·57***	0·39***	0·50***	0·27***	0·77***	0·09***
	(46·39)	(108·22)	(33·05)	(24·75)	(96·02)	(36·60)	(165·44)	(3·72)
Observations	16098703	2395089	16098703	12832386	19693011	19692925	16098703	6155454
Adjusted R^2	0·095	0·305	0·267	0·184	0·111	0·109	0·124	0·131

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the coefficients of the ordinary least squares regression described in Equation 2.1. The dependent variables are the loan-to-income ratio (*LTI*), the loan-to-value ratio (*LTV*), a dummy variable that is equal to 1 for conforming loans (*Conforming*), a dummy variable equal to 1 if it is a high cost loan (*High Cost*), a dummy variable equal to 1 if the loan was rejected by the lender (*Rejected*), a dummy variable that is equal to 1 if the borrower withdrew the application (*Withdrawn*), a dummy variable equal to 1 if the loan was sold after origination (*Sold*) and a dummy variable that is equal to 1 if the mortgage was distressed (*Distressed*). *RepoSeller* is a dummy equal to 1 if the firm was identified as a repo seller, *AMC* is 1 if the firm is an affiliated mortgage company, *IMC* is 1 if the firm is an independent mortgage company, ,*Home Improvement* and *Refinance* are dummy variables indicating the purpose of the loan, , *Not Owner Occupied* is 1 if the owner does not live on the property, and *Purchased* is equal to 1 if the lender purchased the loan and not originated it. Additional coefficients not shown in the table include the loan guarantee (FHA, VA or FSA/RHS), the borrower's gender, race and ethnicity). All regressions have county-year fixed effects and are clustered at the county level.

Table 2.4: Frequency Table.

		Non-MRA		MRA		All	
Type	SIC	Total	Bankrupt	Total	Bankrupt	Total	Bankrupt
Commercial Banks	6020	829	9	3	3	832	12
Federal Savings Institutions	6035	284	4	3	2	287	6
Mortgage Bankers and Correspondents	6162	30	-	18	7	48	7
Real Estate Investment Trusts	6798	5	-	29	6	34	6
Total		1,148	13	53	18	1,201	31

The table reports the number of firms in the Compustat sample. The sample includes commercial banks, federal savings institutions, mortgage bankers and correspondents, and REITs. There are 1,201 firms, 53 of them were identified as MRA sellers and 31 of them filed for bankruptcy or were liquidated during the sample period (2000Q1–2012Q4)

Table 2.5: Summary Statistics.

	N	$Mean$	$Median$	Min	Max
Total assets ($M)	37,499	34813·15	970·39	0·07	3879171·80
Short Term Liabilities/Total Assets	37,499	0·79	0·82	0·00	0·99
Leverage	37,499	0·89	0·91	0·00	1·00
Book-to-Market	36,092	3·16	0·76	0·03	6390·34
Cash	37,329	0·06	0·04	−0·00	1·00

The table reports the summary statistics of the Compustat variables used in the regression. The sample period is 2000Q1–2012Q4. Columns 1–4 show the summary statistics for companies that were not identified as MRA sellers. *Short Term Liabilities* include all liabilities that mature in less than a year, *Leverage* is the ratio of *Total Liabilities* to *Total Assets*, *Book-to-Market* is the ratio of *Book Value of Equity* to the market value of equity (*Number of Outstanding Shares x Stock Closing Price at the end of the quarter*). *Cash* is the ratio of the amount of cash to total assets.

Table 2.6: Bankruptcy Dates.

Company Name	MRA Flag	Bankruptcy Quarter	SIC
AAMES INVESTMENT CORP	1	2007-Q4	6798
ABN-AMRO HOLDINGS NV	1	2008-Q4	6020
ACCREDITED HOME LENDERS HLDG	1	2005-Q4	6162
ALTIVA FINANCIAL CORP	1	2002-Q1	6162
AMERICAN HOME MTG INVT CORP	1	2007-Q3	6798
AMERICANWEST BANCORP	1	2009-Q2	6020
AMRESCO INC	1	2002-Q3	6162
BANK OF FLORIDA CORP	1	2010-Q2	6020
BANKUNITED FINANCIAL CORP	1	2009-Q2	6035
BAYERISCHE HYPO- & VEREINSBK	0	2008-Q4	6020
CAPE FEAR BANK CORP	0	2009-Q4	6020
CAPITOL BANCORP LTD	0	2012-Q3	6020
CERVUS FINANCIAL GROUP INC	1	2006-Q3	6162
COLUMBIA BANCORP/OR	0	2010-Q1	6020
CORUS BANKSHARES INC	0	2009-Q3	6020
COUNTRYWIDE FINANCIAL CORP	1	2008-Q1	6162
FIRST FED BANKSHARES INC	0	2010-Q1	6035
FIRSTFED FINANCIAL CORP/CA	0	2010-Q1	6035
GUARANTY FINANCIAL GROUP INC	0	2009-Q3	6020
HARRINGTON WEST FINL GROUP	0	2010-Q3	6035
HOMEBANC CORP	1	2007-Q3	6798
IMPERIAL CREDIT INDS INC	1	2003-Q3	6162
INDYMAC BANCORP INC	1	2008-Q3	6162
LUMINENT MORTGAGE CAPITAL	1	2008-Q3	6798
MERCANTILE BANCORP INC/IL	0	2012-Q3	6020
MIDWEST BANC HOLDINGS INC	0	2011-Q2	6020
NETBANK INC	1	2008-Q3	6035
NEW CENTURY FINANCIAL CORP	1	2007-Q2	6798
PFF BANCORP INC	0	2008-Q4	6035
R&G FINANCIAL CORP -CL B	0	2010-Q2	6020
THORNBURG MORTGAGE INC	1	2009-Q2	6798

The table lists the firms that went bankrupt during the sample period (2000Q1–2012Q4). The *MRA Flag* is set to one if the firm used MRAs to finance its mortgage originations

Table 2.7: Repo Sellers Bankruptcy Regression.

	2000Q1–2008Q4		2000Q1–2009Q4		2000Q1–2010Q4		2000Q1–2012Q4	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crisis x RepoSeller	0·049**	0·043**	0·042**	0·038**	0·040***	0·033**	0·033***	0·028**
	(2·48)	(2·19)	(2·57)	(2·31)	(2·70)	(2·25)	(2·60)	(2·21)
Crisis	0·002	−0·002	0·002	−0·002	0·00099**	−0·0034	0·0010**	−0·0031
	(1·08)	(−0·90)	(1·43)	(−0·70)	(2·03)	(−1·60)	(2·12)	(−1·45)
Log(Total assets)		0·0030*		0·0024		0·0020		0·0015
		(1·80)		(1·52)		(1·41)		(1·33)
Cash		0·008		0·010		0·011		0·007
		(0·70)		(1·02)		(1·18)		(0·89)
Short Term Liabilities/Total Assets		0·000		0·003		0·002		0·001
		(0·05)		(0·34)		(0·30)		(0·20)
Leverage		0·030		0·033*		0·034**		0·020*
		(1·47)		(1·79)		(2·06)		(1·80)
Book-to-Market		0·000		0·00		0·000		0·000
		(0·25)		(0·70)		(0·71)		(0·71)
Constant	−0·00048	−0·047**	−0·00063	−0·046***	−0·00069	−0·045***	−0·00082*	−0·028***
	(−1·19)	(−2·36)	(−1·49)	(−2·60)	(−1·59)	(−2·77)	(−1·88)	(−2·68)
Observations	28248	25457	30794	27904	33156	30174	37499	34358
Adjusted R^2	0·014	0·013	0·011	0·011	0·011	0·010	0·009	0·008

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the results of the Linear Probability Model defined in Equation 2.2 for different sample periods. The first two columns are for the sample period beginning in 2000Q1 and ending in 2008Q4, columns 3 and 4 extend the sample to 2009Q4, in columns 5 and 6 the sample ends in 2010Q4 and columns 7–8 use the full sample (2000Q4–2012Q4). The MRA flag is set to one for firms that were identified as MRA sllers and the crisis flag is set to 1 for all quarters after 2007Q2. The regression also includes a set of lender characteristics. *Short Term Liabilities* include all liabilities that mature in less than a year, *Leverage* is the ratio of *Total Liabilities* to *Total Assets*, *Book-to-Market* is the ratio of *Book Value of Equity* to the market value of equity (*Number of Outstanding Shares x Stock Closing Price at the end of the quarter*). *cash* is the ratio of the amount of cash to total assets. All regressions include lender and quarter fixed effects and the standard errors are clustered at the firm level.

Table 2.8: The Ten Most Active Repo Buyers.

Name	Parent
Taunus Corporation	Deutsche Bank
Utrecht- America Holdings	Rabobank International Holdings
JPMorgan Chase & Co.	
New York Private Bank & Trust	
Citigroup Inc.	
HSBC North America Holdings	HSBC Group
Bank of America Corporation	
Cass Information Systems, Inc.	
Amalgamated Investments Company	
W Holding Company	

The table shows the top bank holding companies that were repo buyers prior to the crisis, Data are obtained from the FR Y-9C reports

Table 2.9: Summary Statistics.

	N	$Mean$	$Median$	Min	Max
TA	12496	12817562·55	937783·00	65535·00	2·36e+09
Mortgage/TA	12496	0·14	0·13	0·00	0·68
C&I/TA	12496	0·11	0·09	0·00	0·59
Deposits/TA	12496	0·77	0·79	0·01	0·99
NII/TA	12496	0·02	0·02	0·00	0·19
Chargeoff (%)	12471	0·24	0·02	−3·49	27·81
Mortnpa (%)	12475	2·87	1·86	0·00	56·10
Tier1 Capital	12496	12·02	11·20	−14·33	843·00
Liquid	12496	0·11	0·09	0·00	0·71
ROE	12496	−0·43	0·05	−6968·75	1620·19

The table includes summary statistics of the main variables used in the regression: *TA* measures the total assets (in thousands), *Mortgage* is the volume of outstanding mortgage principal on the balance sheet, *C&I* are commercial and industrial loans, *Deposits* are the total demand deposits, *NII* is the net interest income, *Chargeoff* is the percentage of net chargeoffs on 1-4 residential mortgages, *Mortnpa* are the non performing mortgages scaled by total mortgages *Tier 1 Capital* is the ratio or tier 1 capital to risk adjusted assets, *Liquid* is the ratio of liquid assets to total assets (liquid assets include cash and securities) and ROE is the return on equity.

Table 2.10: Mortgage Net Chargeoffs.

	2008Q1			2009Q4		
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis	0.032**	0.027*	0.030	0.96***	0.93***	0.97***
	(2.41)	(1.78)	(1.28)	(9.90)	(10.04)	(10.07)
Crisis x Warehouse	0.036**	0.031*	0.032*	0.17**	0.16*	0.17*
	(2.01)	(1.73)	(1.79)	(1.97)	(1.78)	(1.88)
Crisis x OTD		0.015	0.016		0.064	0.074*
		(0.91)	(1.06)		(1.58)	(1.75)
Crisis x RepoSell			-0.0059			-0.054
			(-0.27)			(-1.25)
Observations	6235	6080	6080	11695	11400	11400
R^2	0.05	0.05	0.05	0.21	0.24	0.24

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the regression defined in Equation 2.3. The dependent variable is net mortgage chargeoffs, scaled by the total volume of mortgages. *Crisis* indicates the crisis period and is set to 1 after 2007Q2, *Warehouse* is set to 1 for lenders that were repo buyers at least once during the pre-crisis period (2006Q1–2007Q2), *OTD* is a dummy variable equal to 1 if the BHC participated in the OTD market in any of the quarters prior to the crisis, *RepoSell* is a dummy variable equal to 1 if the BHC acted as a repo seller in at least one quarter prior to the crisis. All regressions include a set of lender controls (log of the total assets, C&I loans to asset ratio, deposits to asset ratio, net interest income to assets ratio, tier 1 capital ratio, liquidity (defined as the fraction of cash and liquid securities) to asset ratio, mortgages to assets ratio and Return on Equity (ROE)), that are not reported in the tables, as well as lender and quarter fixed effects. Standard errors are clustered at the lender level. Columns 1–3 include quarters between 2006Q1–2008Q1 and columns 4–6 include the full sample (2006Q1–2009Q4).

Table 2.11: Non-Performing Mortgages.

	2008Q1			2009Q4		
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis	0.64***	0.54***	0.53***	2.73***	2.59***	2.80***
	(5.65)	(4.79)	(3.38)	(8.51)	(7.73)	(7.66)
Crisis x Warehouse	0.19	0.20	0.19	0.79***	0.73**	0.76**
	(1.12)	(1.10)	(1.09)	(2.64)	(2.40)	(2.50)
Crisis x OTD		0.044	0.040		0.31*	0.36**
		(0.47)	(0.39)		(1.91)	(2.22)
Crisis x RepoSell			0.022			-0.31
			(0.16)			(-1.46)
Observations	6236	6080	6080	11696	11400	11400
R^2	0.08	0.09	0.09	0.28	0.28	0.28

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the regression defined in Equation 2.3. The dependent variable is the volume of non performing mortgages, scaled by the volume of total mortgages. *Crisis* indicates the crisis period and is set to 1 after 2007Q2, *Warehouse* is set to 1 for lenders that were repo buyers at least once during the pre-crisis period (2006Q1–2007Q2), *OTD* is a dummy variable equal to 1 if the BHC participated in the OTD market in any of the quarters prior to the crisis, *RepoSell* is a dummy variable equal to 1 if the BHC acted as a repo seller in at least one quarter prior to the crisis. All regressions include a set of lender controls (log of the total assets, C&I loans to asset ratio, deposits to asset ratio, net interest income to assets ratio, tier 1 capital ratio, liquidity (defined as the fraction of cash and liquid securities) to asset ratio, mortgages to assets ratio and Return on Equity (ROE)), that are not reported in the tables, as well as lender and quarter fixed effects. Standard errors are clustered at the lender level. Columns 1–3 include quarters between 2006Q1–2008Q1 and columns 4–6 include the full sample (2006Q1–2009Q4) .

Table 2.12: Allowance for Loan and Leases Losses.

	2008Q1			2009Q4		
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis	0.063***	0.045***	0.068***	0.80***	0.76***	0.79***
	(4.18)	(2.86)	(3.14)	(10.80)	(10.35)	(9.65)
Crisis x Warehouse	0.044*	0.036	0.040	0.28***	0.25***	0.26***
	(1.77)	(1.47)	(1.64)	(3.69)	(3.25)	(3.33)
Crisis x OTD		0.034**	0.040***		0.12***	0.13***
		(2.45)	(2.92)		(3.51)	(3.61)
Crisis x RepoSell			-0.033**			-0.036
			(-2.08)			(-0.97)
Observations	6248	6080	6080	11715	11400	11400
R^2	0.07	0.08	0.08	0.38	0.38	0.38

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the regression defined in Equation 2.3. The dependent variable is the ratio of ALLL to total loans. *Crisis* indicates the crisis period and is set to 1 after 2007Q2, *Warehouse* is set to 1 for lenders that were repo buyers at least once during the pre-crisis period (2006Q1–2007Q2), *OTD* is a dummy variable equal to 1 if the BHC participated in the OTD market in any of the quarters prior to the crisis, *RepoSell* is a dummy variable equal to 1 if the BHC acted as a repo seller in at least one quarter prior to the crisis. All regressions include a set of lender controls (log of the total assets, C&I loans to asset ratio, deposits to asset ratio, net interest income to assets ratio, tier 1 capital ratio, liquidity (defined as the fraction of cash and liquid securities) to asset ratio, mortgages to assets ratio and Return on Equity (ROE)), that are not reported in the tables, as well as lender and quarter fixed effects. Standard errors are clustered at the lender level. Columns 1–3 include quarters between 2006Q1–2008Q1 and columns 4–6 include the full sample (2006Q1–2009Q4).

Table 2.13: Mortgage Offloading.

