Shadow Banks and Balance Sheets

Greg Buchak, Gregor Matvos, Tomasz Piskorski and Amit Seru*

This Version: JUNE 2018

Abstract

Shadow banks account for substantial share of financial intermediation activity. In the $10 trillion US residential mortgage market, they account for more than half of new lending. Using micro data from this market, we document a large degree of market segmentation in the penetration of shadow banks: they substitute for the decline in traditional banking activity in the conforming market but are unable to do so in the jumbo market. The lack of substitutability and resulting market segmentation seems to arise because some intermediation activities require on-balance sheet financing, which only traditional—deposit taking—banks have. The amount of balance sheet capacity in this market is related to bank capitalization; banks endogenously seem to change their financing and business model to behave more like shadow banks when they are poorly capitalized. Motivated by this evidence, we build a new structural model of credit market which features strategic interaction between traditional and shadow banks, and shows how different models of financing shape outcomes. We estimate this model, and study impact of policies such as capital requirements, conforming credit limits, and unconventional monetary policy. All of these policies lead to significant changes in the equilibrium quantity, pricing, and distribution of mortgage credit. Moreover, the endogenous choice of banks' financing highlights how these policies affect the amount of loans on balance sheets, and, therefore bank stability. Importantly, we find that strategic response of the shadow bank sector in response to such policies impacts the nature and magnitude of these effects, accounting for as much as 70 percent of the aggregate response. Ignoring the feedback between banks and shadow banks, and solely focusing on bank data can therefore both severely underestimate or overestimate the effects depending on a specific policy. Finally, we illustrate that such interventions in the intermediation market that is segmented can have significant redistributional consequences. Our work suggests that a complete quantitative policy analysis of the credit market critically requires analyzing simultaneously the impact of the policy on banks and shadow banks, and accounting for their equilibrium interaction.

Keywords: Fintech, Shadow Banks, Regulatory Arbitrage, Lending, Mortgages, FHA

---

* Buchak is with the University of Chicago (buchak@uchicago.edu), Matvos is with the McCombs School of Business, University of Texas at Austin and NBER (Gregor.Matvos@mccombs.utexas.com), Piskorski is with Columbia Graduate School of Business and NBER (tp2252@gsb.columbia.edu), and Seru is with Stanford GSB, the Hoover Institution, SIEPR and NBER (aseru@stanford.edu). We thank Susan Cherry, Monica Clodius, and Sam Liu for outstanding research assistance, and the participants of the SITE Financial Regulation conference.

First Version: February 2018.

Section I: Introduction

Policy makers, as well as researchers have commonly viewed deposit taking institutions—traditional banks—as the main supplier of loans to households and firms. As a result, when thinking about stability of credit provision, they have largely focused on regulation and supervision of activities on the asset and liability sides of the banks' balance sheet. However, a large share of intermediation activity has moved to shadow banks (Buchak et al. 2017). In the $10 trillion US residential mortgage market, shadow banks now account for the majority of new lending. In this paper, we document that shadow banks substitute for traditional banks in some markets, but not in other markets. We try to understand reasons for the lack of substitutability in some markets and argue that it arises because some intermediation activities require on-balance sheet financing, lending an advantage to deposit taking institutions. We illustrate that ignoring differences in endogenous substitutability between banks and shadow banks alters the equilibrium quantity and price of credit resulting from different policies and impacts inferences on bank stability as well as on distributional consequences.

We start by documenting a series of new facts related to two main residential mortgage market segments in the US: the conforming market and the jumbo market. These two segments account for the vast majority of residential mortgages originated during our sample period (2007 to 2016). The conforming loan market is the largest residential market segment and consists of mortgages with balances below the conforming loan limit. Mortgages which exceed the conforming limit are termed "jumbo." Conforming loans are issued with the participation of government sponsored enterprises (GSEs), which facilitates their securitization. Because jumbo mortgages are ineligible for GSE financing, they are issued without government guarantees and are significantly more difficult to securitize. Indeed, unlike conforming loans, the vast majority of jumbo loans are retained on the lenders' balance sheets.

We first document large swings in the share of jumbo mortgage originations during this period. The share of jumbo originations declined precipitously—29% to 10%—from 2007 to 2009 relative to conforming mortgages, only to reverse back to 30% by 2016. Second, we document that these market swings coincided with a dramatic increase in the share of residential mortgages originated by shadow banks. Consistent with Buchak et al (2017), we find that the share of conforming mortgages originated by shadow banks grew from less than 20% in 2008 to almost 50% by 2015. The market for jumbo mortgages, on the other hand, saw little penetration of shadow banks, despite large declines in the quantity of lending by traditional banks, with the market share of traditional banks persisting well above 80%.

These results suggest that market segmentation occurs because traditional banks and shadow banks differ in their ability to extend jumbo and conforming mortgages. We argue that the comparative advantage of traditional banks arises from their ability to hold these loans on their balance sheets. To separate this explanation from alternatives, we examine the market share of shadow banks around the conforming loan size limit. One would imagine that borrowers' demand for banking services would increase continuously with mortgage size, as mortgages transition from conforming to jumbo. The ability to securitize a mortgage, on the other hand, discontinuously drops at the conforming loan amount. We find a 10 percentage point (pp) sharp increase in banks' market share at the conforming limit. In other words, our results suggest that jumbo and conforming markets are segmented, with traditional banks holding an advantage in the jumbo sector relative to the conforming sector.

To show that balance sheet capacity is related to market segmentation, we look within the banking sector itself. We show that better capitalized banks, those with larger balance sheet capacity, are more likely to hold loans on their balance sheet. As banks' capitalization increases, so does the share of originations they hold on the balance sheet. Moreover, well capitalized banks' market share jumps by over 10% at the conforming limit. These result points to market segmentation within traditional banking sector between well and poorly capitalized banks: well capitalized banks are more likely to retain larger fraction of their loans and specialize in the segment of loans that are harder to securitize. They also suggest that banks business models are adaptable. Banks, which are flush with capital, behave as standard models of banking would suggest: they use deposits to extend loans which they hold on their balance sheets. However, as a bank's balance sheet capacity declines, it switches to originating mortgages, which it can sell, behaving more like a shadow bank.

In addition to the changes in the market share of mortgages, we also document large changes in the relative pricing of jumbo mortgages relative to conforming mortgages. While jumbo loans are generally more expensive, the relative price differential experiences a significant variation during our sample period. In particular, the relative price of jumbo mortgages increased by almost 40 basis points on average from 2007 to 2009, and then declined by up to around 60 basis points from 2009 to 2014. The contemporaneous decrease in quantity and increase in price suggests a negative supply shock to jumbo mortgages during the 2007 to 2009 period. In other words, our evidence suggests that the decline in the jumbo share during this period does not only reflect lower demand for jumbo loans due to the decline in house prices and temporary increases in conforming loan limits that also occurred during this time. To lend further support to this view, we show that jumbo spread evolves with the aggregate relative capitalization of lenders in the jumbo and conforming sector. The balance sheet driven market segmentation appears to be also an important determinant of aggregate mortgage prices.

Together, these facts provide a consistent view of the role of banks and shadow banks in the mortgage market. Banks' advantage lies in originating mortgages on their balance sheet, and their balance sheet capacity is limited by their capitalization. This advantage implies that traditional banks dominate the jumbo mortgage segment where it is harder to securitize loans and compete with shadow banks in the conforming market. More capitalized banks endogenously shift their business model towards more balance sheet retention, and towards jumbo market segment. Shadow banks, on the other hand, benefit from a lower regulatory burden and mainly focus on the originate-to-distribute (OTD) conforming market. Such specialization implies that shocks and interventions, which affect only one type of lender, spill over to other lenders. Moreover, because markets are segregated, interventions have redistribution consequences, and affect bank stability. For example, tightening capital requirements on banks may decrease the supply of jumbo mortgages, and could increase the supply of conforming mortgages. Moreover, mortgage risk could shift from bank balance sheets to GSEs. Because of the expansion of off-balance sheet lending, this increase in bank stability might have small effect on overall mortgage volume, which would primarily be borne for highest income borrowers. In other words, this policy would have strong redistributional consequences.

To quantitatively analyze these effects in equilibrium, we build and estimate a model of the US residential mortgage market. The goal of the model is to capture the interaction of traditional and shadow banks across mortgage markets, and to allow banks to choose not which mortgages to originate, but to choose how much to originate on balance sheet versus securitize. We capture the redistributive consequences and accommodate realistic consumer substitution patterns by allowing rich heterogeneity on the demand side following Berry et al (1995) and Nevo (2000). Consumers with heterogeneous preferences over price, quality, and mortgage size choose among a menu of mortgages offered by various types of originators. Importantly, consumers *choose* their mortgage size, and consequently, decide whether they want a conforming or jumbo mortgage.

We separately estimate demand and supply parameters. We instrument for price endogeneity in demand estimation by exploiting an institutional feature of how GSEs set prices of conforming mortgages across regions. Moreover, we use micro moments from the conforming limit discontinuity directly in the demand estimation. We estimate supply side parameters using firm price setting and financing decisions. We show that our model captures the salient features of the data and allows us to evaluate the consequences of alternative regulatory policies.

We next use our estimate model to consider four policy relevant counterfactuals. First, we study the impact of stricter capital requirements and other regulatory constraints on the types and prices of mortgages originated. Second, we consider the impact of weak or strong bank capitalization. Third, we study the impact of the GSE conforming loan limit to investigate how the presence of available but restricted GSE credit has impacted shadow bank growth, loan pricing, and the types of mortgage products that banks offer. Fourth, we study the impact of unconventional monetary policy on the mortgage market equilibrium.

In all cases, we find that capital requirements, bank capitalization, GSE restrictions, and unconventional monetary policy lead to significant changes in the quantity, pricing, and distribution of mortgage credit, as well as determining where the credit risk in the economy is held. Importantly, we demonstrate that the strategic response of the shadow bank sector plays an important role in the *nature* and *magnitude* of these effects, accounting for more than 70 percent of the aggregate response in some cases. Endogenous changes in the business model of traditional banks in response to these factors play also an important role in determining these effects. We illustrate that ignoring the differences between banks and shadow banks, and solely focusing on bank data can both severely *underestimate* or *overestimate* the effects depending on specific policy. Finally, we also find that interventions which affect only one type of lender have significant redistribution consequences.

More broadly, our paper speaks to the theories of banking in the presence of shadow banks. The traditional view of banks is that they use deposits to make loans, which they hold on their balance sheet. As is now well known, banks have been moving towards the originate-to-distribute model, in which they originate loans that are then securitized (see Keys et al. 2013). Our results suggest that the choice of business model of banks depends on both their capitalization and their equilibrium interaction with shadow banks. We show that the choice of banks' business model is fluid, and depends on their balance sheet capacity. On one end of the spectrum are well capitalized banks, which dominate the market for loans that are held on the balance sheet. At the other end of the spectrum are shadow banks, which originate to distribute. In the middle are poorly capitalized banks with limited balance sheet capacity, whose participation in the market for portfolio loans is limited. Our results also imply that the worsening of a bank's capitalization is partially alleviated by the ability of the bank to move to the originate-to-distribute model and by expansion of shadow bank lending.

Section II: Related Literature

Our paper is most closely related to other studies that have examined the changing nature of mortgage origination in the United States. The wake of the financial crisis saw increased interest in the functioning and impact of the originate-to-distribute model, which was seen to contribute significantly to the recent housing crisis. In particular, papers have focused on the originate-to-distribute model and its costs and benefits. See, for example, Berndt and Gupta (2009), Mian and Sufi (2009), Piskorski et al. (2010), Keys et al. (2010) and (2013), Purnanandam (2011), Bord and Santos (2012), Piskorski et al. (2015). In addition to the originate-to-distribute model specifically, the increased amount of bank-like activity taking place outside the traditional banking system has attracted increased attention. Buchak et al. (2017) provide a comprehensive analysis of the recent dramatic growth of shadow banks and fintech lenders in the residential mortgage market and find that the regulatory burden faced by traditional banks and growth of financial technology can account, respectively, for about 70% and 30% of the recent shadow bank growth. Fuster et al. (2018) provide related analysis, suggesting that fintech lenders may adjust supply more elastically than other lenders in response to exogenous mortgage demand shocks, thereby alleviating capacity constraints associated with traditional mortgage lending. In contrast, our paper focuses particularly on what has driven the originate-to-distribute model following the crisis, and how it has impacted the structure of the mortgage market both in segments where originate-to-distribute is common and in segments where it is less common. In doing so, we develop and use a structural model of the US mortgage market to assess the role of capital requirements, bank capitalization, government credit subsidies, and unconventional monetary policy on the overall distribution of mortgage credit across US borrowers and the relative pricing of loans.

Our paper is also related to the literature on the GSEs.[1] The analysis in this paper focuses particularly on how GSE financing and the types of products that GSEs are allowed to finance, in conjunction with recent regulatory and bank capital changes, has contributed to shadow bank growth and increased specialization in the mortgage market. In particular, we study how market segmentation arises out of the particular rules of the GSE market interacting with lender capital availability and bank capital regulation, and how it affects overall origination volume, distribution of credit across borrowers, and relative pricing of products.

Our paper also connects to a large literature that examines the impact of government regulations and various policy interventions adopted during and after the financial crisis on banking. See, for example, Mayer et al. 2014, Haughwout et. al. 2016, Agarwal et al. 2015 and 2017). Like Agarwal et. al. (2014), Lucca et. al. (2014), Granja et al. (2014), Piskorski et al (2015), Fligstein and Roehrkasse (2016), Di Maggio et al. (2016, 2017), Gete and Reher (2017). Within this literature, Buchak et al. (2017) analyze the role of regulation and bank capital constraints in driving the recent growth of shadow bank lending in the US mortgage market. Benetton (2018) provides an analysis of the impact of bank capital regulation on the UK residential mortgage market. Our paper focuses, instead, on the role of shadow banks and their interplay with traditional banks for the credit market equilibrium. In doing so, we assess the effects of alternative polices, including changes in bank capital requirements, government credit subsidies, and unconventional monetary policy, and find that all of these factors lead to significant changes in the equilibrium quantity, pricing, and distribution of mortgage credit. Importantly, we demonstrate that the shadow bank sector plays an important role in the nature and magnitude of these effects.

Our paper is also related to a growing literature using tools for consumer demand estimation in the context of consumer finance. Our model follows the form of consumer demand models like Berry et al. (1995) and described in detail in Nevo (2000), and applies these modeling techniques for the purpose of answering regulatory and policy questions in finance. Egan, Hortacsu, and Matvos (2017), for example, study banking competition and financial fragility through the context of a structural model of demand for bank deposits, and Egan, Lewellen, and Sunderam (2017) structurally decompose the sources of bank value.[2] Buchak et al. (2017) use a structural framework to analyze the drivers of the recent growth of shadow bank and fintech lenders in the US residential mortgage market. Benetton (2018) uses a structural framework to analyze the impact of bank capital regulation on the UK residential mortgage market. Our paper uses similar tools to answer fundamentally different questions. In particular, we decompose changes in the supply and demand in mortgage markets and study the drivers of supplier specialization and market segmentation. This

---

[1] Following the financial crisis and the collapse of the private securitization market, GSE securitizations and their accompanying guarantees have dominated mortgage securitization and consequently the organization of the overall residential mortgage market. GSEs were originally established to affect the political goal of promoting housing ownership, particularly in underserved and underbanked areas. Many papers, e.g., Acharya et al. (2011), Bhutta (2012), Hurst et al (2016), Elenev et al. (2016), have studied how successful GSEs have been in affecting these goals and have found mixed results.

[2] See also Cox (2017) who develops a structural model of the borrowers' repayment preferences in the student loan market and uses it to measure the overall gains in consumer surplus from risk-based pricing.

allows us to study the overall quantity, pricing, and distribution of mortgage credit distribution of mortgage credit across borrowers, which distinguishes our paper from prior work in this area.

Our paper is also connected to recent quantitative equilibrium models of mortgage and housing markets with heterogonous agents (e.g., Favilukis, Ludvingson, Van Nieuwerburgh 2016; Kaplan, Mitman, and Violante 2016; Greenwald, Landvoigt, and Van Nieuwerburgh 2017; Guren, Krishnamurty, and McQuade 2017). Such models can provide many valuable insights, including the quantitative assessment of various effects. There are two key differences between our paper and this literature. First, we differ in terms of methodology. Unlike other papers that use computational tools developed in the quantitative macroeconomics literature, we follow the structural industrial organization literature and build a credit market framework with supply and demand functions that can be directly estimated on micro-level data. Second, our focus is different. In particular, our paper aims to assess the implications for the credit market outcomes of the organizational structure of the lending market, including the differences in the lender capital, regulatory barriers, and the role of shadow banks and their interplay with traditional banks.

Finally, our paper is related to the recent work focusing on various forms of bank-like activities taking place outside the traditional banking system and studding the implications of such shifts (see Gennaioli, Shleifer, and Vishny 2013 and Ordonez 2018 for models of shadow banking and Adrian and Ashcraft (2016) for an exhaustive summary). Among this recent work, Kojin and Yogo (2016) analyze the implications of reinsurance market that allows regulated life insurance companies to move some of their liabilities to shadow reinsures. Dreschler et al. (2017) and Xiao (2017) show that when the Fed funds rate rises, banks widen the spreads they charge on deposits, and deposits flow out of the banking system towards the uninsured shadow banking sector, affecting the transmission of monetary policy. In this regard we contribute to this emerging literature by recognizing the central role of shadow banks in the lending market and study their implications for the quantity, price, and allocation of mortgage credit as well as their their interaction with various polices.

III: Institutional Setting and Data

III.A US Residential Mortgage Market

The residential mortgage market is the largest consumer finance market in the US. There are currently more than 50 million residential properties that have a mortgage with a combined outstanding debt of about $10 trillion (Source: Corelogic Data). In the US, the process by which a mortgage is secured by a borrower is called origination. This involves the borrower submitting a loan application and documentation related to his or her financial history and/or credit history to the lender. We discuss the main segments of the US residential mortgage market and the associated lenders active in these markets below.

III.A.1 Banks, Shadow Banks, and Business Models

There are two main groups of mortgage originators in the US: banks and shadow banks (non-bank lenders). These originators differ on at least three dimensions. First, banks (traditional banks and credit unions) rely on their insured deposit base as part of their capital. Shadow banks do not take deposits. Second, they differ in terms of their business models. After originating a loan, the originator can keep the loan on their balance sheet as a portfolio loan. Alternatively, the originator can originate-to-distribute, i.e. sell the loan as well as servicing rights. Banks engage in the origination of portfolio loans, comprising about 40% of their originations, and originate-to-distribute about 60% of their originations during our sample period. Shadow banks, on the other hand, do not retain loans and engage almost exclusively in the originate-to-distribute model. Finally, banks are subject to substantially higher regulatory burdens than shadow banks, including capital requirements, enhanced supervision from a wide set of regulators, such as the FDIC, FED, OCC, and state regulators, as well as compliance with a more extensive set of rules.[3]

The nature of lenders in the mortgage market has changed substantially from 2008 to 2015. Buchak et al. (2017) document a decline in traditional bank originations and the growth of shadow banks, with the shadow bank market share growing from 30% to more than 50% by 2015. The rise in shadow banks has coincided with a shift away from "brick and mortar" originators to online intermediaries. Buchak et al. (2017) provide evidence that both the increasing regulatory burden faced by traditional banks and growth of financial technology can account for a substantial part of this trend.