	2008Q1			2009Q4		
	(1)	(2)	(3)	(4)	(5)	(6)
Crisis	0.23***	0.19***	0.21***	0.0090	-0.050***	-0.028
	(10.71)	(8.98)	(9.01)	(0.45)	(-2.61)	(-1.28)
Crisis x Warehouse	0.066***	0.033	0.037	0.10***	0.053**	0.057**
	(2.73)	(1.36)	(1.52)	(4.17)	(2.21)	(2.36)
Crisis x OTD		0.12***	0.12***		0.17***	0.17***
		(6.82)	(6.94)		(9.62)	(9.67)
Crisis x RepoSell			-0.033*			-0.032*
			(-1.91)			(-1.75)
Observations	6248	6080	6080	11715	11400	11400
R^2	0.46	0.48	0.48	0.38	0.39	0.39

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the regression defined in Equation 2.3. This is a Linear Probability Model, where the dependent variable set to 1 if the lender sold more loans than it has originated during the quarter. *Crisis* indicates the crisis period and is set to 1 after 2007Q2, *Warehouse* is set to 1 for lenders that were repo buyers at least once during the pre-crisis period (2006Q1–2007Q2), *OTD* is a dummy variable equal to 1 if the BHC participated in the OTD market in any of the quarters prior to the crisis, *RepoSell* is a dummy variable equal to 1 if the BHC acted as a repo seller in at least one quarter prior to the crisis. All regressions include a set of lender controls (log of the total assets, C&I loans to asset ratio, deposits to asset ratio, net interest income to assets ratio, tier 1 capital ratio, liquidity (defined as the fraction of cash and liquid securities) to asset ratio, mortgages to assets ratio and Return on Equity (ROE)), that are not reported in the tables, as well as lender and quarter fixed effects. Standard errors are clustered at the lender level. Columns 1–3 include quarters between 2006Q1–2008Q1 and columns 4–6 include the full sample (2006Q1–2009Q4)

Table 2.14: Warehouse Lender Originated and Purchased Mortgage Characteristics.

	LTI	*Income*	*Conforming*	*HighCost*	*Rejected*	*Withdrawn*	*Sold*	*Distressed*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MRA Buyer	−0·04***	0·02***	0·00	0·03***	0·14***	0·08***	0·04***	0·00
	(−3·87)	(4·75)	(1·41)	(7·12)	(26·94)	(28·07)	(4·21)	(1·12)
AMC	0·10***	−0·03***	−0·00	0·11***	−0·02***	0·02***	0·09***	0·02***
	(11·34)	(−12·07)	(−1·36)	(31·71)	(−8·22)	(5·89)	(15·41)	(9·97)
Home Improvement	−1·06***	−0·17***	0·07***	0·11***	0·24***	0·07***	−0·41***	
	(−46·23)	(−23·11)	(11·34)	(32·68)	(50·73)	(21·76)	(−37·93)	
Refinance	0·07***	−0·09***	0·03***	0·05***	0·14***	0·09***	−0·00	−0·05***
	(5·64)	(−15·41)	(9·12)	(19·71)	(36·48)	(41·23)	(−0·89)	(−13·80)
Not Owner Occupied	−0·82***	0·50***	0·01***	0·01***	−0·02***	−0·03***	−0·03***	0·01***
	(−67·28)	(70·76)	(3·15)	(3·76)	(−11·63)	(−24·99)	(−6·65)	(3·61)
Purchased	−0·24***	0·02***	0·03***				−0·16***	
	(−20·14)	(3·91)	(8·79)				(−18·22)	
Constant	2·09***	4·42***	0·87***	−0·00	−0·00	0·07***	0·58***	0·11***
	(210·29)	(711·39)	(200·83)	(−0·22)	(−0·70)	(24·64)	(74·59)	(34·37)
Observations	2830785	2830785	2981935	2498626	3307084	3125325	2981935	876562
Adjusted R^2	0·133	0·264	0·161	0·100	0·115	0·037	0·141	0·058

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The table shows the coefficients of the ordinary least squares regression described in Equation 2.4. The dependent variables are the loan-to-income ratio (*LTI*), the log of the borrower's income (*Income*), a dummy variable that is equal to 1 for conforming loans (*Conforming*), a dummy variable equal to 1 if it is a high cost loan (*High Cost*), a dummy variable equal to 1 if the loan was rejected by the lender (*Rejected*), a dummy variable that is equal to 1 if the borrower withdrew the application (*Withdrawn*), a dummy variable equal to 1 if the loan was sold after origination (*Sold*) and a dummy variable that is equal to 1 if the mortgage was distressed (*Distressed*). *Repo Buyer* is a dummy equal to 1 if the BHC is a warehouse lender, *AMC* is 1 if the firm is an affiliated mortgage company, *Home Improvement* and *Refinance* are dummy variables indicating the purpose of the loan, , *Not Owner Occupied* is 1 if the owner does not live on the property and *Purchased* is equal to 1 if the lender purchased the loan and not originated it. Additional coefficients not shown in the table include the loan guarantee (FHA, VA or FSA/RHS), the borrower's gender, race and ethnicity). All regressions have county-year fixed effects and are clustered at the county level.

Table 2.15: CMO AAA tranche mid prices before and after BAPCPA was put into law (April 2005).

	Log(Price)			Price Change		
	All	Prime	Non-Prime	All	Prime	Non-Prime
	(1)	(2)	(3)	(4)	(5)	(6)
BAPCPA	0.0137***	0.0172***	0.0103***	0.0138***	0.0174***	0.0102***
	(3.93)	(2.91)	(2.63)	(3.84)	(2.75)	(2.81)
y1	0.0705	0.00820	0.133**	0.0733	0.0142	0.128**
	(1.42)	(0.11)	(2.41)	(1.47)	(0.17)	(2.15)
y10	-0.0345	0.0144	-0.0829**	-0.0358	0.0120	-0.0800*
	(-0.95)	(0.25)	(-2.13)	(-0.97)	(0.19)	(-1.93)
y30	-0.0116**	-0.00470	-0.0197***	-0.0114**	-0.00297	-0.0191***
	(-2.08)	(-0.57)	(-3.17)	(-2.11)	(-0.37)	(-2.65)
HPI	-0.00540*	-0.00218	-0.00869**	-0.00542*	-0.00206	-0.00851**
	(-1.73)	(-0.47)	(-2.42)	(-1.71)	(-0.39)	(-2.26)
Rate	0.00182	-0.0165	0.0228***	0.00256	-0.0163	0.0202***
	(0.28)	(-1.59)	(3.06)	(0.41)	(-1.58)	(2.71)
Log(P(t-1))	0.867***	0.703***	1.258***			
	(6.98)	(4.92)	(12.96)			
Constant	1.622**	1.682	0.511	1.050*	0.416	1.634**
	(2.07)	(1.52)	(0.58)	(1.66)	(0.40)	(2.20)
Observations	32215	16122	16093	32215	16122	16093
Adjusted R^2	0.592	0.493	0.835	0.002	0.003	0.002

* p <0.1, ** p <0.05, *** p <0.01. t statistics in parentheses.

The sample period is November 2004 - October 2005. *BAPCPA* is equal to 1 after April 2005, *y1* is the one year treasury bond yield, *y10* is the 10 year treasury bond yield and *y30* is the 30 years treasury bond yield. *HPI* is FHFA House Price Index, *Rate* is the 30 years mortgage rate, as reported by Freddie Mac, and P is the price of the bond. Columns 1-3 we use the log of the prices as the dependent variable, and in columns 4-6 we use the changes in prices as the dependent variable. Columns 1 and 4 include the whole sample, columns 2 and 5 include tranches collateralized by prime mortgages and columns 3 and 6 include tranches collateralized by non-prime mortgages (Alt-A or Subprime). All regressions include month and cusip fixed effects. Standard errors are clustered at the cusip level.

Table 2.16: CMO AAA tranche bid prices before and after BAPCPA was put into law (April 2005).

	Log(Price)			Price Change		
	All	Prime	Non-Prime	All	Prime	Non-Prime
	(1)	(2)	(3)	(4)	(5)	(6)
BAPCPA	0.0286***	0.0405***	0.0192***	0.0291***	0.0413***	0.0177**
	(3.49)	(2.71)	(2.85)	(3.43)	(2.58)	(2.56)
y1	0.219*	0.207	0.257**	0.229**	0.225	0.233*
	(1.93)	(1.19)	(2.26)	(1.99)	(1.16)	(1.81)
y10	-0.138*	-0.123	-0.168**	-0.146*	-0.140	-0.152*
	(-1.73)	(-0.99)	(-2.13)	(-1.80)	(-1.00)	(-1.71)
y30	-0.0135	-0.00255	-0.0287**	-0.0112	0.00663	-0.0282*
	(-0.84)	(-0.10)	(-2.22)	(-0.64)	(0.20)	(-1.81)
HPI	-0.0151**	-0.0155	-0.0164**	-0.0154**	-0.0157	-0.0152*
	(-2.12)	(-1.42)	(-2.26)	(-2.13)	(-1.27)	(-1.87)
Rate	-0.00865	-0.0372	0.0288**	-0.00785	-0.0398	0.0222
	(-0.47)	(-1.09)	(2.17)	(-0.45)	(-1.23)	(1.56)
Log(P(t-1))	0.788***	0.593***	1.504***			
	(4.32)	(3.48)	(10.43)			
Constant	3.963**	4.888**	0.967	3.114**	3.255	2.990*
	(2.54)	(2.18)	(0.66)	(2.15)	(1.32)	(1.87)
Observations	32215	16122	16093	32215	16122	16093
Adjusted R^2	0.369	0.273	0.730	0.001	0.002	0.002

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. t statistics in parentheses.

The sample period is November 2004 - October 2005. *BAPCPA* is equal to 1 after April 2005, *y1* is the one year treasury bond yield, *y10* is the 10 year treasury bond yield and *y30* is the 30 years treasury bond yield. *HPI* is FHFA House Price Index, *Rate* is the 30 years mortgage rate, as reported by Freddie Mac, and *P* is the price of the bond. Columns 1-3 we use the log of the prices as the dependent variable, and in columns 4-6 we use the changes in prices as the dependent variable. Columns 1 and 4 include the whole sample, columns 2 and 5 include tranches collateralized by prime mortgages and columns 3 and 6 include tranches collateralized by non-prime mortgages (Alt-A or Subprime). All regressions include month and cusip fixed effects. Standard errors are clustered at the cusip level.

Chapter 3

GSE Insured Mortgage Backed Securities: The Myth of Convexity Spirals

Co-Authored with Christopher Lako[1], Richard Stanton [2] and Nancy Wallace [3]

3.1 Introduction

In most academic term-structure models, the interest rate risk of any particular bond can be exactly replicated with a portfolio of bonds of other maturities, so shocks to supply or demand for any bond maturity must affect the entire yield curve. However, under the "preferred habitat" view of interest rates, first described by Culbertson (1957) and modeled theoretically by Vayanos and Vila (2009), investor clienteles have preferences for particular maturities, so shocks local to a particular maturity may affect that interest rate without affecting interest rates of other maturities. This view is consistent with a large literature over the years showing the importance of local supply and demand shocks for the level of interest rates with specific maturities (e.g., Greenwood and Vayanos, 2010, 2014; Modigliani and Sutch, 1966; Ross, 1966; Wallace, 1967; Krishnamurthy and Vissing-Jørgensen, 2011; Gagnon et al., 2011).

Historically, this literature has focused on regulation changes or other government actions over the years that have significantly affected the supply or demand for bonds of a particular maturity. Due to the sheer size of the outstanding stock of mortgage-backed securities in the U.S. (about $13 trillion pre-crisis) and recent crisis-related stabilization policy initiatives on the part of the Federal Reserve Board, such as Quantitative Easing I–III and Operation

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Twist, that have specifically targeted the purchase of mortgage-backed securities, it is important both for our general understanding of the term structure and for evaluating and modifying these intervention policies to fully understand the exact channels through which shocks to mortgage backed securities affect the Treasury yield curve.

Recently, some authors (in particular, Hanson, 2014; Malkhozov et al., 2016) have argued that the negative convexity of mortgages and mortgage-backed securities means that the change in aggregate interest rate risk caused by duration shifts in these securities is of comparable magnitude to that caused by government interventions, and that this can lead to an amplification of bond-market shocks. Empirically, these authors look for a relationship between bond risk premia and mortgage duration by regressing excess bond returns on mortgage duration and other controls, such as the Cochrane and Piazzesi (2005) factor. When we study these regressions in more detail, we find that the evidence is rather weaker than it first seems, being very dependent on the exact sample period chosen, and also driven at least in part by modeling changes by Barclays during the period. However, a more fundamental problem is that the mechanism proposed to explain these results relies on MBS holders buying long term Treasuries when duration is low. Analyzing the behavior of the majority of MBS investors, we find that investors generally do not act in this way.

To identify the impact of duration and MBS holdings on the Treasury positions of banks we use call report data. We are able to estimate the change in Treasury holdings separately for banks that hedge and banks that do not hedge, identified by their holdings of interest rate derivatives, in response to duration. For foreign investors we use data from the Treasury International Capital (TIC) dataset that lists monthly Treasury holdings by country for major foreign holders. The GSEs hold a very small amount of Treasury debt, however they are known to be the most aggressive hedgers. Using quarterly data from FHFA/OFHEO regulatory reports we study the impact of the GSE hedging positions on excess bond returns. Unfortunately, for pensions and retirement funds we are not able to observe Treasury or MBS holdings. The annual comprehensive annual financial reports (CAFRs) for pensions and retirement funds only report the percentage of their assets in US bonds, which includes both Treasuries and MBS (among other assets). We estimate the effect of duration on Treasury holdings of mutual funds using data from CRSP. Lastly, using NAICS data we estimate the probability of life insurance companies buying Treasuries in a given month based on lagged MBS duration.

We find that the only investors that may follow the models of Hanson (2014) and Malkhozov et al. (2016) are foreign investors in Switzerland and the United Kingdom and life insurance firms. Life insurance firm market share has declined over the period, dropping below 10% since 1996 and reaching 4% in 2016. Furthermore, Switzerland and the United Kingdom are not major participants in the US Treasury market. Other foreign investors (including the PBOC and BOJ, by far the largest foreign investors in US Treasuries) and the other investor groups studied do not trade long-term Treasuries (or trade in the opposite direction one would expect) as a result of MBS duration. Of the investors we are not able to study, hedge funds and pensions/retirement funds are the two investor groups that may trade along the Hanson (2014) and Malkhozov et al. (2016) models. These two investor groups held almost

25% of the Agency MBS market (including households and non profit organizations) in the late 1990s, however post crisis their share has fallen below 10%.

3.2 Duration

Duration is a name given to a number of measures of interest-rate sensitivity. For a fixed-coupon bond, the first such measure, Macaulay duration (Macaulay, 1938), is a weighted average of the time to each payment, the weights proportional to the PV of each payment (discounting using the bond's yield to maturity, y). For a bond with yield to maturity y compounded n times per year, its Macaulay duration, D_{mac}, is

$$D_{\text{mac}} = \frac{1}{P} \sum_{i=1}^{n} t_i \times \frac{C_i}{(1 + y/n)^{n t_i}},$$

where t_i is the time (in years) until the ith payment. A more commonly used measure in practice is modified duration, D_{mod} (Hicks, 1939):[4]

$$D_{\text{mod}} = \frac{D_{\text{mac}}}{(1 + y/n)}.$$

It is a simple matter to show that

$$D_{\text{mod}} = \frac{D_{\text{mac}}}{(1 + y/n)} = -\frac{1}{P} \frac{\partial P}{\partial y}, \tag{3.1}$$

so for small changes in y, the bond's price changes by approximately

$$\begin{aligned} \frac{\Delta P}{P} &\approx \frac{-D_{\text{mac}}}{1 + y/n} \times \Delta y \\ &= -D_{\text{mod}} \times \Delta y. \end{aligned}$$

To hedge a portfolio, we add another security until the portfolio's overall duration is zero.

The definition of both Macaulay and modified duration requires the cash flows on the security to be fixed. Duration can, however, be extended to securities with interest-rate-dependent cash flows (e.g., securities with embedded options) by using Equation (3.1) as the *definition* of "effective duration,"

$$D_{\text{eff}} = -\frac{1}{P} \frac{\partial P}{\partial y}.$$[5]

All of these measures relate a bond's price to changes in its own yield, which can cause problems when aggregating to the portfolio level, since the yields on different bonds do

[4] Note that Macaulay and modified duration coincide with continuous compounding, where $n \to \infty$.

[5] When modified duration can be calculated, it is always equal to effective duration. However, effective duration can be calculated for a wider range of securities.

not necessarily move exactly together. More consistent is to measure the sensitivity of all bonds to movements in the *same* underlying state variable. Fisher and Weil (1971) duration is similar to Macaulay duration, but each cash flow is discounted using the appropriate-maturity spot interest rate. It thus measures a bond's sensitivity to parallel shifts in the entire (not necessarily flat) yield curve. Similarly, in models based on the dynamics of the short-term riskless rate, r (e.g., Vasicek, 1977; Cox et al., 1985), we can calculate the duration of a security relative to r,

$$-\frac{1}{P}\frac{\partial P}{\partial r},$$

and in models with more than one factor, we can calculate durations with respect to each of the underlying state variables.[6]

Given an interest-rate model, the derivatives above can be evaluated either in closed form or numerically. However, any errors in the model will give rise to errors in the resulting durations and hedge ratios. An alternative, model-free, technique is to calculate a security's "empirical duration" (see, for example, Hayre, 2001, Chapter 14), in which returns on the security are regressed on changes in one or more state variables to estimate directly the average change in price for a given change in the underlying variable.[7] An extension of this idea is key-rate duration (Ho, 1992), where a multivariate regression is run of returns against changes in several different interest rates, thus estimating the sensitivity of the security to changes in each of these "key rates" keeping the other rates constant.