III.A.2 Mortgage Products

We focus on two main residential mortgage market segments in the US: the conforming loan market and the jumbo loan market. Together these two segments account for more than 80% of all US residential mortgages originated during our sample period (based on HMDA). The largest residential market segment in the US consists of conforming loans. These are usually extended to borrowers with relatively high credit scores, conservative loan-to-value (LTV) ratios (e.g., up to 80%), and fully documented incomes and assets. Conforming mortgages must be below the conforming loan limit, which grew from $417,000 in 2006 to $453,100 in 2018 for a one-unit, single-family dwelling in a low-cost area, and from $625,000 to $679,650 for the same unit type in a high cost area. In addition, the American Recovery and Reinvestment Act of 2009 temporarily increased these limits in certain high cost areas to up to 729,500. Mortgages that exceed the conforming limit are termed "jumbo."

Conforming loans are issued with the participation of government sponsored enterprises (GSEs), while jumbo loans are not. GSEs allow for a substantially easier securitization of conforming mortgages. For example, Fannie Mae and Freddie Mac, the two most prominent GSEs, purchase conforming mortgages and package them into mortgage-backed securities (MBS), insuring default risk. These MBS are particularly attractive to investors interested in relatively safe assets. In 2017,

[3] See Stanton et al. (2014, 2017) for discussion of the industrial organization of the US residential mortgage market.

conforming loans packed in mortgage-backed securities guaranteed by Fannie Mae and Freddie Mac made up about 50% of the outstanding residential loans (Source: Securities Industry and Financial Markets Association Data). Because jumbo mortgages are ineligible for GSE financing, they are issued without government guarantees. As a consequence, these mortgages are significantly more difficult to securitize and the vast majority are retained on the lenders' balance sheets.

III.B Description of Datasets

Our paper brings together a number of datasets which we describe below.

HMDA: Mortgage level application data is the main source for market shares across lender and product types. The Home Mortgage Disclosure Act (HMDA) collects the vast majority of mortgage applications in the United States, along with their approval status. In addition to the application outcome, the data includes loan type, purpose, amount, year of origination, and location information down to the applicant's census tract. It further contains demographic information on the applicant, including race and income. Important for this analysis, it includes the originator's identity, which we link manually across years. Finally, it documents whether the originator sells the loan to a third party, and if so, whether the loan purchaser is a GSE. An important caveat with the sales data is that if the originator retains the loan through the end of the calendar year and sells it in the subsequent year, it is recorded in HMDA as a non-sale. We use data beginning in 2010 and ending in 2016.

Fannie Mae and Freddie Mac Single-Family Loan Origination Data: These datasets, provided both by Fannie Mae and Freddie Mac, contain origination data from the GSEs' 30-year, fully amortizing, full documentation, single-family, conforming fixed-rate mortgage purchases.[4] The loan-level data contain information on the loan, property, and borrower, including loan size, interest rate, loan purpose, property location, borrower credit score, loan-to-value ratio, and importantly, the identity of the lender that sold the loan to the GSE. We use this data to calculate average interest rates by lender type and market.

Black Knight McDash Loan-Level Mortgage Performance Dataset: BlackKnight is a private company that provides a comprehensive, dynamic loan-level dataset on mortgages, including loans serviced by the ten largest US mortgage servicers, and accounts for approximately 75% of all mortgages in the US as of year-end 2010 (Black Knight McDash estimate). Importantly for our purpose, Black Knight includes information on both jumbo and GSE loans and includes loans retained on banks' balance sheets. Much like the Fannie Mae and Freddie Mac data, Black Knight McDash data contain interest rates and a large number of borrower and loan-specific

[4] The dataset does not include ARM loans, balloon loans, interest-only mortgages, mortgages with prepayment penalties, government-insured mortgage loans such as FHA loans, Home Affordable Refinance Program mortgage loans, Refi Plus™ mortgage loans, and non-standard mortgage loans. The data also excludes loans that do not reflect current underwriting guidelines, such as loans with originating LTVs over 97%, and mortgage loans subject to long-term standby commitments, those sold with lender recourse or subject to other third-party risk-sharing arrangements, or were acquired by Fannie Mae on a negotiated bulk basis.

characteristics, including FICO score at origination, loan-to-value ratio, five-digit zip code of origination, loan purpose, and whether the loan is fixed or adjustable-rate. The Black Knight McDash data also include dynamic data on monthly payments, mortgage balances, and delinquency status.

Blackbox: BlackBox is a private company that provides a comprehensive, dynamic loan-level dataset with information about more than twenty million privately securitized subprime, Alt-A, and prime loans originated after 1999. These loans account for about 90% of all privately securitized mortgages from that period. Much like the Fannie Mae and Freddie Mac data, the Blackbox data contain interest rates and a large number of borrower and loan-specific characteristics, including FICO score at origination, loan-to-value ratio, five-digit zip code of origination, loan purpose, and whether the loan is fixed or adjustable-rate. The BlackBox data also include dynamic data on monthly payments, mortgage balances, and delinquency status.

US Census Data: We use metropolitan statistical area-level data from the US Census and American Community Survey between 2010 and 2015. In particular, we use incomes, homeownership rates, and home values.

Federal Reserve Bank Data: We use banking regulatory call reports to measure bank capital ratios, assets, deposits, and other data from bank balance sheets.

III.C Lender Classification

We classify lenders as in Buchak et al. (2017). The process is described in detail there. Briefly, a “bank” is a depository institution and “shadow bank” is not. This definition parallels that of the Financial Stability Board, which defines banks as “all deposit-taking corporations” and shadow banks as “credit intermediation involving entities and activities outside of the regular banking system.”[5]

Section IV: Motivating Facts

We begin by presenting a set of empirical facts regarding recent changes in the price, quantity, and distribution of mortgage credit, which motivate our analysis and model. In doing so, we also shed light on the drivers of the comparative advantage of banks and shadow banks.

We note that larger balance sheet capacity, potentially tied to the subsidized deposit financing, could provide traditional banks with an advantage in making loans that are harder to sell in the secondary loan market. Accordingly, the extent of this advantage could vary with access to the securitization market, with shadow banks having a relatively larger presence in the markets in which it is easier to securitize loans. On the other hand, the relatively lighter regulatory regime faced by shadow banks could provide some comparative advantage relative to traditional banks. In this case, we would expect that the stricter regulatory regime including bank capital

[5] http://www.fsb.org/wp-content/uploads/global-shadow-banking-monitoring-report-2015.pdf

requirements faced by traditional banks would facilitate expansion of shadow bank lending, especially in highly regulated market segments. We postulate that changes in these factors could have a significant impact on the product market segmentation across lenders and the equilibrium market outcomes.

We focus our analysis on two main residential mortgage market segments in the US: the conforming loan market and the jumbo loan market. As we discussed above, these two segments account for more than 80% of all US residential mortgages (based on HMDA) originated during our sample period (2007-2016).

IV.A Aggregate Facts: Quantity and Pricing of Credit, Shadow Bank Share, Bank Balance Sheet Capacity, and Market Segmentation

We start by documenting several aggregate facts, which motivate the analysis and model in the rest of the paper. We document large changes in the composition and pricing of mortgages originated by the traditional banking and shadow banking sector, and relate those changes to the balance sheet capacity of the banking sector.

IV.A.1 Mortgage Origination Trends: Conforming and Jumbo Market Segments

We first present two aggregate market trends in the quantity and pricing of jumbo and conforming mortgages. The conforming loan origination volume varied between about $750 billion to more than $1.25 trillion per year (Figure 1, Panel (a)). The jumbo origination volume was smaller, ranging from $150 billion to around $500 billion per year. The changes in volume were not uniform. The relative share of the jumbo market in the overall loan origination volume declined sharply from about 28% in 2007 to less than 10% in 2009 (Figure 1, Panel (b)). From 2009 onwards, the jumbo share experienced a substantial increase reaching more than 30% in the 2015 to 2016 period. The jumbo market collapsed relative to the conforming market and then recovered back to similar levels.

IV.A.2 Relative Product Pricing: Conforming and Jumbo Interest Rates

The changes in the jumbo market share were accompanied by changes in the relative interest rates of jumbo mortgages to conforming mortgages (jumbo spread). Panel (c) of Figure 1 presents time series data relating interest rate spreads between conforming and jumbo loans. Before the crisis, the aggregate data shows virtually no aggregate jumbo spread. As quantity of jumbo mortgages contracted towards 2009, their relative price increased by almost 40 basis points on average and as much as 70 basis points in the early 2009. As the market share of jumbo mortgages recovered, the jumbo spread decreased by up to 60 basis points. The positive correlation between aggregate price and quantity suggests that supply shocks were at least partially responsible for driving the aggregate trends. If the contraction in jumbo quantity were solely driven by demand for jumbos (e.g., due to a decline in house prices), we should also observe a decrease in the pricing of jumbo mortgages.

IV.A.3 Penetration of Shadow Banks, Market Segmentation, and Banks' Business Model

We next investigate the penetration of shadow banks in the mortgage lending market during the same period. Consistent with Buchak et al (2017), we find a dramatic increase in the share of residential mortgages originated by the shadow banks during the 2011 to 2016 period. We further note that Buchak et al. (2017) find that the tightening of regulatory constraints faced by traditional banks was an important driver of this shadow bank expansion in the mortgage lending.

Interestingly, while the overall traditional bank market share has been declining significantly, we find that these effects occur entirely within the conforming mortgage market. Traditional bank market share in the conforming market has declined from slightly under 80% in 2007 to about 50% in 2016 (Figure 2 Panel (a)). This contrasts significantly with the jumbo market. Bank market share in the jumbo market has remained roughly constant, varying between 85% to 95%. In other words, the contraction and later expansion in the amount of jumbo lending is mainly driven by changes in originations by traditional banks. The changes in the conforming market, on the other hand, are driven by changes in both shadow bank and traditional bank originations.