Measuring the duration of GSE MBS

Hanson (2014) and Malkhozov et al. (2016) focus on the role of prepayment related shocks to the duration of outstanding residential mortgage backed securities that, in turn, lead to large-scale shocks to the quantity of interest rate risk borne by professional bond investors. Both papers use duration measures obtained from Datastream that are the product of proprietary prepayment models developed Barclays Capital, formerly Lehman Brothers. The Barclays U.S. MBS index covers mortgage backed pass-through securities guaranteed by Government National Mortgage Association (GNMA), the Federal National Mortgage Association (FannieMae), and the Federal Home Loan Mortgage Corporation (FreddieMac), collectively known as U.S. Agency MBS. The index is composed of pass-through securities backed by conventional fixed-rate mortgages. The MBS index does not include non-agency or private-label MBS (e.g.,MBS backed by Jumbo, Alt-A, or subprime mortgages).

Somewhat surprisingly, Malkhozov et al. (2016) use a duration-to-worst measure (LHMN-BCK(DU) in Datastream) which is an MBS duration computed using the bond's nearest call date or maturity, whichever comes first. This measure, thus, ignores future cash flow fluctuations due to embedded optionality which does not seem desirable given that the intent

[6]Hedging a portfolio in a (say) two-factor world involves adding at least two additional securities until both durations equal zero.

[7]This assumes that the sensitivity remains fixed over the period of the regression (see Boudoukh et al., 1995, for a discussion and extensions).

of their empirical exercise is to measure the impact of prepayment related shocks on the quantity of interest rate risk. Malkhozov et al. (2016) then scale their duration-to-worst measure by the average unit price of U.S. agency MBS which produces a dollar duration per unit of MBS in the market not the aggregate MBS dollar duration.

Hanson (2014) uses two measures of duration also constructed using data from Barclays Capital models and obtainable from Datastream. The first of these is an effective duration (corresponding to (LHMNBCK(DM) in Datastream) for the Barclays MBS Index and measures the percentage change in U.S. agency MBS market value following a shift in the yield curve. His second preferred duration measure is the contribution of MBS bonds to the Barclays Aggregate Index duration. This measure is constructed by weighting the effective duration measure by the ratio of the market value of MBS, using Barclays U.S. Mortgage Backed Securities – Market Value (MM), to the Barclays measure of the U.S. Aggregate – Market Value (MM). This scaled duration measure is therefore $Effective\,Dur_{t-12m}\frac{MBSMV_{t-12m}}{AGGMV_{t-12m}}$ where $MBSMV_{t-12m}$ is U.S. Mortgage Backed Securities – Market Value (MM) and $AGGMV_{t-12m}$ is the U.S. Aggregate – Market Value (MM). The measure, captures the fact that shifts in MBS duration in the U .S. have had a growing impact on aggregate bond market duration due to the growth of the MBS market. The measure proxies for the transient component of aggregate bond market duration due to MBS and constitutes his preferred forecasting variable.

We apply a "prepayment model free" empirical duration measure using the universe of outstanding Fannie Mae MBS (results are similar for Freddie Mac and Ginnie Mae MBS). Our empirical duration estimates the sensitivity of daily MBS price changes to daily changes in 10-year Treasury yields. We use 10-year zero coupon Treasury yields from Grkaynak, Sack, and Wright (2007) and TBA prices at the agency, maturity, and coupon level from EMBS to estimate the following equation:

$$\frac{TBAPrice_{t,c,p} - TBAPrice_{t-1,c,p}}{TBAPrice_{t-1,c,p}} = \alpha + \beta\frac{yield_t - yield_{t-1}}{100} + \epsilon_{t,c,p} \tag{3.2}$$

where $-1 * \beta$ is the empirical duration, t is time (daily), c is coupon (in 50bps increments), and p is program (i.e. FNMA 30-year or GNMA 15-year). The following analysis uses data for FNMA 30-year MBS with a coupon between 2.5 and 10%.

For our second duration measure, we scale our empirical duration by the market value of the outstanding stock of U.S. MBS and the market value of the Barclays Aggregate following Hanson (2014).[8] Our second measure is thus, $Empirical\,Dur_{t-12m}\frac{MBSMV_{t-12m}}{AGGMV_{t-12m}}$, where $MBSMV_{t-12m}$ is the EMBS measure of the market value of the outstanding stock of U.S. agency MBS and $AggMV_{t-12m}$ is the U.S. Aggregate – Market Value (MM). Our final preferred duration measure is our empirical duration measure times U.S. Mortgage Backed Securities – Market Value (MM) to Barclays aggregate effective, duration obtained from DataStream, times U.S. Aggregate – Market Value, $\frac{EmpDur_{t-12m}MBSMV_{t-12m}}{AggDur_{t-12m}AggMV_{t-12m}}$. This is the

[8]Our EMBS measure of the market value of the outstanding stock of U.S. agency MBS exactly matches the Barclay measure U.S. Mortgage Backed Securities – Market Value (MM).

relative contribution of MBS dollar duration to the aggregate dollar duration. Malkhozov et al. (2016) notes that the duration channel is stronger when GSE share is higher. They base this on the correlation between the rolling R-squared from the regression of excess bond return on duration and the share of MBS held by the GSEs. This contrasts with the implications of the model in Hanson (2014). Hanson notes that the MBS buyers that delta hedge bear a constant amount of interest rate risk and are not important for the channel. As shown in the GSE section, the GSEs do not influence excess bond returns by their hedging activity. The GSEs primarily use swaps, swations, Treasury futures options, Eurdollar futures options, and other interest rate derviaties as well as their issuance of Agency debt to hedge their duration exposure. They do not use Treasury debt for this purpose. Consequently an increase in GSE share should reduce the importance of the duration channel on bond returns if trading in the derivatives markets does not influence excess bond returns.

On a similar note, the model in Malkhozov et al. (2016) relies on the difference between the average MBS coupon and the 5-year swap rate. Figure 3.1 shows the distribution of FNMA MBS and the respective weighted average coupon, similar to the measure used by Malkhozov et al. (2016). Note that the average does not account for the change in distribution. It also does not account for various measures that are paramount in prepayment modeling, such as: SATO, the percent underwater, FICO, etc.

Barclays Modeling Changes

Starting in November 2008 Barclays regularly updated their prepayment model to capture changes in the market and regulatory environment. Primarily, Barclays is interested in capturing frictions associated with mortgage terminations. The model changes are in effect structural breaks in the data. These changes can have dramatic (and persistent) effects on duration. The Barclays effective duration measure changed by 1.64 (from 1.29 to 2.93 versus a change from 1.2 to 1.48 in the empirical duration measure) between August and September 2010, primarily due to the model change in September 2010.

Figure 3.2 shows the difference between Barclays effective duration and FNMA 30-year empirical duration. The series is roughly white noise around zero until 2008. Starting in late 2008 the model starts to deviate from the zero trend, with the biggest break in September 2010 when Barclays introduced changes to their prepayment model that had large effects on their duration measures.

Influence of Extreme Observations

Given the issues with the Barclays duration measure and the relatively stable nature of duration except for a few periods of extreme and persistent changes in duration it is natural to see if the result is driven by a few extreme observations or the subsample that does not include model changes.

We first consider our two measures of effective duration, Barclays effective duration and our empirical effective duration. Column 1 of Table 3.1 replicates the finding of Hanson

(2014). Columns 2-3 estimate the regression using Barclays and empirical duration starting in February 1996, the earliest month empirical duration is available, through December 2013. Both duration measures are significant over this period. If we look at the period ending in August 2008 (the last month before the Barclays duration measure experiences frequent model updates) we find both measures are still significant (columns 4-5), however, if we include fixed effects for the late 1990s and early 2000s refinance cycles the results disappear (even if we start the sample in January 1989 to increase the number of observations - columns 6-8). If we include fixed effects for the late 1990s and early 2000s refinance cycles and the four periods of Federal Reserve intervention over the period from February 1996 until December 2013 the result remains for Barclays duration (column 9), however the empirical effective duration is now statistically significantly different from zero at less than the 10% level (column 10). As we will discuss, given the issues with model risk for the Barclays duration measure over this later period we put more emphasis on the empirical duration result for the full sample.

The specifications in Columns 9 and 10 are especially important because we would expect the Federal Reserve interventions to directly influence excess 10 year Treasury returns as the Federal Reserve entered the market to influence bond yields, especially during Operation Twist. Operation Twist started in September 2011 and lasted through 2012, however, unlike the other three quantitative easing programs Operation Twist's sole intention was to buy long term Treasury debt and sell short term Treasury debt. The consequences should be a decrease in the excess return measure that we use as the long rate should decline as long term debt prices are bid up and the short rate should increase as short term debt prices sell off. As such it is very difficult to attribute the excess bond return dynamics over this period to MBS duration.

Table 3.2 shows the same regressions as Table 3.1 however now the measures of duration that we use are aggregate MBS dollar duration and aggregate empirical MBS dollar duration. Our measure of dollar empirical duration is significant over the sample that includes the major Fed QE policy interventions (colums 3 and10) and remains significant when fixed effects are included (column 10). The empirical dollar duration measure is not statistically significant in the pre-intervention era, nor is the Barclays duration measure. We also find that controlling for the two prepayment waves in January 1998 through January 1999 and again in August 2002 and June 2003, these intervals were also associated with significant short-term rate reductions (see, Gurkaynak et al., 2005), that both of the empirical duration measures are not statistically significantly different from zero at conventional cut off levels. Interestingly, both measures remain statistically significant for the longer sample with the inclusion of fixed effects for the Federal Reserve activity starting with QE 1.

Table 3.3 shows the similar regressions as Table 3.1, however, now the measure of duration that we use is MBS duration weighted by the share of the MBS market relative to the aggregate fixed income market. Both of these duration measures are statistically significantly different from zero in the time series sample that includes the major Fed QE policy interventions (colums 3 and10) and both remain significant when fixed effects are included (column 10), although again similar to the results in Table 3.1 the statistical significance of the empirical duration measure falls to less than the 10% level. The empirical dollar duration measure is not statistically significant in the pre-intervention era, nor is the Barclays duration measure. We also again find that controlling for the two prepayment waves in January 1998 through January 1999 and again in August 2002 and June 2003, that both duration measures are no longer statistically significantly different from zero at conventional cut off levels for the pre-QE sample.

Finally, in Table 3.4 we compare the performance of uses the ratio of MBS interest rate risk relative to aggregate interest rate risk using Barclays effective duration measure and our empirical duration measure. We find similar results as Table 3.1, however the result in column 10 is not significant at the 10% level. Overall, these results that the Barclays measure has persistent and statistically significant effects on10 year Treasure 12 month excess bond returns. Controls for the Federal Reserve policy interventions lessen the statistical significance and the economic magnitude of the effect on excess returns but they do not extinguish the effect. The empirical duration measure performs quite differently and appears more sensitive to Fed policy interventions designed to affect interests as is evident both by excluding the post-crisis intervention period and by introducing controls for these interventions. We find that both the statistical and economic importance of the empirical duration based measures are consistently reduced with proper controls for this alternative channel.

To better understand these findings. In Figure 3.3 a we present the diagonal entries from the hat matrix based on the regression of excess 10-year bond returns on Barclays effective duration between January 1989 and December 2013. We see that the there are a few influential points primarily stemming from the early 2000s refinance cycle and the later periofd when the model started to experience structural breaks.

Figure 3.3 b shows the diagonal values of the hat matrix from a regression of excess 10-year bond returns on FNMA 30 year empirical duration from February 1996 to December 2013. Influential observations are not as prevalent when the FNMA 30 year empirical duration measure is used. This finding concerning the deep structure of the data suggests that the Barclays effective duration appears to rest on the 1998 and 2002 refinance periods and a period with structural breaks stemming from model changes.

3.3 Evidence for MBS Investor Hedging

Using the Federal Reserve Flow of Funds, Agency MBS investors are presented in Figure 3.4. The investors we can account for are the Federal Reserve, banks, foreign investors, the GSEs, mutual funds, and life insurance companies. We do not account for brokers/dealers, federal/state/local government, property/casualty insurance companies, households and non-profit organizations (includes hedge funds), retirement and pension funds, issuers of ABS, and REITs. Overall, we are able to estimate the hedging response of investors comprising at least 70% of the MBS market since the first quarter of 2001 (barring a few months where their share dipped slightly below 70%) and in some months more than 80% of the market.

The Federal Reserve

Since November 2008 the Federal Reserve has purchased over \$2.3 trillion dollars of mortgage backed securities through its quantitative easing programs (Federal Housing Finance Agency Officer of Inspector General, 2014). By the first quarter of 2014, the Federal Reserve held \$1.5 trillion Freddie Mac PCs, Fannie Mae mortgage backed securities, and GNMA mortgage backed securities on its balance sheet (Patrabansh, Doerner, and Asin 2014). The Federal Reserve does not hedge nor do they care about portfolio duration so this important investor cannot important for the measurement of the overall U.S. GSE MBS duration. Malkhozov et al. (2016) finds that the Federal Reserve's market share is negatively correlated with the strength of the duration channel. This is attributed to the Federal Reserve abstaining from hedging. However, the period when Federal Reserve MBS holdings are higher is the period during unconventional monetary policy and thus it is difficult to attribute the reduction in the strength of the duration channel over this period to Federal Reserve MBS holdings or Federal Reserve open market operations more broadly (such as Operation Twist).

Government Sponsored Enterprises

Malkhozov et al. (2016) notes that the duration channel is stronger when GSE share is higher. They base this on the correlation between the rolling R-squared from the regression of excess bond return on duration and the share of MBS held by the GSEs. This contrasts with the implications of the model in Hanson (2014). Hanson notes that the MBS buyers that delta hedge bear a constant amount of interest rate risk and are not important for the channel. As shown in the GSE section, the GSEs do not influence excess bond returns by their hedging activity. The GSEs primarily use swaps, swations, Treasury futures options, Eurdollar futures options, and other interest rate derivatives as well as their issuance of Agency debt to hedge their duration exposure. They do not use Treasury debt for this purpose. Consequently an increase in GSE share should reduce the importance of the duration channel on bond returns if trading in the derivatives markets does not influence excess bond returns.

Figure 3.5 shows the holders of Treasury debt. The GSE share is not visible, rising to a maximum of only 1.8% over the period. Figure 3.6 shows the distribution of the GSEs derivatives portfolio revealing that interest rate swaps are the dominant instrument used for hedging. Note, Figure 3.6 does not show the non-mortgage investments portfolio, which comprises Treasury debt.

However, Treasury debt is not broken out separately and is rolled into the Other category, showing that it is a very small investment category for the GSEs. The GSE hedging portfolio data includes holdings of interest rate derivative products by the GSEs (as shown in Figure 3.6). Using quarterly data from the FHFA/OFHEO regulatory reports we test the effect of the GSE derivatives portfolio on log excess return for 10-year zero coupon bonds. The following regression is estimated:

$$rx_t^{(10)} = \alpha + \beta_1 \times GSEHedgingPortfolio_{t-12m} + \epsilon_t^{(10)} \tag{3.3}$$

Equations including Barclays effective and FNMA empirical duration are also estimated. The data are quarterly and standard errors are Newey West allowing 18 months of serial correlation. Regressions of changes in duration and interest rate derivative holdings on the change in excess return are also estimated.

If the GSEs buy more interest rate derivatives when duration declines and the buying of these contracts influences excess bond returns then β_1 should be negative. Tables 3.5 and 3.6 show that the GSE hedging portfolio does not have an impact on the excess return and the coefficient is positive. Including duration or estimating the regression with differences instead of levels does not change the finding.

Note, the Flow of Funds data (L.211) measures GSE holdings of agency and GSE backed securities. However, the GSEs hold a large amount of whole loans and private label securities (PLS), which are not included in the Flow of Funds data (Figure 3.7).

Further complicating matters, in Q1 of 2010 there was an accounting policy change that dramatically reduced reported GSE holdings (and increased their liabilities). The retained portfolio reporting data does not show a similar drop in Q1 2010. Using FHFA/OFHEO retained portfolio reporting data we find that before 2002 the retained portfolio dynamics followed the Flow of Funds data but diverged afterwards. Agency MBS holdings (FNMA, FHLMC, and GNMA MBS) in the FHFA data closely track the Flow of Funds data. However the FHFA data do not show a decline in 2010 from the accounting change.

Also, the retained portfolio compositions have changed over time and varies by GSE. Fannie Mae's retained portfolio is largely comprised of whole loans and Fannie Mae MBS (Figure 3.8a).