One possible way to interpret the facts above is that traditional banks *uniformly* contracted their lending, but shadow banks chose to only enter the conforming market. Here we show that this is not the case and that traditional banks significantly changed their lending composition. In particular, as panel (b) of Figure 2 shows the share of traditional bank originations in the jumbo market doubled during the expansion of shadow bank lending in the conforming sector (from about 20% in 2011 to more than 40% by 2016). This suggests that that an expansion of shadow bank lending in the conforming market has resulted in traditional banks shifting their originations towards the jumbo market segment. We note, however, that before this shift, traditional banks first contracted jumbo lending significantly, from 30% in 2007 to 10% in 2009 and initially focused on the conforming loan market.

Overall, these results imply that traditional banks substantially changed their business model during the crisis. Jumbo mortgages are mainly held on the balance sheet of the originating bank, while conforming loans are securitized and sold to GSEs. As banks first shifted their origination from jumbo mortgages towards conforming, and then back to jumbo mortgages during the shadow bank expansion, they also switch between the classic banking model (originating for portfolio loans) and the originate-to-distribute model.

IV.A.4 Balance Sheet Capacity of the Banking Sector and the Mortgage Market Trends

We next show that the capitalization of the banking sector is correlated with trends in the mortgage market. Panel (a) of Figure 3 illustrates that the banking sector capitalization originally declined, bottoming out in 2009, and then began increasing. Moreover, panel (b) and (c) point to a strong positive association between bank capitalization and volume and share of jumbo originations. Overall, these patterns along with our prior findings indicate that traditional bank capitalization closely follows the share of jumbo mortgage originations, their relative pricing, and banks' choice of whether to lend on their balance sheet or originate-to-distribute.

IV.A.5 Summary: Aggregate Facts

The aggregate facts we document are consistent with the idea that banks and shadow banks differ in their ability to extend jumbo and conforming mortgages, resulting in market segmentation. We argue that this market segmentation arises because jumbo mortgages are mainly kept on the portfolio of lenders. Since shadow banks do not have much balance sheet capacity, they originate-to-distribute, which is limited to the conforming market.

Such market segmentation implies that a decline in the balance sheet capacity of the banking system leads to a relatively larger contraction in traditional jumbo mortgage supply through two channels. First, shadow banks, lacking balance sheet capacity, respond to the decline in the conforming market, but cannot do so in the jumbo market. Second, traditional banks, lacking balance sheet capacity, tilt their activity towards conforming originations and the originate-to-distribute model. The larger contraction in the supply of jumbo mortgages leads to an increase in their relative price, i.e. an increase in the jumbo-conforming spread.

IV.B. Micro Evidence: Balance Sheet Capacity, Bank Business Model, Market Segmentation, and Product Pricing

In this section, we provide micro-level evidence on balance sheet capacity, market segmentation, and relative product pricing. Consistent with our aggregate facts, this evidence points to the balance sheet capacity induced market segmentation in the mortgage market.

IV.B.1 Market Segmentation at the Conforming Loan Limit

We start our analysis by looking at the conforming loan size limit to take a first stab at establishing the importance of bank balance sheet capacity in driving the market segmentation. As we discussed in Section III, there is a sharp loan amount cutoff to qualify as a conforming loan. One would imagine that borrowers' demand for banking services would not increase discontinuously with mortgage size, as mortgages transition from conforming to jumbo. The ability to securitize a mortgage, on the other hand, discontinuously drops at the conforming loan amount. So observing a discontinuous jump in the bank market share at the conforming limit would reject the demand alternative.

We first confirm that the probability of loan securitization indeed discretely jumps at the conforming loan limit. We form bins based on the relative percentage of the conforming loan limit and calculate the percentage of loans retained on the balance sheet in that bin. For example, a bin contains all loans of 95% - 100% of the conforming loan limit size. For each bin b, we compute the share of the loans held on the balance sheet:

$$ShareHeld_b = \frac{1}{N_b}\sum_{l\in b} Held_l$$

In which N_b is the number of loans in a bin and $Held_l$ is an indicator variable taking the value of 1 if the loan was not sold, i.e. if the loan is a portfolio loan. Panel (a) of Figure 4 confirms that the probability that a loan is held on the balance sheet discretely increases at the conforming limit: only 20% of loans just below the conforming loan limit are held on the balance sheet, whereas 60-70% of loans just above the conforming loan limit are held on the balance sheet.

We next examine whether banks' market share discretely increases at the conforming loan limit. In other words, we test whether banks specialize in large loans or in conforming loans. We examine the same bins as before, but we compute banks' market share within each bin:

$$ShareBank_b = \frac{1}{N_b}\sum_{l\in b} Bank_l$$

In which $Bank_l$ is an indicator variable taking the value of 1 if the mortgage was originated by a bank and 0 if it was a shadow bank. Panel (b) of Figure 4 shows that banks' market share of loans just below the cutoff is roughly 60%, whereas bank market share above the cutoff is roughly 75%. The results suggest that banks have a comparative advantage in originating jumbo loans because these loans are difficult to sell.

We more formally test whether there is a jump in loan retention and bank market shares at the discontinuity. We focus on mortgages within 1% of the conforming cutoff and estimate the following regression discontinuity specification at the loan level around the conforming loan limit:

$$Held_{ilt} = \beta \times Jumbo_i + X_i'\Gamma + \gamma_{lt} + \epsilon_{ilt} \quad (1)$$

$$Bank_{ilt} = \beta \times Jumbo_i + X_i'\Gamma + \gamma_{lt} + \epsilon_{ilt} \quad (2)$$

Where $Held_{ilt}$ and $Bank_{ilt}$ are {0,1} indicator variables for whether the loan is financed on the balance sheet or originated at a bank, respectively. $Jumbo_i$ is an indicator for whether the loan size is above the conforming loan limit in the time-county of origination, and the corresponding coefficient β is the object of interest. X_i' is a vector of loan-level controls including log loan size, log applicant income, dummy variables for race, ethnicity, sex, loan type, loan purpose, occupancy, and property type. γ_{lt} is a census tract-origination year fixed effect, which absorbs any variation in local conditions over time, as well as regulatory differences. In other words, we examine the effect by comparing loans from the same census tract and year around the conforming limit, adjusting for observable borrower differences. For robustness, we also experiment with larger samples, those within 5%, 10%, and 25% of the conforming loan limit.

Table 1 Panel (a) shows that loans immediately above the conforming loan limit are roughly 50% more likely to be held on the balance sheet of the lender—portfolio loans. Increasing the bandwidth above 1% produces similar results, as shown in columns (2)-(4). Moreover, focusing only on 2015 data paints an even more striking picture, with loans directly above the cutoff being 63% more likely to be held on balance sheet than loans directly below the cutoff in the same census tract and year.

The differences in financing sources carry through to stark differences in the type of loan originator. Panel (b) column (1) of Table 1 shows that loans directly above the conforming loan limit are nearly 25% more likely to have been originated by a traditional bank, as opposed to a shadow bank. As above, when considering only loans originated in 2015, this difference grows to 38%. It is worth emphasizing that this effect is driven entirely by the presence, or lack thereof, of the GSE financing option for conforming loans. While there exist private financing options for conforming and non-conforming loans alike, the presence of the GSEs in the conforming market appears to exert significant influence on whether a mortgage is financed on the balance sheet, and consequently whether the mortgage is originated by a lender with the balance sheet capacity to finance internally: traditional banks.

IV.B.2 Within Bank Analysis: Bank Capital Ratios, Balance Sheet Lending, and Market Segmentation

The above findings are consistent with the idea that banks' ability to finance loans with their balance sheets generates a strong comparative advantage in the segment for difficult to securitize loans—jumbo loans. However, balance sheet capacity is not the only differentiating factor between banks and shadow banks; for example, shadow banks are subject to a very differential regulatory burden than traditional banks (see Buchak et al. 2017). To isolate further the effect of balance sheet capacity, we look within traditional banks, allowing us to hold fixed the regulatory regime.

Specifically, we compare better capitalized banks, those with larger balance sheet capacity, to poorly capitalized banks, those with low balance sheet capacity. If low balance sheet capacity is the source of market segmentation between banks and shadow banks, then we should observe similar segmentation between well capitalized and poorly capitalized banks. Last, we look within banks' changes in balance sheet capacity and show that changes in balance sheet capacity are tightly linked to the business model of banks. As balance sheet capacity declines, banks move from portfolio lending towards the originate-to-distribute model.

We first examine whether a bank's capitalization is indeed related to its balance sheet capacity, i.e. its ability to originate loans and hold them on the balance sheet. In other words, we examine whether bank capitalization is related to a bank's choice of business model on the dimension of originating portfolio loans versus originating-to-distribute. At the bank-year level, we calculate the percentage of loans held on the balance sheet, $Held_{bt}$, and regress this on the bank capital ratio CR_{bt} :

$$Held_{bt} = \beta CR_{bt} + \gamma_t + \gamma_b + X_{bt}'\Gamma + \epsilon_{bt}$$

γ_b are bank fixed effects, controlling for differences in banks' propensity towards portfolio lending, as well other time invariant differences in business models. γ_t are time fixed effect, which absorb any aggregate changes that would affect the business model of banks, including aggregate demand or supply fluctuations that would affect the propensity to hold loans on the balance sheet. X_{bt} contains bank controls, including log number of originations, log bank assets, deposits to liabilities, log of the average loan size and applicant income of the bank's originations, and log of the number of unique census tracts in which the bank lends. We estimate these specifications for both levels and changes in these variables.