Freddie Mac's retained portfolio however is comprised largely of Freddie Mac MBS and PLS, with whole loans representing a very small share (Figure 3.8b). Freddie Mac's retained portfolio PLS share peaked in 2005 at 33%, while Fannie Mae's retained portfolio PLS share peaked at 14% (Figure 3.9). Freddie Mac also holds a much larger percentage of its competitor's (Fannie Mae) MBS compared to Fannie Mae's holdings of Freddie Mac MBS (Figure 3.10). This is likely for the management of the Fannie Mae/Freddie Mac MBS spread.

Banks

Using call report data we test the impact of duration on Treasury bond holdings of banks. We divide the sample into banks with MBS pass-through holdings in their non-trading accounts that have and have never held interest rate contracts in their non-trading accounts. Regressions are ran using all Treasury bond holdings, Treasuries with more than three years remaining maturity, and Treasuries with three or fewer years remaining maturity as the dependent variable (normalized by total assets). The following equation is estimated:

$$\frac{Treasuries_{t,i}}{Assets_{t,i}} = \alpha + \beta_1 \times Duration_{t-12m} + \mathbb{X}_i + \mathbb{Y}_{t-12m} + \epsilon_{t,i} \quad (3.4)$$

where i is a bank, $\mathbb{X}_i$ are bank fixed effects, and $\mathbb{Y}_{t-12m}$ are time fixed effects. The data are quarterly and standard errors are clustered at the bank level allowing for correlation in the standard errors within banks.

If banks increase Treasury holdings following a decline in duration we would expect β_1 to be negative. With the effect much stronger for banks that do not have IR derivative holdings and for Treasuries with longer duration. Table 3.7 shows results using data for banks that have never had IR derivative holdings in their non-trading accounts at horizons of 3 and 12 months. Column 1 shows that duration is significant, however columns 2 and 3 reveal that the result is driven by an increase in short term Treasuries when duration declines. Thus banks do not increase Treasury bond holdings at the horizon used by past work that have studied convexity spirals. Columns 4–6 of Table 3.7 show that at a horizon of 12 months we see no impact of duration on Treasury holdings.

Table 3.8 shows results using data for banks that have held IR derivative holdings in their non-trading accounts. We find that there is no impact of duration on Treasury holdings at either the 3 or 12 month horizon for any maturity of Treasuries. If instead we look at differences instead of levels the coefficients are largely insignificant (Tables 3.9 and 3.10).

In the Appendix we report results using FNMA empirical duration instead of Barclays effective duration (Tables A.1, A.2, A.3, and A.4). We find that using either levels or differences and only looking at banks that have never held IR derivatives only short term Treasuries are bought when duration declines. Using data for banks that have held IR derivatives we find no evidence of changes in Treasury holdings when duration fluctuates.

Major Foreign Holders

Since 2002 foreign investors have held between 10 and 22% of outstanding Agency MBS (Figure 3.4). Furthermore, foreign investors are major holders of US Treasury debt, holding more than 40% in recent years (Figure 3.5). This is an investor group that holds a sizable MBS portfolio and also holds a significant portion of Treasury debt.

Figure 3.11 shows that China and Japan each hold roughly 10% of total US Treasury debt. Using data from the Treasury International Capital (TIC) dataset the following equation is estimated:

$$\frac{\Delta TSY\,Holdings_{t,t+12m}}{TSY\,Holdings_t} = \alpha + \beta_1 \times \Delta Duration_{t-12m,t} + \beta_2 \times \Delta FX Rate_{t-12m,t} + \epsilon_{t,t+12m} \tag{3.5}$$

where the foreign exchange rate is how many units of the country's currency buys one US Dollar. The data are monthly and the standard errors are Newey West allowing for 18 lags. Regressions are estimated using percentage change in Treasury holdings instead of the difference in Treasury holdings to control for the massive increase in holdings over the period.

If these countries buy Treasuries when duration decreases to extend the duration of their portfolios we should find β_1 to be negative. Investors in these countries may also buy Treasuries when their currency appreciates, in which case we would expect β_2 to be negative.

However, if the country's currency freely floats then low duration may also coincide with a more valuable foreign currency for the country as low duration may be from a low Fed Funds rate, which would depreciate the US dollar relative to foreign currencies. A more valuable foreign currency may lead to increased buying of US Treasury debt. However, countries, such as China and Switzerland, do not freely float their currencies. For these countries the foreign exchange rate may explain growth in Treasury holdings that is independent of duration.

Table 3.11 shows results using Barclays effective duration. The change in duration variable is never significant. Using FNMA empirical duration we find similar results (Table 3.12). In the appendix we report results at a 3 month horizon using Barclays duration and do not find any effect of duration on Treasury holdings (Table A.5). Thus, the largest foreign holders of US Treasuries do not buy Treasuries when duration declines.

Mutual Funds

Using data from CRSP we test the impact of duration on Treasury bond holdings of mutual funds. The data are available quarterly between Q1 1999 and Q4 2014. The following equation is estimated:

$$PerGovtBonds_{t,i} = \alpha + \beta_1 \times Duration_{t-j} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t,i} \tag{3.6}$$

where i is a mutual fund, j is 3-months or 1-year, duration is either empirical or Barclays effective duration, $\mathbb{X}_i$ are mutual fund fixed effects, and $\mathbb{Y}_{t-j}$ are time fixed effects. Standard errors are clustered at the mutual fund level. Regressions are also estimated on changes instead of levels. We estimate the equation for all mutual funds in the sample and for mutual funds that ever had MBS holdings. Data on MBS holdings became available in October 2010, by restricting to mutual funds with MBS holdings we remove mutual funds that closed before October 2010.

If mutual funds increase Treasury holdings following a decline in duration we would expect β_1 to be negative. Table 3.13 reports results for the estimates of the equation on levels and shows that β_1 is positive and significant across all specifications. This shows that mutual funds do not increase their Treasury holdings when duration declines.

However, Table 3.14 reports results for changes and finds β_1 is negative and significant. Duration is relatively stable, with a few jumps for different regimes of duration. The result for the levels likely implies that when duration is low, mutual funds hold fewer Treasuries. The results for the change likely implies that within periods of low (or high) duration, small increases in duration lead to slightly smaller holdings of Treasuries.

Life Insurance Companies

Life insurance company liabilities are generally long duration and require a minimum level of return with minimal risk. To satisfy their liabilities life insurance companies primarily hold fixed income assets. Berends et al. (2013) find that 75% of life insurance general account assets are in bonds. Of the bond holdings 60% are in corporate bonds, 18% are in MBS (both private label and GSE), and only 7% are in Treasuries.

Figure 3.4 shows that insurance companies held roughly 10% of outstanding Agency MBS in 1985 however this share has declined over time (70–80% of these holdings are from life insurance companies). Using data from NAICS we are able to identify life insurance firms that hold MBS (either GSE or private label) and their monthly trading of Treasury securities. We use data from the 300 files, Schedule D Part 1, which reports securities held as of year end. There is also a 303/304 file, Schedule D Part 3, which reports all trades in a year. However data for the 303/304 files ends in 2007, while data for the 300 files ends in 2012.

The downside to using the 300 files is that the reporting will not capture securities held and then sold after a short period of time or securities that mature before the end of the year that they are purchased. However, since we are interested in Treasury holdings that are bought for the purpose of extending portfolio duration during periods of persistent declines in MBS duration this is likely to be less of an issue. In terms of absolute numbers of Treasury purchased the 300 files contain 97% of the number of Treasury purchases compared to the 303/304 files, while the 300 files only contain 79% of all trades compared to the 303/304 files. Thus it seems that Treasuries are likely to be held for extended periods of time. However, comparing counts by tuples of firm and year and month of the trade only 82% of Treasuries in the 303/304 files are matched to the 300 files, thus there is variation in the high frequency data. As a robustness we report regressions for the overlapping period of 2001–2007 for both the 300 and 303/304 files.

To test if life insurance companies buy Treasuries when MBS duration is low we estimate a linear probability model of the probability of buying Treasuries in a given month based on lagged duration with time and firm fixed effects. The equation estimated is:

$$\mathbb{1}_{t,i} = \alpha + \beta_1 \times Duration_{t-j} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t,i} \tag{3.7}$$

where $\mathbb{1}_{t,i}$ is equal to 1 if firm i bought Treasuries in month t+j (for j of 1, 6, or 12 months), $Duration_{t-j}$ is either Barclays effective MBS duration or FNMA empirical duration, $\mathbb{X}_i$ are firm fixed effects, and $\mathbb{Y}_{t-j}$ are monthly time fixed effects. The standard errors are clustered at the firm level. Our identification of Treasuries includes TIPS and excludes when issued and STRIPS. The regressions are estimated using data for firms that held MBS securities (identification of MBS securities includes GSE debt) at any point in the data.

If life insurance companies buy Treasuries when duration is low we would expect β_1 to be negative. Table 3.15 shows that β_1 is negative and significant at the 1% level, indicating that life insurance firms buy Treasuries when MBS duration is low. Many firms infrequently buy Treasuries. 13% never bought Treasuries and 65% bought Treasuries in 12 or fewer months over the 12 year period. Column 7 shows that for these firms the effect is not significant and column 8 shows that the effect is driven by firms that frequently buy Treasuries. Thus the result is driven by less than 35% of life insurance firms. However, as Figure 3.12 shows, there is a slight positive correlation between frequency of Treasury buying and assets.

We impute the maturity of the Treasuries purchased based on the year of the trade and the stated maturity of the Treasury. Roughly 53% have a maturity of 5 or fewer years and 44% have a maturity of more than 5 years (we are missing the maturity for 3% of the bonds). Furthermore, only 33% have a maturity greater than 8 years, thus the Treasuries purchased tend to be of shorter maturity. Column 9 shows results for the linear probability model estimated with the left hand side equal to one if a Treasury with $\leq$5 years is purchased in the given month and 0 otherwise. Conversely, column 10 is estimated with the left hand side equal to one if a Treasury with >5 years maturity is purchased in the given month. Both coefficients are negative and significant.

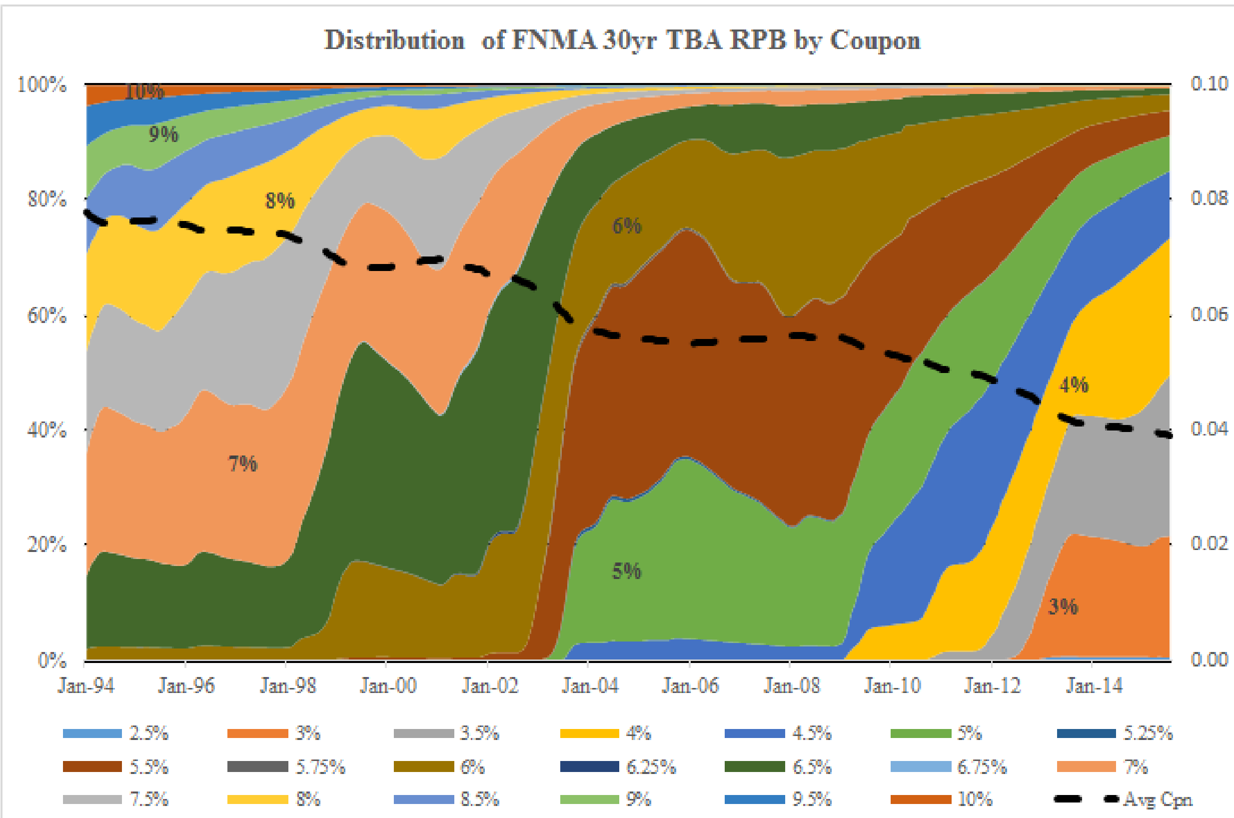
As a robustness check, columns 11–12 show that we obtain similar results if we use either the 300 or 303/304 files over the 2001–2007 period. Table 3.16 shows results using FNMA empirical duration and results are similar. Lastly, it is worth nothing that figure 3.5 shows that over this period insurance companies, including property and casualty insurance companies held a relatively small share of Treasury debt.

3.4 Conclusions

We propose an empirical duration measure for the stock of U.S. Agency MBS that appears to be less prone to model risk than measures such as the Barclays Effective Duration measure. We find that this measure does not appear to have a strong effect on the 12-month excess returns of ten-year Treasuries as would be expected if shocks to MBS duration lead to commensurate shocks to the quantity of interest rate risk borne by professional bond investors (Hanson, 2014; Malkhozov et al., 2016). Given this negative reduced form result, we then explore the mortgage and treasury hedging activities of the primary MBS investors such as commercial banks, insurance companies, the agencies, the Federal Reserve Bank, Mutual Funds, and foreign investors. We find that the only investors that may follow the models of Hanson (2014) and Malkhozov et al. (2016) are foreign investors in Switzerland and the United Kingdom and life insurance firms. Life insurance firm market share has declined over the period, dropping below 10% since 1996 and reaching 4% in 2016. Furthermore, Switzerland and the United Kingdom are not major participants in the US Treasury market. Of the investors we are not able to study, hedge funds and pensions/retirement funds are the two investor groups that may trade along the Hanson (2014) and Malkhozov et al. (2016) models. However, although these two investor groups held almost 25% of the Agency MBS market (including households and non profit organizations) in the late 1990s, post crisis their share has fallen below 10%.

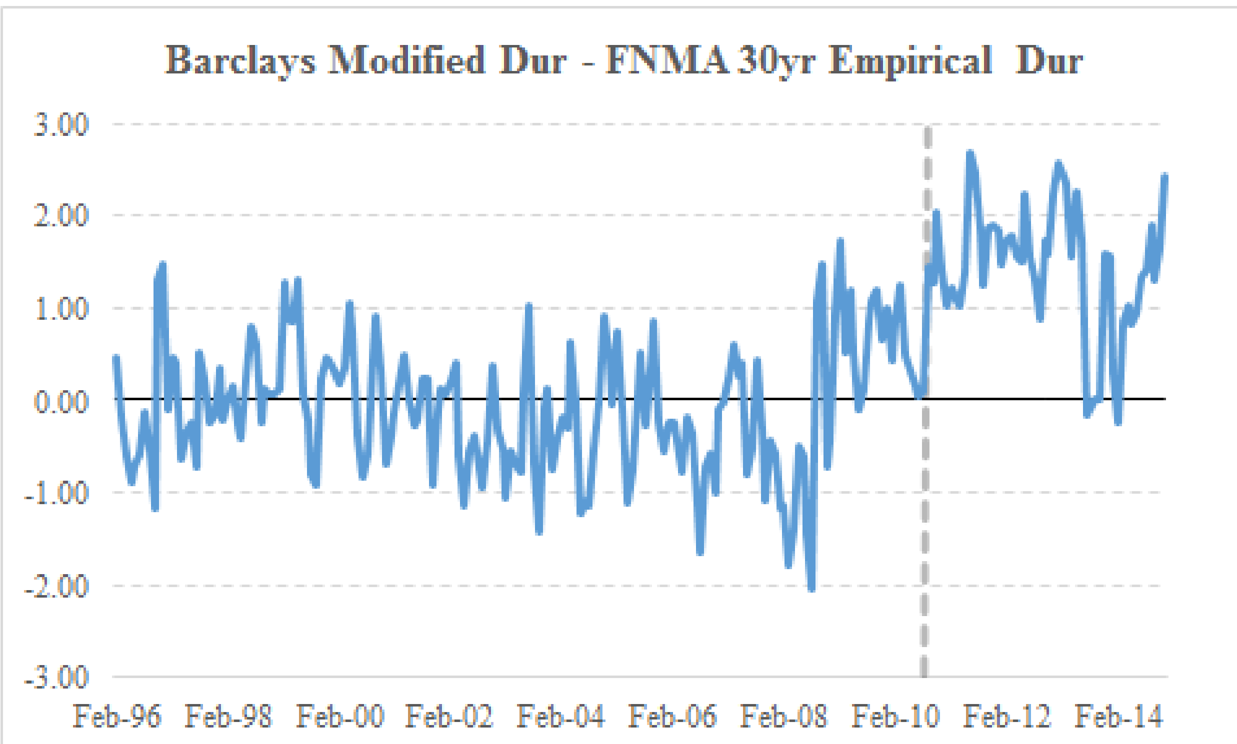
3.5 Figures

Figure 3.1: Distribution by coupon.