Table 2 shows that a 1% increase in a bank's capital ratio is associated with roughly a 4.5% increase in the share of originations which are held on the balance sheet (column 2). We find very similar evidence when we estimate the above specification in changes (column 4).

Figure 5 presents these results less parametrically, through binned scatterplots of $Held_{bt}$ and CR_{bt}, with respect to controls. Panel (a) shows a simple scatter plot of banks' shares of loans held on the balance sheet as a function of their capital ratios. The plot illustrates a strong positive relationship: better capitalized banks retain a higher portion of originated loans on the balance sheet. Panel (b) shows that this is the case within banks as well. Panel (c) and (d) of Figure 5 show that the same inference holds for changes in these variables. Banks that experience a decrease in balance sheet capacity are more likely to sell loans, rather than keep them on the balance sheet. In other words, banks' business models are linked to their balance sheet capacity. In the cross-section, banks with lower balance sheet capacity are more likely to engage in originate-to-distribute, rather than portfolio lending. In the time series, as banks' balance sheet capacity declines, they shift towards the originate-to-distribute model, and then move back towards portfolio lending as their balance sheet capacity improves. These results suggest that the market segmentation we observe between traditional and shadow banks is at least partially due to the balance sheet differences between these two types of financial intermediaries. Both Figure 5 and Table 2 also suggest that banks shift their business model from originate-to-distribute to portfolio lending as their balance sheet capacity decreases.

Last, we confirm that the balance sheet effect also leads to the jumbo/conforming market segmentation among banks. We begin with an approach similar to that used above, by looking at originations above and below the conforming loan limit. First, we look on the retention around the conforming loan limit among traditional banks only. Second, rather than looking at the traditional bank market above and below the limit, we look at the market share of well capitalized banks relative to other traditional banks. If balance sheet capacity leads to market segmentation, we should see well-capitalized banks' origination share relative to other banks' increase discontinuously through the conforming loan limit.

We define a bank to be well capitalized if its capital ratio is in the top 25% of bank capital ratios in the given year. Panel (a) of Figure 6 shows that within traditional banks, the balance sheet retention also dramatically increases among loans above the conforming loan limits. Panel (b) plots the well capitalized banks' share of overall bank lending by conforming loan limit percentile. The figure shows that below the cutoff, the top quarter of banks by capitalization originate slightly more than one quarter of loans, which is not surprising since they represent one quarter of banks. Above the cutoff, however, well capitalized banks play an outsized role in originations, accounting for roughly 40% of originations even they comprise only one quarter of lenders by definition.

As above, we more formally test for these effects in Table 3. We focus only on traditional bank originators and first test whether there are significant differences in financing between loans just above and below the threshold. Panel (a) of Table 3 indicates that while better capitalized banks do more jumbo lending, confirming what we observed in Figure 8, these differences are primarily across banks rather than within banks. Panel (b) of Table 3 confirms that the fraction of loans originated by the well capitalized banks substantially increases for loans just above the conforming loan limit. These results suggest that the balance sheet capacity of well-capitalized banks gives them a comparative advantage in the jumbo sector both relative to shadow banks and poorly capitalized traditional banks, leading to market segmentation.

IV.B.3 Relative Product Pricing: Conforming-Jumbo Spread around the Conforming Limit

The aggregate results indicate that balance sheet contraction of traditional banks leads them to contract supply of jumbo mortgages, increasing the jumbo spread. The aggregate jumbo spread may partially reflect the differences in the mortgage composition, since jumbos are larger and cater to a different population segment. To shed more light on conforming and jumbo loan pricing, we examine the mortgage interest rates around the conforming limit in Figure 7, and compare the period during which the spread was high (2008) with the period in which the spread was low (2014) in the aggregate data. Similar to aggregate data, there is a sharp discontinuity of about 30 to 40 basis points at the conforming loan cutoff in 2008 (panel (b) of figure 7). By 2014, on the other hand we observe much more modest increase in mortgage rates on loans above the conforming loan limit.

As we discussed above, the positive correlation between aggregate price and quantity and bank capitalization suggests that supply shocks were at least partially responsible for driving the aggregate trends. If the contraction in jumbo lending in 2007-2009 period were solely driven by demand for jumbos (e.g., due to a decline in house prices), we should also observe a decrease in the pricing of jumbo mortgages. Instead we find the opposite effect: jumbos are relative more expensive in times of low jumbo market share.

IV.C Micro Evidence: Loan Demand, Supply of Bank Credit, and Market Segmentation

In this section we shed light on the interaction of demand-side effects with loan supply.

IV.C.1 Distribution of Loans and the Borrower Income around the Conforming Loan Limits

We start by examining the distribution of mortgages around the conforming loan limit cut-offs. We document a significant mass of borrowers right below the conforming loan cutoff including those with higher incomes (Figure 8). This evidence suggests that the conforming loan limit is in fact binding constraint for many borrowers.

IV.C.2 Loan Size Choice and the Supply of Bank Credit

We next test the extent to which the supply of bank credit translates to borrowing decisions. In particular, we test whether when banks are more able to make non-conforming jumbo loans, borrowers are more likely to select larger jumbo loans above the conforming limit rather than accepting smaller but conforming loans. To that end, we test whether greater bank market share translates to a smaller mass of borrowers at the conforming loan limit. The intuition underlying this test is that the borrowers who get loans exactly at the conforming loan limit choose precisely that size because other loan characteristics equal, they would prefer a larger loan, but due to a relatively greater supply of conforming loans, the jumbo loans' other characteristics (such as price, terms, or general availability) these borrowers sacrifice the desired loan size and get the largest conforming loan possible. When the supply of jumbo loans increases, the non-size jumbo loan terms become more favorable and we therefore expect these potentially constrained borrowers to be more likely to choose their desired (jumbo) loan size.

We measure the mass of borrowers at the conforming loan limit as

$$\%AtCutoff_{ct} = \frac{1}{N_{ct}} \sum \boldsymbol{I}\left(\frac{LoanSize_i}{LoanLimit_{ct}} \in (0.999, 1.001)\right)$$

That is, $\%AtCutoff_{ct}$ represents the percentage of originations that are within 0.1% of the conforming loan limit. We also run the tests for larger bandwidths between (0.995,1.001) and (0.990,1.001). Note that roughly 1% of loans are within the (0.999,1.001) band, 1.1% of loans are within the (0.995,1.001) band, and 1.2% are within the (0.990,1.001) band. The desired regression specification is

$$\%AtCutoff_{ct} = \beta(\%Bank_{ct}) + \gamma_c + \gamma_t + \epsilon_{ct}$$

Where γ_c and γ_t are county and year fixed effects, respectively. The prediction is that $\beta < 0$. An identification concern is what generates variation in bank share. One worry is that a greater number of borrowers at the cutoff mechanically pushes the relationship between %Bank and %AtCutoff further negative because the loans just below the cutoff are conforming and consequently more likely to be originated by shadow banks. In consequence, we might obtain a negative relationship simply because shadow banks are relatively more likely to originate conforming loans, and counties with many borrowers just below the cutoff have more conforming loans.

A concern pushing the other way is that counties with many borrowers exactly at the conforming loan cutoff are counties where the typical loan size demanded is larger. If the typical loan size demanded is larger, there will be, holding other things constant, a larger demand for jumbo originations *above the cutoff* and consequently more banks present to originate those jumbo loans. Additionally, if the size of loans demanded is large for a given year, it could indicate a healthy local economy with relatively high house prices, and these good local economic conditions attracts more bank lenders. These effects are likely to push the effect from negative towards zero.

To obtain variation in %Bank, we utilize the differential geographic impact of the closure of the OTS. The OTS, which was a "lax" regulator, closed in 2011 and its duties were folded into stricter banking regulators. Counties that ex-ante had a greater share of OTS-regulated lending were likely harder hit by this shock. Consequently, we use the OTS closure (in the time series) interacted with county-level OTS share in 2007 (in the cross section) to obtain time-county variation in bank market share. The first stage regression is:

$$\%Bank_{ct} = Post_t \times \%OTS_{2007,c} + \gamma_c + \gamma_t + \epsilon_{ct}$$

$Post_t$ is an indicator taking the value 1 in the 2012 and thereafter. The IV regression uses predicted $\%Bank_{ct}$ from this regression. From this we obtain variation in %Bank that is no longer mechanically related to the amount of conforming lending in the county at the time and is plausibly exogenous to local economic conditions driving loan demand that are not absorbed by time or county fixed effects. Table 5 shows the results of these series of regressions. Panel (a) shows the (0.999, 1.001) band, and Panel (b) shows the (0.995, 1.001) band.

Focusing on Panel A, column (1) is the first stage regression. It shows a negative relationship between bank market share and OTS closure times ex-ante OTS share. This is consistent with the prediction: Counties with higher OTS share in 2007 received a harsher shock to bank regulation following OTS closure. Column (2) is the reduced form of %AtCutoff regressed on $Post_t \times \%OTS_{2007,c}$. This column shows a positive and statistically significant relationship between OTS closure times ex-ante OTS, indicating that counties receiving this negative shock to bank credit supply see more borrowers getting conforming loans immediately below the line. A 1% greater OTS share corresponds to 0.027% increase in bunching of conforming loans immediately below the cutoff, representing an increase in the number of borrowers who appear to want larger loan sizes but instead get conforming loans.

Column (3) shows the OLS regression, finding a negative and significant relationship between bank share and percentage of bank borrowers immediately below the conforming loan cutoff. Recall for the reasons discussed above, this regression has several endogeneity concerns. The IV result in column (4) shows the results using bank share variation obtained from the OTS closure. This column shows a large negative and statistically significant relationship between bank market share and borrowers at the jumbo cutoff. In other words, decreases in the supply of bank credit appear to increase the number of borrowers exactly below the conforming loan cutoff, as borrowers increasingly take smaller-than-desired loans in exchange for more favorable conforming loan terms. In terms of quantities, this result finds that a 1% increase in bank market share is associated with a 0.14% decrease in conforming loans exactly at the loan limit. The results in Panel B, which widens the bandwidth, are essentially unchanged quantitatively, indicating that most of the variation in shares is indeed coming from the borrowers who are pushed up against the conforming loan limit.

The upshot of this analysis is to show that the presence (or lack thereof) of lenders capable of originating jumbo loans---predominately banks---can lead to significant changes in the loans that consumers ultimately obtain. In particular, when the supply of jumbo loans is restricted, consumers are significantly more likely to opt for conforming loans whose size limits are indeed binding constraints on their borrowing decision. We explore this implication further in the our model.

IV.C.3 Changes in the Conforming Limits, Loan Demand, and Mortgage Market Outcomes

We next utilize discrete changes to conforming loan limits to analyze the impact of loan type demand (conforming versus jumbo) on mortgage market outcomes. Conforming loan limits are adjusted over time. When the conforming loan limit is *increased*, this represents a reduction in the demand for jumbo loans and consequently banks, because moderately large desired loan sizes that would have once been non-conforming and therefore necessitated a jumbo loan are not conforming and easier to originate for shadow banks. Consequently, the changes in conforming loan limits over time offer the opportunity to tie the demand for jumbo loans causally to the amount of bank lending in an area. Additionally, these changes present a validation exercise for our model counterfactuals that we exploit later in the paper.

The data are at the county-year level between 2007 and 2016. The main variables of interest are jumbo origination share, bank origination share, and whether the conforming loan limit increased. This last variable is the percentage difference between the conforming loan limit in year t, county c, and the conforming loan limit in 2007, county c:

$$LimitIncrease_{ct} = \frac{Limit_{ct}}{Limit_{c2007}} - 1$$

The origination-weighted mean of $LimitIncrease_{ct}$ is 0.102 and the median is 0. The specifications to test the impact of these limit increases on jumbo and bank share are as follows:

$$\%Jumbo_{ct} = \beta LimitIncrease_{ct} + \gamma_c + \gamma_t + \epsilon_{ct} \quad (3)$$

$$\%AtCutoff_{ct} = \beta LimitIncrease_{ct} + \gamma_c + \gamma_t + \epsilon_{ct} \quad (4)$$

$$\%Bank_{ct} = \beta LimitIncrease_{ct} + \gamma_c + \gamma_t + \epsilon_{ct} \quad (5)$$

Where γ_c and γ_t are county and year fixed effects, respectively. Specification (3) investigates whether jumbo share of originations decline along with conforming loan limit increases. Specification (4) tests whether the number of *conforming* originations within 0.1% of the conforming loan limit declines. Specification (5) tests whether bank market share declines. The results of these regressions are given in Table 6 columns (1)-(3). Column (1) shows that increasing the conforming loan limit by 1% leads to approximately a 0.35% reduction in the jumbo share in the county, indicating that as the conforming loan limit increases, there is a significant shift into selecting conforming loans. Column (2) shows that when the conforming loan limit increases, the mass of borrowers exactly at the conforming loan cutoff decreases, suggesting that many of these borrowers would have selected larger loans had the conforming loan limits not been in place, and now that the limit has been relaxed, they are able to select larger, now-conforming loans. Column (3) shows that a 1% increase in the conforming loan limit decreases bank market share by roughly 0.03% percentage points.

To study the direct link between jumbo loan demand and bank market share, we first show the naïve OLS regression which is potentially contaminated by supply side effects:

$$BankShare_{ct} = \beta JumboShare_{ct} + \gamma_c + \gamma_t + \epsilon_{ct} \quad (6)$$

This specification is potentially confounded with supply side effects; for example, areas with particularly healthy banks may offer lower interest rates on jumbo loans (which we cannot measure), thus attracting larger shares of jumbo borrowers. We use the changes to the conforming loan limits to generate demand-side variation in jumbo share, with the intuition being that increases in the conforming loan limits reduce the demand for jumbo loans for reasons unrelated to the supply of jumbo loans. With equation (3) representing the first-stage of this regression, the IV specification is:

$$BankShare_{ct} = \beta \widehat{JumboShare}_{ct} + \gamma_c + \gamma_t + \epsilon_{ct} \quad (7)$$

The results of (6) and (7) are shown in Table 6, columns (4) and (5). Note that columns (1) and (3), discussed previously, are the first stage and reduced form specifications, respectively. The OLS results in column (4) find a positive and significant association between bank share and jumbo share, and the IV results in column (5) similarly a positive and significant, though smaller, association. This indicates that at least some of the correlation shown in column (4) arises from supply side effects, but that the demand for jumbo loans itself has a significant effect on bank market share.

The upshot of this analysis shows that demand for conforming loans has a significant negative impact on bank market share, and that the conforming loan limit itself has an important role to play in bank market share. In particular, increases in the conforming loan limit, which reduce the demand for jumbo loans, leads to less jumbo lending, fewer borrowers constrained exactly at the conforming loan limit, and importantly, a smaller bank market share.

IV.D Summary

Before describing the model, we summarize our evidence established above. Shadow banks have gained significant market share, during the period of tightening regulatory constraints faced by traditional banks, but the majority of these gains have been in the OTD conforming sector. Traditional banks retained market share in the jumbo sector by shifting their origination activity towards this sector where their balance sheet capacity gives them an advantage. To confirm this, we note a striking discontinuity in market shares and balance sheet financing around the conforming loan limit. Similar results hold when comparing well capitalized to poorly capitalized banks. Within bank regressions confirm the capitalization channel, with greater capitalization being strongly associated with more balance sheet lending and more jumbo lending. As banks were shifting their origination activity towards jumbo sector we observe progressive decline of jumbo interest rates relative to the conforming market rates.

Together, these facts provide a consistent view of the role of banks and shadow banks in the mortgage market. Banks' advantage lies in originating mortgages on their balance sheet, and their balance sheet capacity is limited by their capitalization. This advantage implies that traditional banks dominate the jumbo mortgage segment where it is harder to securitize loans and compete with shadow banks in the conforming market. More capitalized banks endogenously shift their business model towards more balance sheet retention and towards jumbo market segment. Shadow banks, on the other hand, benefit from a lower regulatory burden and mainly focus on the originate-to-distribute (OTD) conforming market. Such specialization implies that shocks and interventions which affect only one type of lender have redistribution consequences. For example, tightening capital requirements will decrease the supply of jumbo mortgages and could increase the supply of conforming mortgages, benefitting lower income borrowers at the expense of the highest income borrowers. Since all lenders compete in the conforming market, regulation in any part of the sector would spill over to other parts through competition.

Section V: Model of Mortgage Demand and Supply

We build a structural model of the U.S. mortgage market, which features banks competing with shadow banks for consumers. On the demand side, we build a rich discrete choice framework on Berry et al (1995), Nevo (2000), with an application to the mortgage market. We build on Buchak et al. (2017), but develop a substantially richer model in several dimensions. Critically, we account for the market segmentation between conforming and jumbo mortgages both on the demand and supply side. Our model generates endogenous market segmentation between traditional and shadow banks and segmentation within the traditional banking sector between well and poorly capitalized banks. On the supply side we explicitly model different financing choices across intermediaries. On the demand side, we allow preferences of borrowers to be correlated with their income. These differences in preferences, especially for larger mortgages, play a critical role in studying the distributional aspects of policies.

The supply side of the market consists of three types of lenders, banks, and two distinct types of shadow banks: non-fintech shadow bank, and fintech shadow bank. These financial intermediaries engage in two activities, loan origination and financing. Intermediaries can finance mortgages two different ways: portfolio lending or originate-to-distribute. In portfolio lending the intermediary finances the mortgage from its own funds. Therefore, differences in lenders' internal funds—balance sheet capacity—will change their willingness to engage in this activity. Furthermore, capital requirements put regulatory restrictions on the amount of portfolio lending a bank can engage in. Alternatively, intermediaries can originate-to-distribute: they finance the mortgage by selling it to a third-party financier through GSEs. Of course, an intermediary can engage in both types of financing simultaneously.

Following the institutional setup of the US mortgage market, a central distinction between jumbo and conforming mortgages is that only conforming mortgages can be financed by originating-to-distribute; jumbo loans are portfolio loans. Moreover, only banks can access deposits, which give them the ability to finance portfolio loans.[6] Shadow banks can only originate-to-distribute.

V.A Mortgage Demand

A market c is defined at the MSA-year-loan purpose level. For example, a market may be borrowers in New York City in 2010 attempting to refinance their mortgages. Each market has $i = 1, \dots, I_c$ consumers, with an ideal mortgage size, F_i, and $j = 1, \dots, J$ lenders. Lenders can offer up to two types of products, conforming and jumbo mortgages, with conforming mortgage

[6] Because banks have access to a subsidized funding of their balance sheet through insured deposits, one can model the shadow bank decision not to engage in lending on the balance sheet as a competitive outcome with a corner solution.

amounts falling below the market specific conforming loan limit $\bar{F}_c$; and jumbo mortgages above that amount. Let $g \in \{c, nc\}$ denote whether the mortgage is conforming (c) or jumbo (nc). Conditional on an offered rate, consumers can choose any loan size subject to statutory limits.