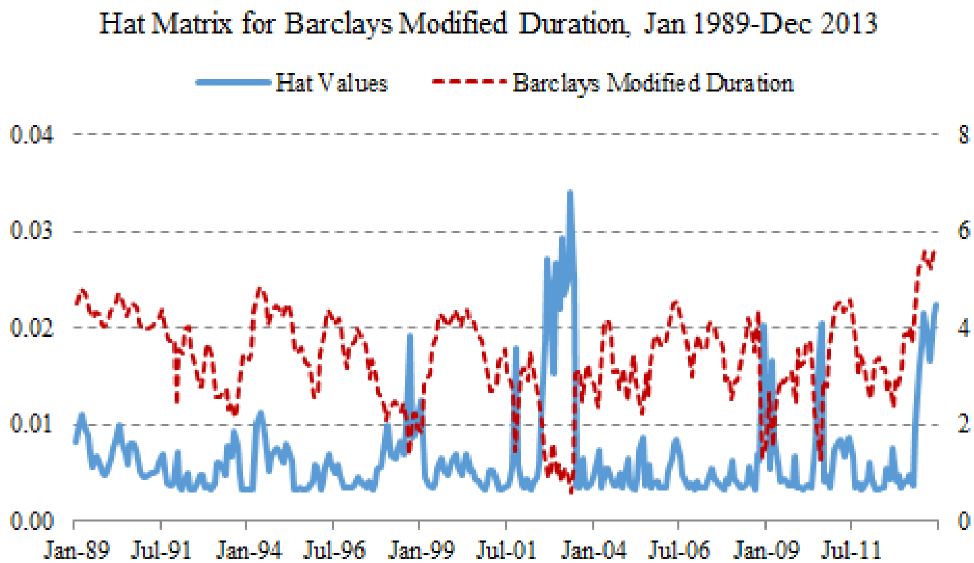
The figure shows the distribution by coupons (between 2.5% and 10% in 0.5% increments, except between 5% and 7% where coupons are reported in 0.25% increments) of the remaining principal balance of FNMA 30 year TBA securities as reported by EMBS between January 1994 and July 2015. The dashed line (right axis) shows the weighted average coupon for this population. The data are reported monthly.

Figure 3.2: Comparing duration measures

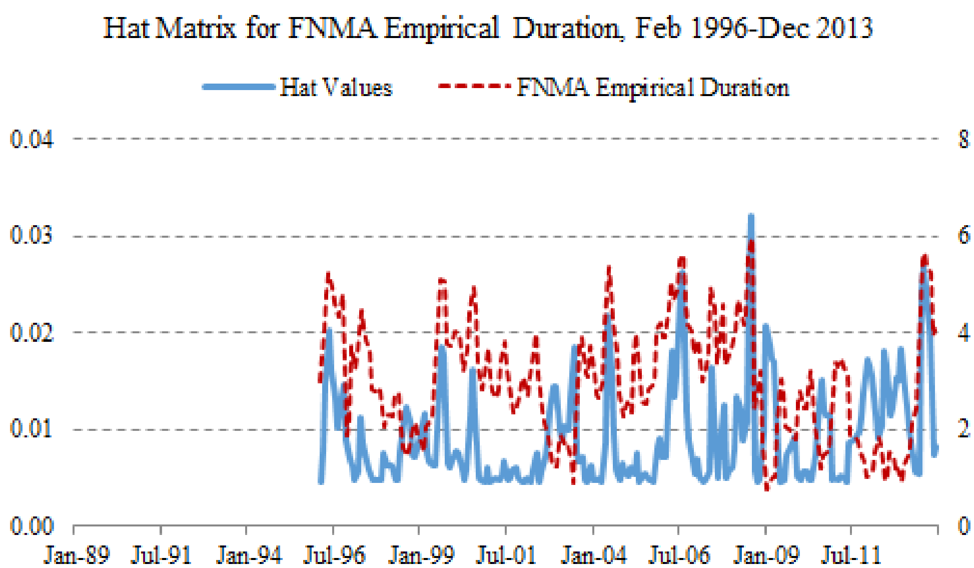


Difference between Barclays effective duration and FNMA 30 year empirical duration from February 1996 to December 2014. The vertical dashed gray line represents September 2010.

Figure 3.3: Hat Matrix



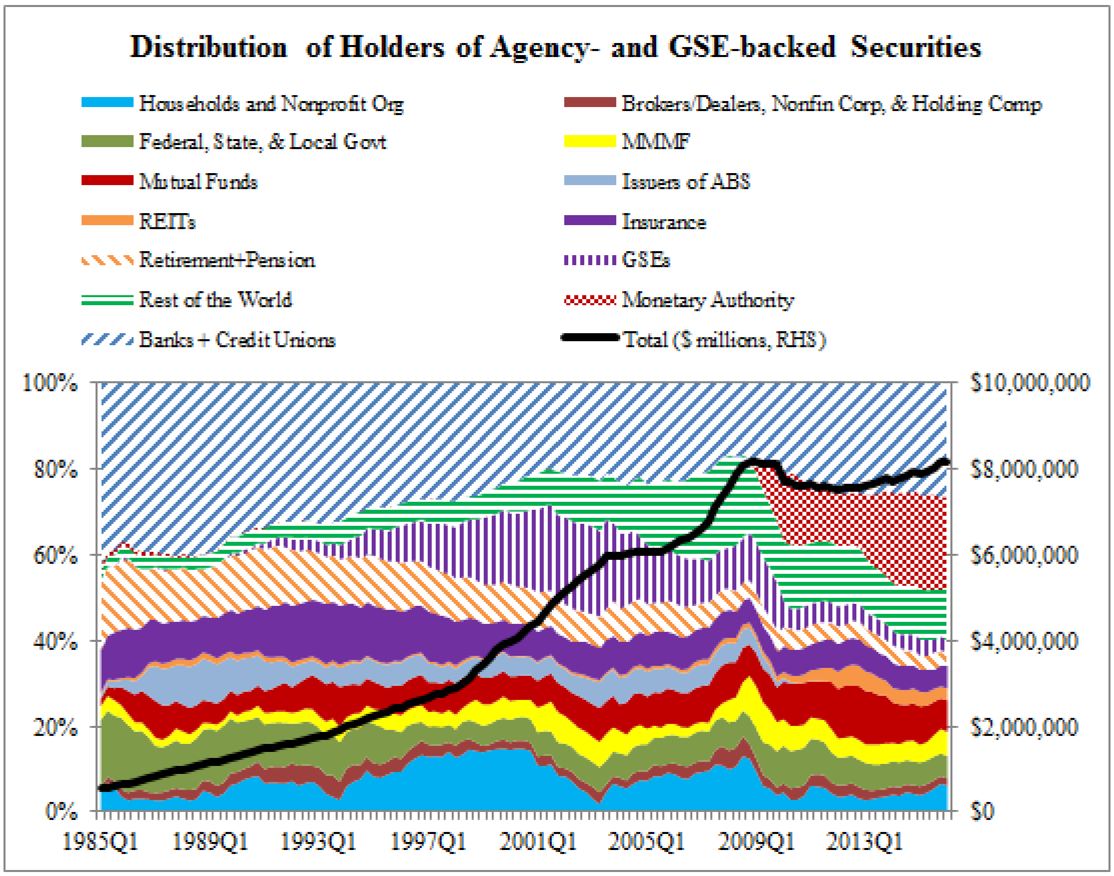
(a)



(b)

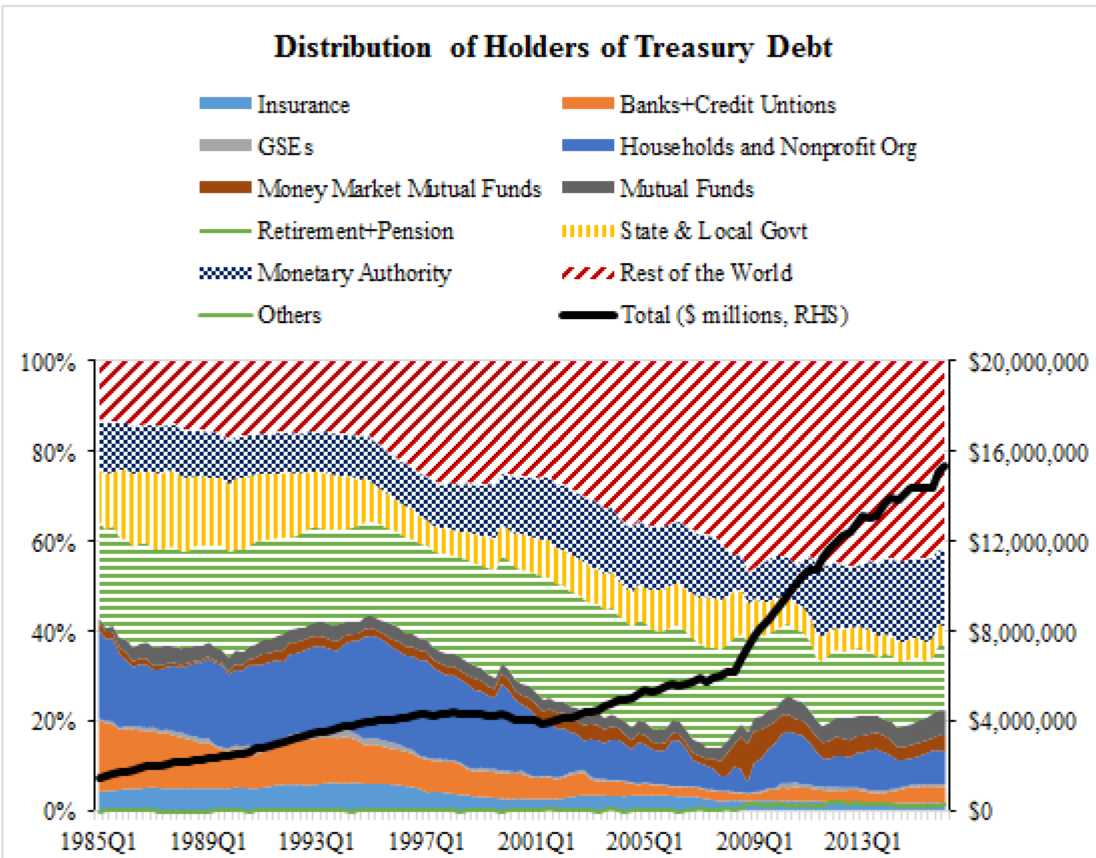
Figure A shows the diagonal of the hat matrix for a regression of $rx_t^{(10)} = \alpha + \beta_1 \times Barclayseffective Duration_{t-12m} + \epsilon_t^{(10)}$ using monthly data between January 1989 and December 2013 (left axis). The right axis shows Barclays effective duration. Figure B shows the diagonal of the hat matrix for a regression of $rx_t^{(10)} = \alpha + \beta_1 \times FNMA30year Empirical Duration_{t-12m} + \epsilon_t^{(10)}$ using monthly data between February 1996 and December 2013 (left axis). The right axis shows FNMA 30 year empirical duration. $rx_t^{(10)}$ are 10 year Treasury 12 month excess bond returns.

Figure 3.4: The distribution of Agency and GSE backed securities holdings by investor group



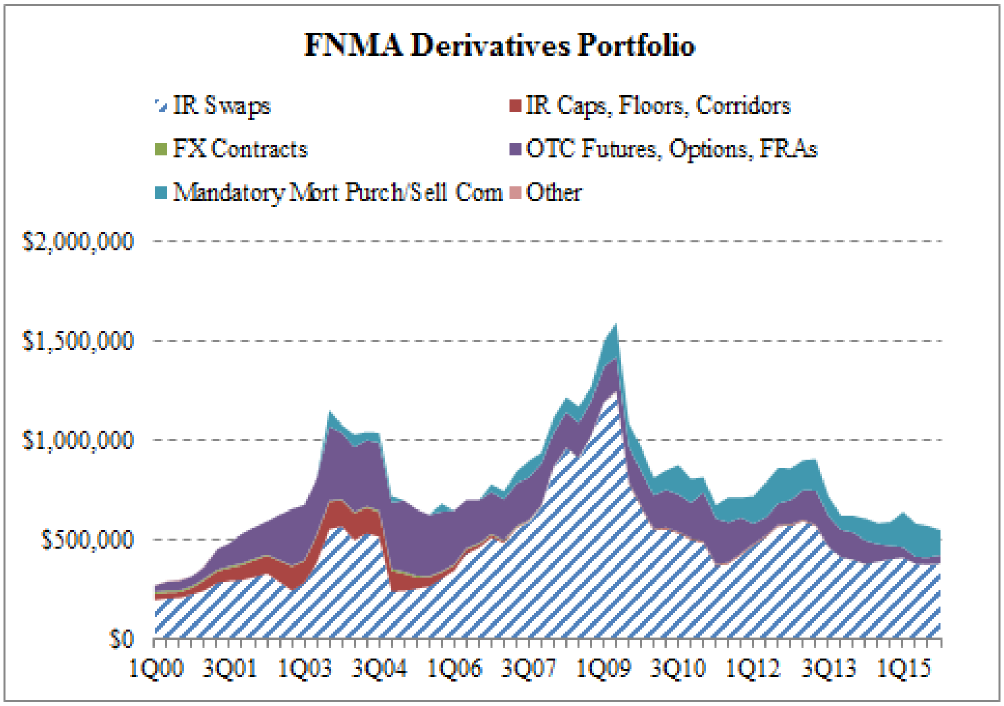
The figure shows the distribution of Agency and GSE backed securities holdings by investor group. The data are from the Federal Reserve flow of funds and are quarterly from Q1 1985 to Q1 2016 (left axis). The solid line (right axis) shows total outstanding Agency and GSE backed securities in USD millions.

Figure 3.5: The distribution of US Treasury holdings by investor group

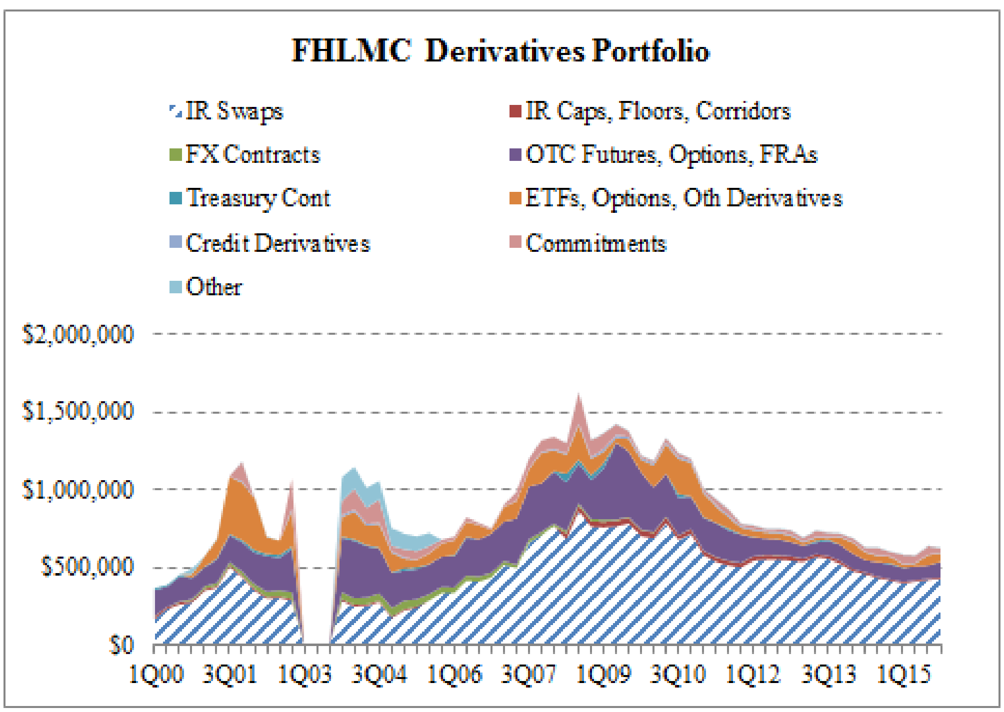


The figure shows the distribution of US Treasury holdings by investor group. The data are from the Federal Reserve flow of funds and are quarterly from Q1 1985 to Q1 2016 (left axis). Other includes non-financial corporate business, non-financial non-corporate business, closed end fund, exchange traded fund, issuer of ABS, security broker and dealer, and holding company holdings of US Treasuries. The solid line (right axis) shows total outstanding US Treasury debt in USD millions.

Figure 3.6: GSE financial derivatives portfolio



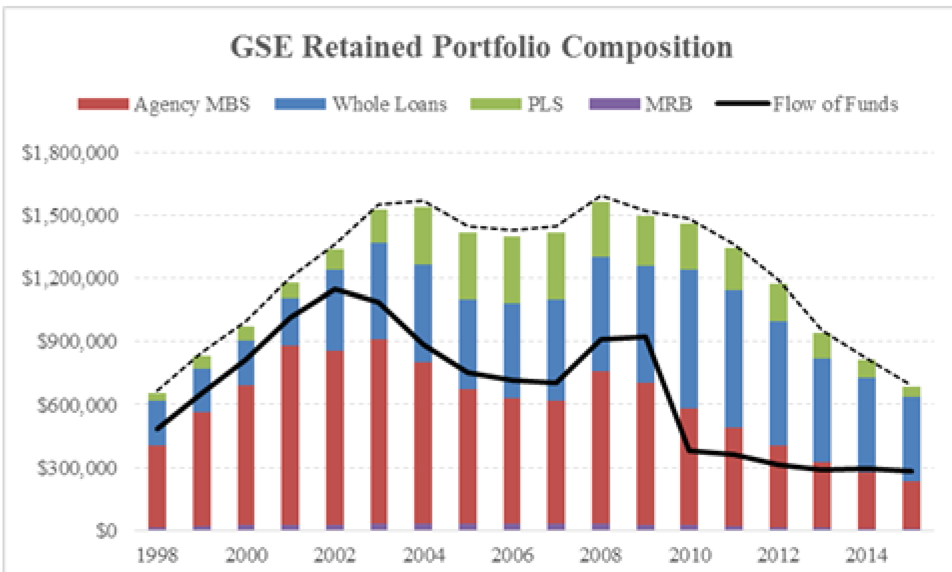
(a) Fannie Mae



(b) Freddie Mac

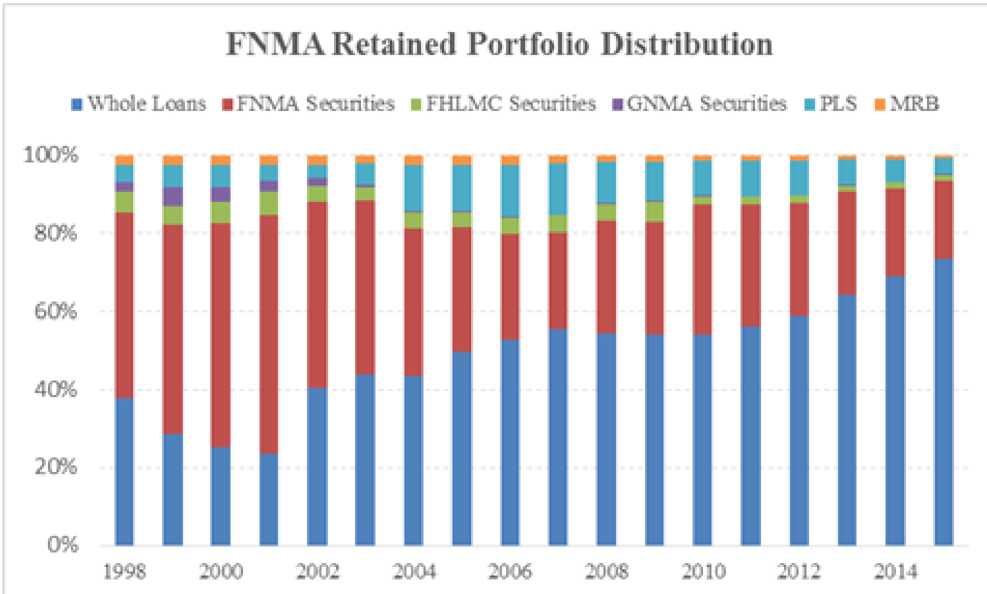
Figures A (Fannie Mae) and B (Freddie Mac) show the total dollar amount (notional, in millions) and composition of the financial derivatives portfolios using quarterly data from the FHFA/OFHEO annual reports to Congress between Q1 2000 and Q4 2015. The categories of securities are not consistent between Fannie Mae and Freddie Mac. The data are not available for Freddie Mac between Q1 2003 and Q3 2003.

Figure 3.7: GSE retained portfolios

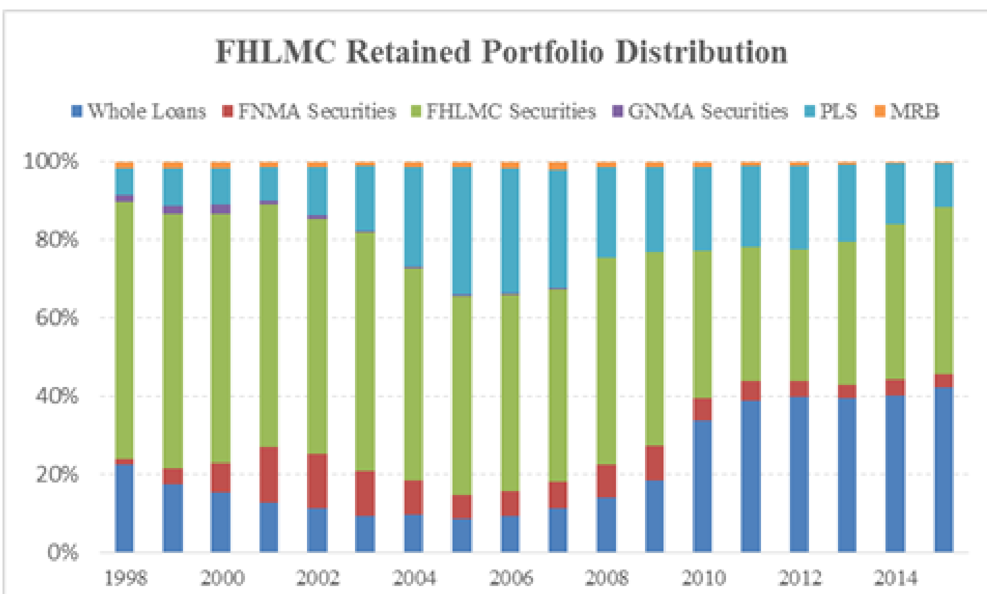


The figure compares the aggregate size of the GSE retained portfolios (for Fannie Mae and Freddie Mac) as reported by the FHFA/OFHEO annual reports to Congress (dotted line) and the Agency and GSE backed holdings of the GSEs as reported by the Federal Reserve flow of funds data (solid line). Within the portfolio reported by the FHFA/OFHEO annual reports to Congress the figure shows the composition by security type (Agency MBS, whole loans, private label MBS, and mortgage revenue bonds). The data are annual between 1998 and 2015.

Figure 3.8: The distribution of the GSEs' retained portfolios



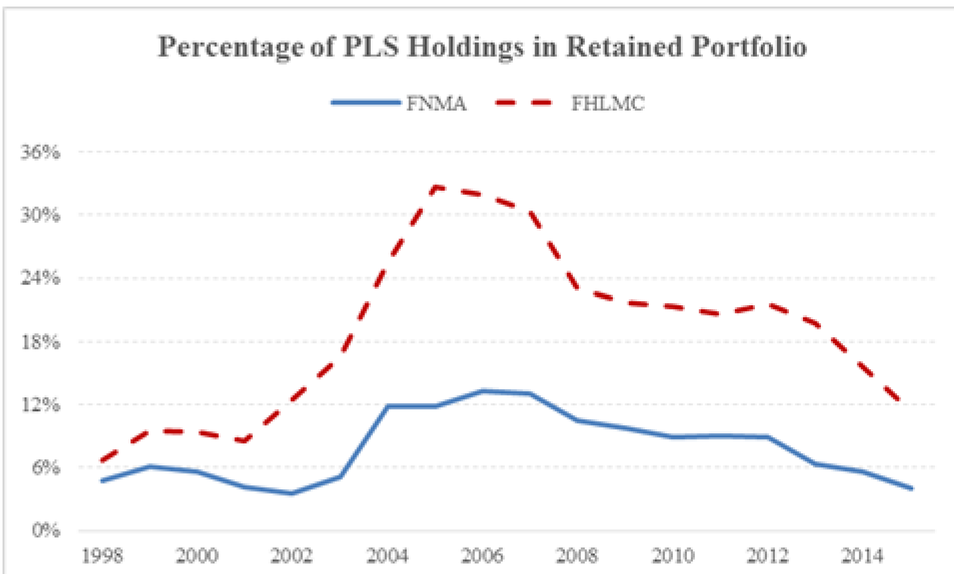
(a)



(b)

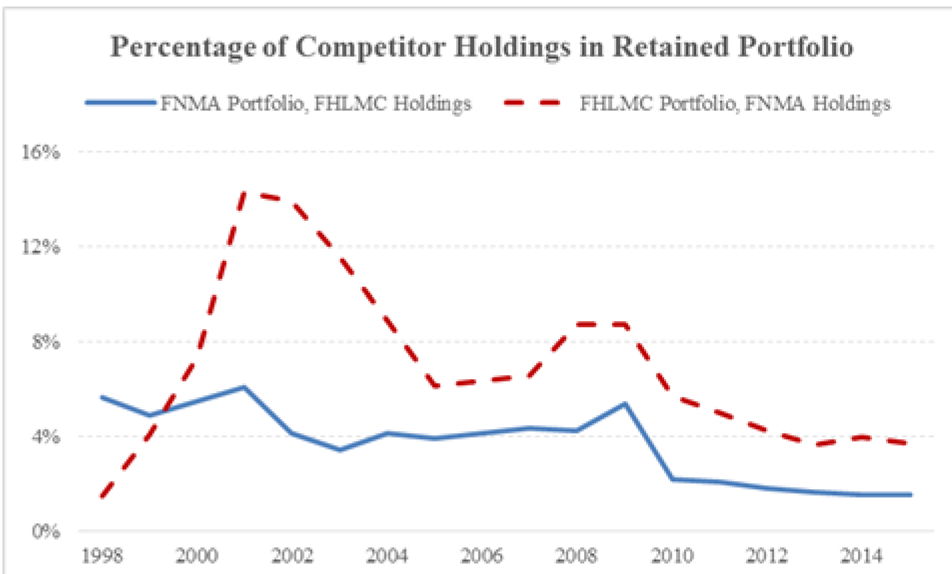
Figures A (Fannie Mae) and B (Freddie Mac) show the distribution of the holdings within their respective retained portfolios as reported by the FHFA/OFHEO annual reports to Congress. The data are annual between 1998 and 2015.

Figure 3.9: GSEs' PLS holdings



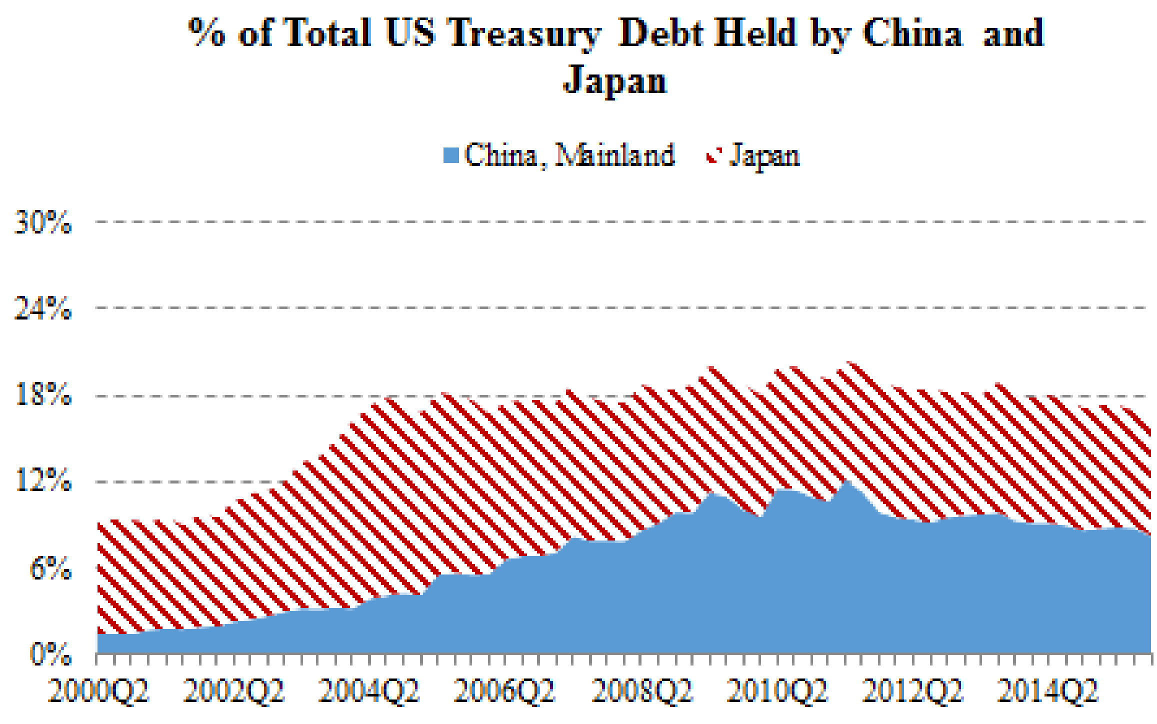
The figure shows the share of private label MBS held by Fannie Mae (solid line) and Freddie Mac (dotted line) in their retained portfolios as reported in the FHFA/OFHEO annual reports to Congress. The data are annual between 1998 and 2015.

Figure 3.10: GSEs' competitor MBS holdings



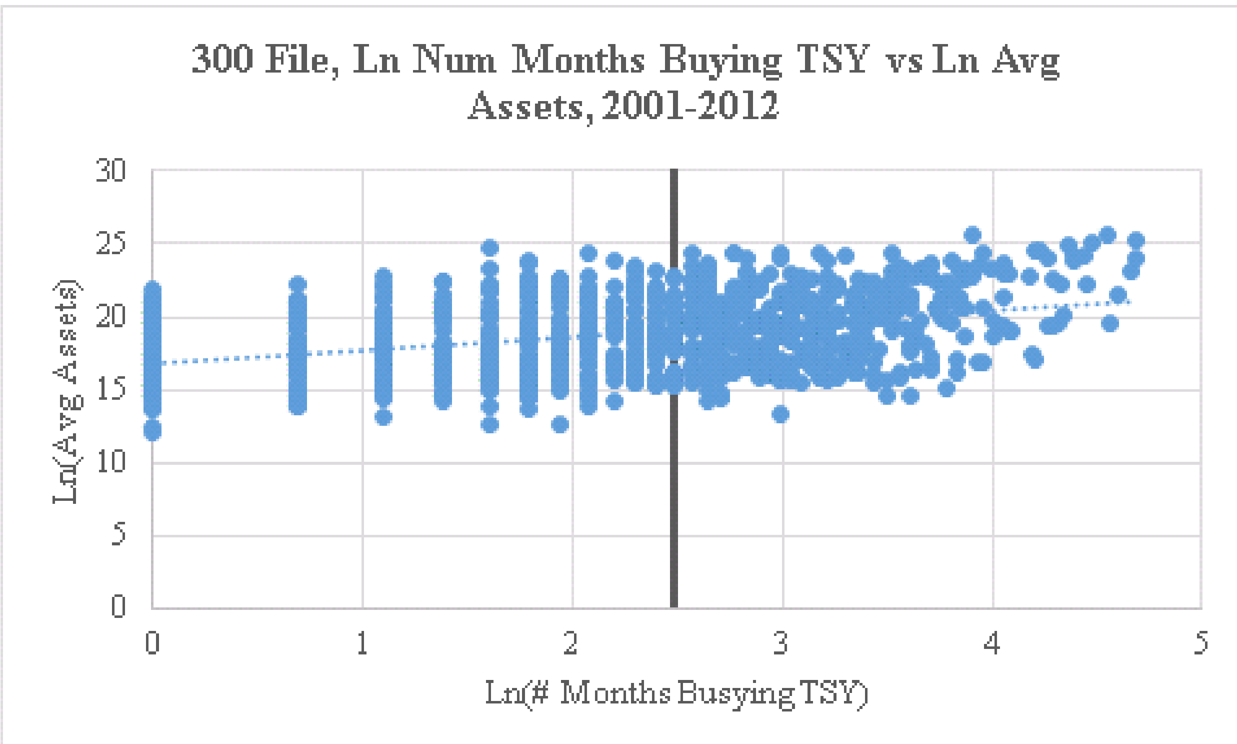
The share of competitor MBS held by Fannie Mae (solid line - shows holdings of Freddie Mac MBS held in Fannie Mae's retained portfolio) and Freddie Mac (dotted line - shows holdings of Fannie Mae MBS held in Freddie Mac's retained portfolio) as reported in the FHFA/OFHEO annual reports to Congress. The data are annual between 1998 and 2015.