Consumers' utility from a mortgage depends on the mortgage interest rate r_{jcg}, chosen mortgage size F_i^*, which can differ from idea mortgage size, and the convenience or quality of the service provided by the lender:

$$u_{ijcg} = \underbrace{-\alpha_i r_{jcg}}_{rate} - \underbrace{\beta_i I(F_i^* < \bar{F})I(F_i > \bar{F}) + \gamma_i I(F_i^* > \bar{F})I(F_i > \bar{F})}_{size} + \underbrace{q_{jc} + \xi_{jc} + \epsilon_{ijcg}}_{service} \quad \text{(D.1)}$$

A consumers' utility declines in the mortgage rate $\alpha_i r_{ijcg}$, with α_i measuring the consumer specific sensitivity to interest rates. Wlog, we normalize the utility from a conforming mortgage for consumers whose ideal mortgage size is conforming to 0. Borrowers whose idea mortgage is a jumbo mortgage, obtain consumer specific utility γ_i from choosing a jumbo mortgage $I(F_i^* > \bar{F})I(F_i > \bar{F})$. If they instead choose a conforming mortgage, they suffer a disutility from choosing a smaller mortgage $\beta_i \boldsymbol{I}(F_i^* < \bar{F})I(F_i > \bar{F}))$,[7] with β_i measuring the consumer specific disutility. Consumers differ in their preference over mortgages $\mathrm{B}_i \equiv (\alpha_i, \beta_i, \gamma_i, F_i)'$. In other words, the optimal mortgage size, interest rate sensitivity, as well as the cost of departing from the optimal mortgage size are consumer specific.

In addition, consumers' preferences over lender differ based on the lenders convenience and/or service quality. $q_{jc} + \xi_{jc}$ measure convenience differences between lender, where q_{jc} is observed by the researcher, and ξ_{jc} is not. Intuitively, consumers like to borrow from the fintech shadow banks such as Quicken, because they offer a convenient way to interact online. Last, borrowers preferences over lenders differ, which is captured in the i.i.d. T1EV borrower specific utility shock ϵ_{ijcg}. For example, some lenders prefer to borrow from JPMorgan Chase over Quicken, because they have a bank account with the former, making it easier to transact.

Consumers' preferences are drawn from a distribution, where the distribution is a function of income and house prices in a market. In particular,

$$\mathrm{B}_i = \bar{\mathrm{B}} + \Pi(D_{ic} - \bar{D}) + \Sigma\nu_i \quad \text{(D.2)}$$

$\bar{\mathrm{B}}$ is the vector of mean consumer preferences, Π maps demeaned consumer demographic characteristics such as income and house prices $(D_{ic} - \bar{D})$ to individual consumer preferences. For example, higher income borrowers can have different price sensitivity than lower income borrowers, and their preferences over mortgage size can differ. Σ scales normal i.i.d. shocks $\nu_i \sim N(0, I)$. In other words, even borrowers with the same observable characteristics, such as income, can differ in their price elasticity or optimal mortgage size. The demand parameters to be estimated are then $\theta_d = (\bar{\mathrm{B}}, \Pi, \Sigma)$.

[7] A consumer will never choose a mortgage, which is too large.

Consumers choose the mortgage that maximizes their utility. In other words, given product characteristics for each mortgage offered in the market jgc (including interest rate, contract type, lender type, statutory size limits, and service quality), and demand parameters θ_d, the set of borrower characteristics (including product-borrower match utilities ϵ_{ijc}), such that borrowers with these characteristics in market c choose product j as

$$A_{jcg}(r_{\cdot c}, g_{\cdot c}, \bar{F}_c, q_{\cdot}, \xi_{\cdot c}; \theta_d) = \{(D_i, g_i, \xi_i, \epsilon_{i0cg}, \dots, \epsilon_{iJcg}) | u_{ijcg} \geq u_{ikcl} | \forall k, l\} \quad \text{(D.3)}$$

With this notation, the market share of mortgage offer j in market c is

$$s_{jcg}(r_{\cdot cg}, g_{\cdot c}, \bar{F}_c, q_{\cdot c}, \xi_{\cdot c}; \theta_d) = \int_{A_{jcg}} \frac{\exp\left(u_{jcg}(\mathrm{B}_i)\right)}{\sum_k \exp\left(u_{kcg}(\mathrm{B}_i)\right)} dP(cg) dD(D_i) \quad \text{(D.4)}$$

Note that the size of mortgages a consumer chooses is implicitly captured in expression D.3. If a consumer prefers a jumbo sized mortgage, and chooses a jumbo mortgage, she does so at the optimal size. If, instead, this consumer chooses a conforming mortgage, she will choose the largest conforming mortgage possible, which implies they will bunch at the conforming loan limit.

V.B Mortgage Supply

There are N_{bc} banks, N_{nc} non-fintech shadow bank, and N_{fc} fintech shadow bank in market c. Lenders choose simultaneously which mortgages to originate across all markets, and how to finance them. A lender j who originates m_{jcg} dollars of type g in market c has to decide how many to retain as portfolio loans on the balance sheet, m_{jcg}^b, and finances the remainder through GSE securitization $m_{jcg} - m_{jcg}^b$. Jumbo mortgages cannot be securitized, and are held on the balance sheet, $m_{jcnc} = m_{jcnc}^b$. Each bank has only one balance sheet across markets in which it participates. Denote by $m_{jg}^b = \sum_c m_{jcnc}^b$ the amount of type g mortgages that lender j chooses to retain on the balance sheet. In other words, suppose the bank originates conforming mortgages in the New York City and Houston MSA, and it chooses to finance \$100 million on its balance sheet. From a financing perspective, it does not matter which market these mortgages were originated from. We first describe the cost of mortgage origination, and then turn to financing costs.

V.B.1 Origination

Mortgage origination is costly, beyond the mere financing cost of a mortgage. Lenders' incur non-financing costs, such as costs of an appraisal and title check, document processing, and loan closure, which involve labor and equipment. We designate the per dollar origination cost of lender j of mortgage type g *as* w_{jg}, and the total origination cost in market c is

$$\sum_{cg} m_{jcg} w_{jg} \quad \text{(S.1)}$$

This specification allows for different origination costs across banks, non-fintech shadow bank, and fintech shadow banks. For example, this heterogeneity allows us to capture potential cost savings from technology employed by fintech shadow banks who use less labor in lending.

V.B.2 Financing

Recall that mortgages can be financed two ways. Conforming mortgages can be sold to through GSEs, i.e. originate-to-distribute. Alternatively, conforming and jumbo mortgages can be financed by using the bank's internal funds as portfolio loans. These two types of financing can have different costs.

Originate-to-Distribute Financing

Lenders can securitize conforming mortgages though GSEs. Since GSEs purchase mortgages at pre-determined prices, all lenders face the same originate-to-distribute financing cost in a given market, which we model as an ability to obtain funding for a conforming mortgage at a rate σ^{GSE}. In other words, when the firm originates-to-distribute a mortgage, it earns the spread on the mortgage rate, minus the origination and non-financing costs $r_{jcnc} - \sigma^{GSE} - w_{jg}$ for every dollar of the mortgage. Reflecting the post-crisis period, which we study, we assume that securitization is only available for conforming loans; jumbo loans must be retained on balance sheet. One could easily account for a jumbo securitization in the same way.

Costs of Portfolio Lending

The cost of portfolio lending depends on the composition of the lenders balance sheet, and the amount of equity capital equity capital e_j. A lender sources financing at the firm level, and has one balance sheet comprising mortgage assets across markets. There are two types of assets held on a lender's balance sheet, mortgages, the amount of which is chosen by the lender in each market, and other assets in the amount m_{jo}^b. The choice of the latter is determined outside the model, and represent other assets that the bank chooses to hold on the balance sheet, such as government bonds, or commercial loans, which it did not securities. Lenders also differ in the amount of equity capital e_j. The amount of equity and the asset composition of the balance sheet jointly determine the cost of portfolio lending for an intermediary.

A lender's risk-adjusted capital ratio, ρ_j, depends on the banks equity capital e_j, and banks' risk weighted assets $\xi_o m_{jo}^b + \sum_{ca} \xi_g m_{jca}^b$:

$$\rho_j = \frac{e_j}{\xi_o m_{jo}^b + \sum_{ca} \xi_g m_{jca}^b.} \tag{S.2}$$

Where ξ_g represents the risk weight of mortgage of type g, and ξ_o the risk weight of other assets the bank holds. Since jumbo mortgages' have higher risk weights, they use up more statutory capital per dollar of actual lending. A banks capital needs to be below its statutory capital requirement $\bar{\rho}$ if it wants to lend on its balance sheet.

The per dollar cost of financing a portfolio loan of lender j depends on its capitalization:

$$\sigma_j^p = \sigma^{b0} + \sigma^{b1}\left(\rho_j - \bar{\rho}\right)^{-\phi} \tag{S.3}$$

The closer a banks risk-adjusted capital ratio is to the statutory requirement, i.e. the smaller is $\left(\rho_j - \bar{\rho}\right)$, the larger is the cost of portfolio loan financing, with $\phi > 0$ and σ^{b1} measuring the extent of the cost. This formulation captures in reduced form the fact that lenders face capital constraints, and that banks choose a capital buffer above the hard capital requirement. The micro-foundations of such a buffer can be generated in a dynamic setting, but are not the central interest in this paper.[8] σ^{b0} represents the balance sheet cost of an unconstrained lender—a lender flush with capital, i.e. in the limit as ρ_j approaches infinity. We assume that shadow banks' capitalization ρ_j is so low that portfolio lending is prohibitively expensive $\rho_j = \bar{\rho}$. This assumption captures in reduced form the notion that shadow banks do not have access to a subsidized deposit funding.