Figure 3.11: US Treasury debt held by China and Japan



The figure shows the percentage of total outstanding US Treasury debt (from the Federal Reserve flow of funds data) held by mainland China and Japan as reported in the Treasury International Capital System (TIC) data. Data are quarterly between Q2 2000 and Q1 2016.

Figure 3.12: Life insurance assets



The figure shows data are from the 300 file (Schedule D, Part 1) from NAICS for life insurance companies. Data are reported annually from 2001 to 2012. Horizontal axis is the number of months that the firm bought Treasury securities (using the date acquired field) and the vertical axis is the average of the annual sum of the fair value of the assets the firm holds as of the year end. The vertical line is at the natural log of 12.

3.6 Tables

Table 3.1: Regressions measuring the effect of effective MBS duration on 10 year Treasury 12 month excess bond returns.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$BarDur_{t-12m}$	2.907***	2.776***		2.596**		2.589*	1.655		2.839***	
	(2.76)	(2.81)		(2.27)		(1.66)	(1.20)		(2.67)	
$EmpDur_{t-12m}$			1.596**		2.090**			1.058		1.138*
			(2.11)		(2.07)			(1.19)		(1.66)
Aug98-Jan99						-13.61***	-15.59***	-16.13***	-14.32***	-16.55***
						(-4.37)	(-5.20)	(-6.66)	(-5.98)	(-8.74)
Aug02-Jun03						2.755	-0.0503	-1.780	2.260	-2.184
						(0.64)	(-0.01)	(-0.70)	(0.74)	(-1.09)
QE1									3.742*	3.384
									(1.73)	(1.36)
QE2									10.13***	13.50***
									(8.00)	(9.17)
QE3									-7.625***	-4.464**
									(-4.67)	(-2.23)
Operation Twist									-2.754	-2.260
									(-1.31)	(-0.98)
Constant	-4.751	-4.170	0.00149	-4.010	-2.809	-4.219	-0.420	1.410	-3.991	1.688
	(-1.18)	(-1.14)	(0.00)	(-0.85)	(-0.67)	(-0.70)	(-0.07)	(0.36)	(-0.92)	(0.57)
# Obs	268	215	215	151	151	236	151	151	215	215
Date Range	Jan89-Apr11	Feb96-Dec13	Feb96-Dec13	Feb96-Aug08	Feb96-Aug08	Jan89-Aug08	Feb96-Aug08	Feb96-Aug08	Feb96-Dec13	Feb96-Dec13

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For MBS duration we use either Barclays effective duration or FNMA empirical duration. Barclays effective duration begins in January 1989, while the FNMA empirical duration series begins in February 1996. Both series have data through December 2013. The model is fitted on monthly data and standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The outlier threshold corresponds to values produced by the hat matrix, duration values from dates where the hat matrix value exceeded the threshold are removed. The regression model is: $rx_t^{(10)} = \alpha + \beta_1 \times Duration_{t-12m} + \epsilon_t^{(10)}$

Table 3.2: Regressions measuring the effect of MBS dollar duration (duration weighted by MBS market value) on 10 year Treasury 12 month excess bond returns.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\frac{BarDur_{t-12m}MBSMV_{t-12m}}{1,000,000}$	0.588***	0.379		0.521		0.248	0.176		0.506***	
	(3.06)	(1.53)		(1.64)		(0.87)	(0.76)		(3.14)	
$\frac{EmpDur_{t-12m}MBSMV_{t-12m}}{1,000,000}$			0.472**		0.361			0.126		0.325**
			(2.43)		(1.48)			(0.77)		(2.37)
Dates in Aug98-Jan99						-16.93***	-17.07***	-17.22***	-15.46***	-16.41***
						(-9.52)	(-8.85)	(-9.56)	(-8.22)	(-10.05)
Dates in Aug02-Jun03						-2.774	-2.938	-3.298*	-1.216	-2.740*
						(-1.41)	(-1.50)	(-1.96)	(-0.63)	(-1.74)
QE1									-0.226	1.564
									(-0.12)	(0.74)
QE2									6.432***	11.17***
									(3.37)	(8.02)
QE3									-10.33***	-6.512***
									(-5.44)	(-3.71)
Operation Twist									-6.272***	-3.366
									(-4.17)	(-1.63)
Constant	0.690	0.858	0.487	0.172	1.158	3.341	3.717	4.044*	1.028	2.628
	(0.32)	(0.32)	(0.22)	(0.05)	(0.39)	(1.31)	(1.44)	(1.83)	(0.44)	(1.35)
# Obs	268	215	215	151	151	236	151	151	215	215
Date Range	Jan89-Apr11	Feb96-Dec13	Feb96-Dec13	Feb96-Aug08	Feb96-Aug08	Jan89-Aug08	Feb96-Aug08	Feb96-Aug08	Feb96-Dec13	Feb96-Dec13

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For MBS duration we use either Barclays effective duration or FNMA empirical duration. MBS market value is provided by Barlcays and only includes GSE and Ginnie Mae MBS. Barclays effective duration begins in January 1989, while the FNMA empirical duration series begins in February 1996. Both series have data through December 2013. The model is fitted on monthly data and standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The outlier threshold corresponds to values produced by the hat matrix from the regression in Table 3.1, duration values from dates where the hat matrix value exceeded the threshold are removed. The regression model is: $rx_t^{(10)} = \alpha + \beta_1 \times \frac{MBSDuration_{t-12m} * MBSMV_{t-12m}}{1,000,000} + \epsilon_t^{(10)}$

Table 3.3: Regressions measuring the effect of MBS duration (weighted by the share of MBS market value to total fixed income market value) on 10 year Treasury 12 month excess bond returns.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$BarDur_{t-12m} \frac{MBSMV_{t-12m}}{AGGMV_{t-12m}}$	11.27***	10.08***		8.018**		10.22**	5.435		8.472***	
	(3.69)	(3.60)		(2.56)		(2.34)	(1.63)		(2.93)	
$EmpDur_{t-12m} \frac{MBSMV_{t-12m}}{AGGMV_{t-12m}}$			4.936**		5.947**			3.140		3.246*
			(2.17)		(2.20)			(1.42)		(1.74)
Dates in Aug98-Jan99						-12.37***	-14.94***	-15.89***	-13.69***	-16.38***
						(-4.11)	(-5.34)	(-6.95)	(-5.74)	(-8.71)
Dates in Aug02-Jun03						4.020	0.365	-1.776	2.300	-2.268
						(1.03)	(0.11)	(-0.78)	(0.80)	(-1.18)
QE1									2.953	3.114
									(1.49)	(1.30)
QE2									10.54***	13.62***
									(8.31)	(9.19)
QE3									-6.066***	-4.009*
									(-3.63)	(-1.84)
Operation Twist									-2.309	-2.282
									(-1.06)	(-0.99)
Constant	-7.179*	-6.188*	-0.251	-4.448	-2.638	-6.546	-1.103	1.339	-4.172	1.773
	(-1.85)	(-1.70)	(-0.08)	(-1.02)	(-0.68)	(-1.18)	(-0.23)	(0.39)	(-1.04)	(0.64)
# Obs	268	215	215	151	151	236	151	151	215	215
Date Range	Jan89-Apr11	Feb96-Dec13	Feb96-Dec13	Feb96-Aug08	Feb96-Aug08	Jan89-Aug08	Feb96-Aug08	Feb96-Aug08	Feb96-Dec13	Feb96-Dec13

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For MBS duration we use either Barclays effective duration or FNMA empirical duration. MBS and total fixed income market value (AGG) are provided by Barlcays. The MBS market value only includes GSE and Ginnie Mae MBS. Barclays effective duration begins in January 1989, while the FNMA empirical duration series begins in February 1996. Both series have data through December 2013. The model is fitted on monthly data and standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The outlier threshold corresponds to values produced by the hat matrix from the regression in Table 3.1, duration values from dates where the hat matrix value exceeded the threshold are removed. The regression model is: $rx_t^{(10)} = \alpha + \beta_1 \times MBSDuration_{t-12m} \frac{MBSMV_{t-12m}}{AGGMV_{t-12m}} + \epsilon_t^{(10)}$

Table 3.4: Regressions measuring the effect of MBS interest rate risk relative to aggregate interest rate risk (the ratio of MBS dollar duration to aggregate fixed income dollar duration) on 10 year Treasury 12 month excess bond returns.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\frac{BarDur_{t-12m}MBSMV_{t-12m}}{AggDur_{t-12m}AggMV_{t-12m}}$	59.68***	55.80***		42.13**		56.42**	28.42		42.03***	
	(3.48)	(3.57)		(2.48)		(2.33)	(1.64)		(2.66)	
$\frac{EmpDur_{t-12m}MBSMV_{t-12m}}{AggDur_{t-12m}AggMV_{t-12m}}$			21.87*		28.80**			14.31		12.85
			(1.81)		(2.08)			(1.37)		(1.41)
Dates in Aug98-Jan99						-11.54***	-14.67***	-15.97***	-13.58***	-16.73***
						(-3.61)	(-5.25)	(-7.33)	(-5.57)	(-9.16)
Dates in Aug02-Jun03						4.688	0.489	-2.131	2.106	-2.863
						(1.15)	(0.15)	(-1.04)	(0.72)	(-1.61)
QE1									2.247	2.745
									(1.13)	(1.16)
QE2									11.50***	13.74***
									(8.59)	(8.95)
QE3									-4.671**	-3.711
									(-2.39)	(-1.55)
Operation Twist									-1.896	-2.625
									(-0.81)	(-1.14)
Constant	-9.092**	-8.247**	-0.0403	-5.701	-3.042	-8.840	-1.939	1.380	-4.870	2.319
	(-2.01)	(-1.97)	(-0.01)	(-1.18)	(-0.74)	(-1.38)	(-0.38)	(0.41)	(-1.09)	(0.83)
# Obs	268	215	215	151	151	236	151	151	215	215
Date Range	Jan89-Apr11	Feb96-Dec13	Feb96-Dec13	Feb96-Aug08	Feb96-Aug08	Jan89-Aug08	Feb96-Aug08	Feb96-Aug08	Feb96-Dec13	Feb96-Dec13

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For MBS duration we use either Barclays effective duration or FNMA empirical duration. For aggregate fixed income duration we use the aggregate fixed income duration provided by Barclays. MBS and total fixed income market value (AGG) are provided by Barlcays. The MBS market value only includes GSE and Ginnie Mae MBS. Barclays effective duration begins in January 1989, while the FNMA empirical duration series begins in February 1996. Both series have data through December 2013. The model is fitted on monthly data and standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The outlier threshold corresponds to values produced by the hat matrix from the regression in Table 3.1, duration values from dates where the hat matrix value exceeded the threshold are removed. The regression model is: $rx_t^{(10)} = \alpha + \beta_1 \times \frac{MBSDuration_{t-12m} * MBSMV_{t-12m}}{AggDur_{t-12m} * AggMV_{t-12m}} + \epsilon_t^{(10)}$

Table 3.5: The effect of the GSE hedging portfolios on Treasury excess bond returns

	(1)	(2)	(3)	(4)	(5)
$BarclaysDur_{t-12m}$	2.640**			3.009**	
	(2.62)			(2.49)	
$EmpiricalDur_{t-12m}$		1.573*			1.710**
		(1.75)			(2.03)
$GSEHedgingPortfolio_{t-12m}$			1.610	3.026	2.178
			(0.97)	(1.63)	(1.34)
Constant	-3.117	0.778	2.624	-9.569	-3.409
	(-0.96)	(0.23)	(0.74)	(-1.41)	(-0.78)
# Obs	56	56	56	56	56

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of the regressions measuring the effect of the GSE hedging portfolios on 10 year Treasury 12 month excess bond returns. MBS duration is also included in columns 1, 2, 4, and 5. For MBS duration we use either Barclays effective duration or FNMA empirical duration. The GSE hedging portfolio data are quarterly and were retrieved from the historical FHFA (OFHEO prior to the creation of FHFA) reports to Congress. GSE hedging portfolio data are the sum of financial derivatives holdings of Fannie Mae and Freddie Mac. The data start in March 2000 and end in December 2013. Standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The regression model is: $rx_t^{(10)} = \alpha + \beta_1 \times HedgingPortfolio_{t-12m} + \beta_2 \times Duration_{t-12m} + \epsilon_t^{(10)}$

Table 3.6: The effect of changes in GSE hedging portfolios on Treasury excess bond returns

	(1)	(2)	(3)	(4)	(5)
$\Delta BarclaysDur_{t-12m,t}$	-2.256*			-2.014*	
	(-1.74)			(-1.68)	
$\Delta EmpiricalDur_{t-12m,t}$		-2.038*			-1.925*
		(-1.97)			(-1.71)
$\Delta GSEHedgingPortfolio_{t-12m,t}$			-1.484	-2.142	-1.222
			(-0.36)	(-0.51)	(-0.28)
Constant	-0.278	-0.525	-0.277	-0.355	-0.708
	(-0.13)	(-0.25)	(-0.12)	(-0.15)	(-0.30)
# Obs	52	52	48	48	48

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of the regressions measuring the effect of the 12 month change in GSE hedging portfolios on the 12 month change in 10 year Treasury 12 month excess bond returns. The 12 month change in MBS duration is also included in columns 1, 2, 4, and 5. For MBS duration we use either Barclays effective duration or FNMA empirical duration. The GSE hedging portfolio data are quarterly and were retrieved from the historical FHFA (OFHEO prior to the creation of FHFA) reports to Congress. GSE hedging portfolio data are the sum of financial derivatives holdings of Fannie Mae and Freddie Mac. The data start in March 2000 and end in December 2013. Standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The regression model is:

$$\Delta rx^{(10)}_{t+12m,t} = \alpha + \beta_1 \times \Delta GSEHedgingPortfolio_{t,t-12m} + \beta_2 \times \Delta Duration_{t,t-12m} + \epsilon^{(10)}_{t+12m,t}$$

Table 3.7: The effect of lagged MBS duration on Treasury holdings for banks that have never held interest rate derivatives in their non-trading accounts

	(1)	(2)	(3)	(4)	(5)	(6)
$Duration_{t-3m}$	-0.0291**	-0.00969	-0.0194**			
	(-2.52)	(-1.52)	(-2.34)			
$Duration_{t-12m}$				-0.00474	-0.000462	-0.00427
				(-0.48)	(-0.07)	(-0.67)
Constant	0.327***	0.126***	0.201***	0.230***	0.0971***	0.133***
	(7.85)	(5.48)	(6.73)	(6.42)	(4.34)	(5.74)
# Obs	355106	355106	355106	329828	329828	329828
R-squared	0.742	0.669	0.663	0.753	0.680	0.670
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month lagged MBS duration on the ratio of Treasury holdings to total assets at the bank level for banks that **have never** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use Barclays effective duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\frac{Treasuries_{t,i}}{Assets_{t,i}} = \alpha + \beta_1 \times Duration_{t-12m} + \mathbb{X}_i + \mathbb{Y}_{t-12m} + \epsilon_{t,i}$

Table 3.8: The effect of lagged MBS duration on Treasury holdings for banks that hold interest rate derivatives in their non-trading accounts

	(1)	(2)	(3)	(4)	(5)	(6)
$Duration_{t-3m}$	0.00242	-0.00762	0.0100			
	(0.39)	(-1.17)	(1.41)			
$Duration_{t-12m}$				0.000101	-0.000518	0.000618
				(0.03)	(-0.18)	(0.26)
Constant	0.161***	0.104***	0.0568**	0.163***	0.0824***	0.0809***
	(7.26)	(4.43)	(2.21)	(13.55)	(7.67)	(9.22)
# Obs	123155	123155	123155	115978	115978	115978
R-squared	0.688	0.639	0.588	0.701	0.650	0.603
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month lagged MBS duration on the ratio of Treasury holdings to total assets at the bank level for banks that **have** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use Barclays effective duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\frac{Treasuries_{t,i}}{Assets_{t,i}} = \alpha + \beta_1 \times Duration_{t-12m} + \mathbb{X}_i + \mathbb{Y}_{t-12m} + \epsilon_{t,i}$

Table 3.9: The effect of MBS duration on Treasury holdings for banks that have never held interest rate derivatives in their non-trading accounts

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta BarclaysDur_{t-3m,t}$	-0.00136	-0.0000401	-0.00132			
	(-0.61)	(-0.03)	(-1.00)			
$\Delta BarclaysDur_{t-12m,t}$				0.00645	-0.00215	0.00860
				(0.75)	(-0.66)	(1.19)
Constant	-0.00483***	-0.00110	-0.00373***	0.0137	0.0213***	-0.00758
	(-3.63)	(-1.18)	(-4.50)	(1.18)	(4.82)	(-0.78)
# Obs	346562	346562	346562	297776	297776	297776
R-squared	0.0425	0.0341	0.0404	0.115	0.0945	0.101
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month changes in MBS duration on the 12 month changes in the ratio of Treasury holdings to total assets at the bank level for banks that **have never** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use Barclays effective duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\Delta \frac{Treasuries_{t\to t+12m,i}}{Assets_{t\to t+12m,i}} = \alpha + \beta_1 \times \Delta Duration_{t-12m\to t} + \epsilon_{t\to t+12m,i}$

Table 3.10: The effect of MBS duration on Treasury holdings for banks that hold interest rate derivatives in their non-trading accounts

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta BarclaysDur_{t-3m,t}$	-0.00254	-0.00459*	0.00205			
	(-0.89)	(-1.78)	(1.03)			
$\Delta BarclaysDur_{t-12m,t}$				0.00107	-0.000664	0.00174
				(0.50)	(-0.28)	(1.22)
Constant	-0.00332*	-0.00303*	-0.000289	0.00285	0.0156***	-0.0127***
	(-1.88)	(-1.89)	(-0.22)	(0.92)	(4.63)	(-5.85)
# Obs	120754	120754	120754	106499	106499	106499
R-squared	0.0325	0.0275	0.0256	0.102	0.0877	0.0728
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month changes in MBS duration on the 12 month changes in the ratio of Treasury holdings to total assets at the bank level for banks that **have** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use Barclays effective duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\Delta \frac{Treasuries_{t\to t+12m,i}}{Assets_{t\to t+12m,i}} = \alpha + \beta_1 \times \Delta Duration_{t-12m\to t} + \epsilon_{t\to t+12m,i}$

Table 3.11: The effect of changes in Barclay's MBS duration on the percentage change in US Treasury holdings of mainland China and Japan

	(1)	(2)	(3)	(4)
$\Delta BarclaysDur_{t-12m,t}$	-0.0142	-0.00844	-0.0198	-0.0207
	(-0.66)	(-0.40)	(-0.75)	(-0.74)
$\Delta FX = 1USD_{t-12m,t}$		-0.00461**		-0.0977
		(-2.17)		(-0.35)
Constant	0.106**	0.105***	0.243***	0.228***
	(2.60)	(2.73)	(4.86)	(3.58)
# Obs	175	175	175	175
Country	Japan	Japan	China	China

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month changes in MBS duration on the 12 month percentage change in US Treasury holdings of mainland China and Japan. Change in FX rates are also included as a control in some specifications. Country level US Treasury holding data are from the Treasury International Capital (TIC) dataset. MBS duration is measured with Barclays effective duration. The data are monthly from June 2000 to December 2014. Standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The regression model is:
$\frac{\Delta TSYHoldings_{t,t+12m}}{TSYHoldings_t} = \alpha + \beta_1 \times \Delta Duration_{t-12m,t} + \beta_2 \times \Delta FXRate_{t-12m,t} + \epsilon_{t,t+12m}$

Table 3.12: The effect changes in FNMA empirical MBS duration on the change in US Treasury holdings of mainland China and Japan

	(1)	(2)	(3)	(4)
$\Delta EmpiricalDur_{t-12m,t}$	-0.0104	-0.00375	0.00153	0.000963
	(-1.06)	(-0.38)	(0.07)	(0.05)
$\Delta FX = 1USD_{t-12m,t}$		-0.00464**		-0.0886
		(-2.11)		(-0.31)
Constant	0.105***	0.104***	0.241***	0.229***
	(2.61)	(2.75)	(4.58)	(3.47)
# Obs	175	175	175	175
Country	Japan	Japan	China	China

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The table shows the coefficients of regressions measuring the effect of 12 month changes in MBS duration on the 12 month percentage change in US Treasury holdings of mainland China and Japan. Change in FX rates are also included as a control in some specifications. Country level US Treasury holding data are from the Treasury International Capital (TIC) dataset. MBS duration is measured with FNMA empirical duration. The data are monthly from June 2000 to December 2014. Standard errors are Newey West with 18 lags to account for the overlapping structure of the data. The regression model is:

$$\frac{\Delta TSYHoldings_{t,t+12m}}{TSYHoldings_t} = \alpha + \beta_1 \times \Delta Duration_{t-12m,t} + \beta_2 \times \Delta FXRate_{t-12m,t} + \epsilon_{t,t+12m}$$

Table 3.13: The effect of MBS duration on the percentage of assets held in Treasury bonds by mutual funds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$BarclaysDur_{t-3m}$	4.101***		7.623***					
	(12.37)		(18.12)					
$BarclaysDur_{t-12m}$		3.971***		7.382***				
		(12.37)		(18.12)				
$EmpiricalDur_{t-3m}$					10.17***		18.90***	
					(12.37)		(18.12)	
$EmpiricalDur_{t-12m}$						7.059***		13.12***
						(12.37)		(18.12)
Constant	-12.81***	-14.58***	-20.91***	-24.20***	-23.98***	-21.00***	-41.67***	-36.14***
	(-7.78)	(-8.14)	(-10.07)	(-10.72)	(-9.40)	(-9.09)	(-12.94)	(-12.40)
# Obs	1071732	1071732	310364	310364	1071732	1071732	310364	310364
R-squared	0.704	0.704	0.708	0.708	0.704	0.704	0.708	0.708
Lag on Duration	3m	12m	3m	12m	3m	12m	3m	12m
Only Funds with MBS Positions?	N	N	Y	Y	N	N	Y	Y
Duration Measure	Barclays	Barclays	Barclays	Barclays	Empirical	Empirical	Empirical	Empirical

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regressions measuring the effect of MBS duration on the percentage of assets held in Treasury bonds by mutual funds. Mutual fund data are from CRSP and are quarterly from Q1 1999 to Q4 2014. MBS duration is either Barclays effective duration or FNMA empirical duration. Standard errors are clustered at the mutual fund level. Models with a 3 month and a 12 month lag of duration are estimated. The regression model is: $PerGovtBonds_{t,i} = \alpha + \beta_1 \times Duration_{t-j} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t,i}$

Table 3.14: The effect of the change in MBS duration on the change in the percentage of assets held in Treasury bonds by mutual funds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta BarclaysDur_{t-3m,t}$	-0.197***		-0.285***					
	(-5.31)		(-5.43)					
$\Delta BarclaysDur_{t-12m,t}$		-0.636***		-0.760***				
		(-4.72)		(-4.17)				
$\Delta EmpiricalDur_{t-3m,t}$					-0.236***		-0.342***	
					(-5.31)		(-5.43)	
$\Delta EmpiricalDur_{t-12m,t}$						-0.581***		-0.694***
						(-4.72)		(-4.17)
Constant	-0.0987***	-0.897***	-0.0833**	-1.132***	-0.254***	-1.341***	-0.307***	-1.662***
	(-3.72)	(-5.26)	(-2.14)	(-5.02)	(-4.99)	(-5.10)	(-4.54)	(-4.79)
# Obs	1056324	1009643	308625	303095	1056324	1009643	308625	303095
R-squared	0.0856	0.190	0.208	0.324	0.0856	0.190	0.208	0.324
Lag on Delta Tsy Holdings	3m	12m	3m	12m	3m	12m	3m	12m
Only Funds with MBS Positions?	N	N	Y	Y	N	N	Y	Y
Duration Measure	Barclays	Barclays	Barclays	Barclays	Empirical	Empirical	Empirical	Empirical

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regressions measuring the effect of the change in MBS duration on the change in the percentage of assets held in Treasury bonds by mutual funds. Mutual fund data are from CRSP and are quarterly from Q1 1999 to Q4 2014. MBS duration is either Barclays effective duration or FNMA empirical duration. Standard errors are clustered at the mutual fund level. Models with a 3 month and a 12 month change are estimated. The regression model is: $\Delta PerGovtBonds_{t\to t+j,i} = \alpha + \beta_1 \times \Delta Duration_{t-j\to t} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t\to t+j,i}$

Table 3.15: The effect of lagged Barclays MBS duration on life insurance firms' Treasury holdings.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$BarclaysDuration_{t-1m}$	-0.695***			-0.762***	-1.324***	-0.582***	-0.236***	-0.532***	-0.545***
	(-7.24)			(-4.06)	(-8.02)	(-7.12)	(-3.21)	(-3.63)	(-3.81)
$BarclaysDuration_{t-6m}$		-0.157***							
		(-7.24)							
$BarclaysDuration_{t-12m}$			-0.0979***						
			(-7.24)						
Constant	2.184***	0.744***	0.526***	2.372***	4.123***	1.794***	0.767***	1.696***	1.732***
	(7.72)	(8.81)	(9.64)	(4.26)	(8.50)	(7.40)	(3.54)	(3.90)	(4.09)
# Obs	119402	119402	119402	27741	49917	119402	119402	76988	78867
R-squared	0.168	0.168	0.168	0.0398	0.134	0.126	0.139	0.183	0.184
Years	All	All	All	All	All	All	All	2001-2007	2001-2007
Num Mo With TSY Trade	All	All	All	≤ 12	>12	All	All	All	All
File	300	300	300	300	300	300	300	300	303/304
TSY Maturity	All	All	All	All	All	STN	LTD	LTD	All

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regressions estimate a linear probability model of the probability of life insurance firms buying Treasuries due to lagged MBS duration. Life insurance holding data are from NAICS and are monthly from 2001 to 2012. MBS duration is Barclays effective duration. Firm and monthly time fixed effects are also included. Standard errors are clustered at the firm level. Models with 1, 6, and 12 month lags on the MBS duration variable are estimated. The regression model is: $\mathbb{1}_{t,i} = \alpha + \beta_1 \times Duration_{t-j} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t,i}$

Table 3.16: The effect of lagged FNMA empirical MBS duration on life insurance firms' Treasury holdings.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$EmpiricalDuration_{t-1m}$	-0.0588***			-0.0645***	-0.112***	-0.0493***	-0.0199***	-0.158***	-0.161***
	(-7.24)			(-4.06)	(-8.02)	(-7.12)	(-3.21)	(-3.63)	(-3.81)
$EmpiricalDuration_{t-6m}$		-0.0367***							
		(-7.24)							
$EmpiricalDuration_{t-12m}$			-0.0484***						
			(-7.24)						
Constant	0.316***	0.280***	0.295***	0.322***	0.563***	0.228***	0.133***	0.678***	0.690***
	(12.07)	(13.01)	(12.58)	(5.93)	(13.01)	(9.80)	(6.63)	(4.40)	(4.58)
# Obs	119402	119402	119402	27741	49917	119402	119402	76988	78867
R-squared	0.168	0.168	0.168	0.0398	0.134	0.126	0.139	0.183	0.184
Years	All	All	All	All	All	All	All	2001-2007	2001-2007
Num Mo With TSY Trade	All	All	All	≤ 12	>12	All	All	All	All
File	300	300	300	300	300	300	300	300	303/304
TSY Maturity	All	All	All	All	All	STN	LTD	LTD	All

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regressions estimate a linear probability model of the probability of life insurance firms buying Treasuries due to lagged MBS duration. Life insurance holding data are from NAICS and are monthly from 2001 to 2012. MBS duration is FNMA empirical duration. Firm and monthly time fixed effects are also included. Standard errors are clustered at the firm level. Models with 1, 6, and 12 month lags on the MBS duration variable are estimated. The regression model is: $\mathbb{1}_{t,i} = \alpha + \beta_1 \times Duration_{t-j} + \mathbb{X}_i + \mathbb{Y}_{t-j} + \epsilon_{t,i}$

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Appendix A

Appendix Tables

Table A.1: Regressions measuring the effect of 12 month lagged MBS duration on the ratio of Treasury holdings to total assets at the bank level for banks that **have never** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use FNMA empirical duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\frac{Treasuries_{t,i}}{Assets_{t,i}} = \alpha + \beta_1 \times Duration_{t-12m} + \epsilon_{t,i}$

	(1)	(2)	(3)
$Duration_{t-12m}$	-0.00714	-0.00151	-0.00563
	(-0.99)	(-0.32)	(-1.27)
Constant	0.240***	0.101***	0.139***
	(8.64)	(5.54)	(8.12)
# Obs	329828	329828	329828
R-squared	0.753	0.680	0.670
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.2: Regressions measuring the effect of 12 month changes in MBS duration on the 12 month changes in the ratio of Treasury holdings to total assets at the bank level for banks that **have never** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use FNMA empirical duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\Delta \frac{Treasuries_{t \to t+12m,i}}{Assets_{t \to t+12m,i}} = \alpha + \beta_1 \times \Delta Duration_{t-12m \to t} + \epsilon_{t \to t+12m,i}$

	(1)	(2)	(3)
$\Delta Duration_{t-12m,t}$	-0.00604*	0.000795	-0.00684**
	(-1.67)	(0.29)	(-2.12)
Constant	-0.00594	0.0256***	-0.0315***
	(-0.89)	(5.04)	(-5.38)
# Obs	297776	297776	297776
R-squared	0.115	0.0945	0.101
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Regressions measuring the effect of 12 month lagged MBS duration on the ratio of Treasury holdings to total assets at the bank level for banks that **have** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use FNMA empirical duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\frac{Treasuries_{t,i}}{Assets_{t,i}} = \alpha + \beta_1 \times Duration_{t-12m} + \epsilon_{t,i}$

	(1)	(2)	(3)
$Duration_{t-12m}$	-0.00165	-0.00341	0.00175
	(-0.29)	(-0.84)	(0.44)
Constant	0.170***	0.0937***	0.0763***
	(7.68)	(6.00)	(4.97)
# Obs	115978	115978	115978
R-squared	0.701	0.650	0.603
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Regressions measuring the effect of 12 month changes in MBS duration on the 12 month changes in the ratio of Treasury holdings to total assets at the bank level for banks that **have** held interest rate derivatives in their non-trading accounts. The bank level data are retrieved from the bank call reports and are quarterly from June 1997 to December 2013. For MBS duration we use FNMA empirical duration. Bank and time fixed effects are also included. Standard errors are clustered at the bank level (rssd9001). The regression model is: $\Delta \frac{Treasuries_{t\to t+12m,i}}{Assets_{t\to t+12m,i}} = \alpha + \beta_1 \times \Delta Duration_{t-12m\to t} + \epsilon_{t\to t+12m,i}$

	(1)	(2)	(3)
$\Delta Duration_{t-12m,t}$	-0.000397	-0.000174	-0.000224
	(-0.20)	(-0.12)	(-0.13)
Constant	0.000703	0.0162***	-0.0154***
	(0.18)	(5.74)	(-4.57)
# Obs	106499	106499	106499
R-squared	0.102	0.0877	0.0728
Maturity of Dep Variable	All	$> 3yrs$	$\leq 3yrs$

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Regressions measuring the effect of 3 month changes in MBS duration on the 3 month percentage change in US Treasury holdings of mainland China and Japan. Change in FX rates are also included as a control in some specifications. Country level US Treasury holding data are from the Treasury International Capital (TIC) dataset. MBS duration is measured with Barclays effective duration. The data are monthly from June 2000 to December 2014. Standard errors are Newey West with 3 lags to account for the overlapping structure of the data. The regression model is: $\frac{\Delta TSYHoldings_{t,t+12m}}{TSYHoldings_t} = \alpha + \beta_1 \times \Delta Duration_{t-12m,t} + \beta_2 \times \Delta FXRate_{t-12m,t} + \epsilon_{t,t+12m}$

	(1)	(2)	(3)	(4)
$\Delta BarclaysDur_{t-3m,t}$	-0.00129	0.00609	0.00317	0.00345
	(-0.20)	(1.05)	(0.42)	(0.46)
$\Delta FX = 1USD_{t-3m,t}$		-0.00405***		0.0230
		(-4.08)		(0.19)
Constant	0.0228***	0.0239***	0.0529***	0.0536***
	(3.71)	(4.26)	(5.63)	(5.12)
# Obs	182	182	182	182
Country	Japan	Japan	China	China

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$