Setting Mortgage Rates

Taking other lenders' actions as given, an individual lender sets interest rates across all markets, as well as the choice of securitization, in order to maximize its profits. Denote by r_j the set of prices of all products, conforming and jumbo, across all markets, $\boldsymbol{r_j} = \{r_{jcg}: \forall c, g\}$. Since all jumbo mortgages are securitized, the only decision in addition to setting interest rates is how many, if any, conforming mortgages to hold on the balance sheet m_{jc}^b, and how many to securitize, $m_{jc}^{GSE} = \sum_c \left(m_{jcc} - m_{jcc}^b\right)$. Then the lenders' chooses interest rates, and the amount of conforming mortgages to hold on the balance sheet by maximizing the following profits:

$$max_{\boldsymbol{r_j}, m_{jc}^b} \underbrace{\sum_{cg} r_{jcg} m_{jcg}}_{rate\ income} - \underbrace{\sum_{cg} m_{jcg} w_{jg}}_{origination\ cost} - \underbrace{\left(m_{jc}^{GSE}\sigma_j^{GSE} + \left(m_{jc}^b + m_{jcnc}^b\right)\sigma_j^p\right)}_{financing\ cost} \tag{S.4}$$

Intermediaries' profits comprise interest rate income (either collected by themselves, or through servicing rights), origination costs, and financing costs. Note that interest rates enter profits both directly and indirectly through market shares. In other words, the amount of mortgages originated, m_{jcg}, is implicitly a function of both the interest rates of the lender $\boldsymbol{r_j}$, and other lenders $-\boldsymbol{r_j}$, which we omit for ease of notation.

Equilibrium

We study symmetric equilibria. Demand is characterized by consumers' choice of mortgages and market share equations. Consumers maximize utility taking prices and lender characteristics as given. Supply is characterized by intermediaries' maximization in S.4. Banks, non-fintech shadow banks, and fintech shadow banks set mortgage rates across all markets in which they participate. Moreover, banks have to decide how many of the mortgages to hold on hold on the balance sheet.

[8] See, for example, Corbae and D'Erasmo (2018)

V.C Estimation

We estimate the demand and supply parameters separately. To estimate the model, we aggregate the loan level data to market-lender-type observations. A market is defined as an MSA-year-loan purpose, e.g., refinances in New York City in 2013. In each MSA-year, we measure demographic data including means and standard deviations of log incomes and log house prices from the ACS. Within MSA-years, we separate markets into mortgages originated for new purchases and mortgages originated for refinances, the idea being that a borrower looking for one type of loan is not in the market for another type. Among each offering, we adjust conforming and jumbo interest rates by regressing interest rates on FICO and LTV, and then adjusting each individual loan to the overall average FICO and LTV values on the basis of the regression before averaging interest rates within product offering.

In addition to market shares from HMDA and prices from Fannie Mae, Freddie Mac, and Blackbox, we obtain the number of unique lenders (above N_b, N_f, and N_n) by taking the median number of lenders per census tract within the MSA. This captures the typical number of loan offerings from each type of lender that a borrower faces. Market size is defined as the total number of households in the case of new originations and as the total number of outstanding mortgages in the case of refinances.

V.C.1 Demand Estimation

Our estimation roughly follows Berry et al (1995), and Nevo (2000) with several differences. The most important difference is the use of the discontinuity at the conforming loan limit. As is standard, we calculate the model-implied market shares of each offer in each market. We apply the standard contraction mapping given in Nevo (2010) to obtain a vector $\xi_{\cdot c}$ such that model-implied market shares are equal to observed market shares. To instrument for prices exploiting an institutional feature of how GSEs set prices of conforming mortgages. Hurst et. al. (2016), show that GSEs mortgage pricing faced by lenders is not adjust for risk across geographies, leading to de facto differences in mortgage costs across regions. We use these cost shocks to lenders to instrument for mortgage pricing.

In addition to aggregate data, we also exploit several micro-level data moments, specifically, the mean and standard deviation of realized loan sizes for jumbo and conforming loans within a market. These moments help identify the latent distribution of optimal mortgage size.

The most significant departure from standard Berry et al (1995), and Nevo (2000) style estimation is the use of discontinuity at the conforming loan limit. We discuss the nature of the discontinuity extensively in Sections IVB-C. This type of discontinuity has been used in reduced form work to identify the price elasticity of demand. We use two moments around the conforming limit discontinuity. First is the market share of borrowers who obtain conforming loans exactly at the conforming loan limit (see Figure 8 panel a). Intuitively, as the model suggests, these are the borrowers, who would have preferred a jumbo mortgage, but chose a conforming mortgage instead, because of the lower price. The second moment we match is the income difference between borrowers exactly at the conforming loan limit and those nearby (see Figure 8 panel b). This moment aids in identifying the correlation between income, and preferences for a jumbo mortgage, in other words, the structure of the correlation in the random coefficients.

Demand Estimates

We estimate the model over the period 2010-2015. The results are shown in Table 7. Note that time varying parameters on lender quality are also estimated but not shown. Recall that borrowers broadly differ on their price sensitivity, and their preference over mortgage size, both in how large their optimal mortgage is, and how costly departures from the optimal mortgage size are.

One way to evaluate the model fit is to see whether our model can match the size distribution from the data. Figure 9 shows the bunching at the conforming loan limit generated by our model, versus the actual amount of bunching observed in the data. The model fits the data quite closely, both in qualitatively replicating the bunching patters, as well as quantitatively matching the extent of bunching in the data.

Price sensitivity

Our estimates of mean price sensitivity suggest that borrowers are quite price elastic, and the differences in price elasticity are small. The mean parameter $\bar{\alpha} = 0.67$ implies a price elasticity of roughly 2.7. This estimate is close to DeFusco and Paciorek (2017), who estimate the elasticity from the conforming loan discontinuity using reduced form methods. The estimate of $\sigma_{\alpha}^{2} = .06$ suggests that borrower differences in price elasticity are relatively small, ranging from 2.2 to 3.2 for borrowers two standard deviations below the mean, and borrowers with two standard deviations above the mean in price sensitivity. Second, we find that price elasticity is decreasing in borrower income, i.e. wealthier borrowers are less sensitive to higher interest rates. Moreover, borrower in higher house price areas are less price elastic. Since jumbo mortgages cater to wealthier borrowers in high house price areas, this implies that they cater to a less price elastic part of the borrower population, allowing, all else equal, higher mark-ups earned on these mortgages.

Optimal mortgage size

The preference over mortgage size is a central driver of consumers choosing jumbo versus conforming mortgages. The optimal mortgage size is larger for wealthier individuals, with an elasticity of 0.32. In other words, as income rises by 1%, the desired mortgage size increases by 0.3%. This estimate is not far from the heuristic that an average household should not exceed 30% of income. The preferences over mortgages also increase with house prices, with an elasticity of approximately 0.5. When borrowers depart from their optimal mortgage size, they find this departure costly. For borrowers who would otherwise prefer a jumbo mortgage, we estimate a mean disutility of taking a smaller loan to be $\bar{\beta} = 2.89$, which is equivalent to a roughly 4.5% higher interest rate. Similarly, for example, borrowers do not want to borrow mortgages, which are too large, which is estimated as a preference over conforming mortgages. These parameters are identified primarily off of the amount of bunching at the conforming loan limit: Greater disutility from taking a smaller loan means that more borrowers will choose jumbo loans rather than bunch at the conforming limit.

Third, we find that borrowers with high income are less sensitive to taking smaller loans, while borrowers with high house prices are more sensitive to taking smaller loans. This is an intuitive finding: High-income borrowers are likely to be able to adjust to smaller loan sizes by putting up more of their own money. Borrowers buying high-price homes, on the other hand, are more dependent on larger loan sizes and consequently are less willing to substitute a small conforming loan for a large jumbo loan. Fourth, we a positive preference for conforming loans overall as opposed to jumbo loans, possibly reflecting the fact that lenders steer borrowers towards more standardized conforming loans. Finally, unsurprisingly, borrowers with higher house prices are significantly more likely to seek larger loan sizes.

V.C.2 Supply Estimation and Results

To estimate the supply-side parameters, which govern intermediaries' behavior, we use the revealed preferences of intermediaries when setting interest rates, and choosing how many loans to retain on the balance sheet. We estimate parameters governing the costs of origination for the three types of intermediaries we observe, the financing cost of balance sheet lending, as well as costs of originate-to-distribute. Intuitively, using demand estimates we can compute the mark-ups that intermediaries earn. We use the pricing decisions, combined with the mark-ups to infer the costs of lending. For example, if an intermediary is charging higher prices, for a given level of mark-up, this will imply this intermediary is facing higher lending costs, which it is passing on to consumers. Recall that for banks, the costs of portfolio lending cost depends on their capital ratios, the current statutory capital, which in turn depends on the statutory capital ratio $\bar{\rho}$ and other parameters such as the risk weights, ξ_g and ξ_j, and the type of mortgage. If low capitalization is indeed the cause of higher cost of portfolio lending, then the model implies how this higher costs should be passed through to different types of mortgages, given estimated demand. Table 8 shows the estimated parameters.

Because we estimate costs using intermediaries' pricing decisions, we cannot separate the baseline origination and financing costs. Intuitively, if a bank's baseline financing costs increase by 0.5% (50 basis points), but origination costs decline by 0.5%, the costs of making a loan do not change. With that in mind, the baseline costs of originating and financing a mortgage is varies from 2.3% – 2.8%. This number represents the cost of financing and originating a new purchase mortgage for a bank, which is flush with capital.

To better understand the different costs of mortgages, Figure 10 plots total marginal costs for different levels of excess bank capitalization, defined as the difference between the bank's capital ratio and the statutory requirement, $\rho - \hat{\rho}$. Several things stand out. First, well capitalized banks have a cost advantage over shadow banks. Their origination costs are 6pp-9pp lower. Second, their financing costs are approximately 4bp lower. Overall, well capitalized banks command an approximately 10bp premium in funding costs of conforming mortgages.

Second, financing jumbo mortgages is more expensive than financing conforming mortgages, even when the latter are held on the balance sheet. Jumbo mortgages' risk weight is 2.5 that of conforming mortgages, i.e. a dollar in a jumbo mortgage tightens the capital constraint more than a dollar of conforming mortgages, resulting in higher financing costs. This difference declines with bank capitalization. In other words, if the capital constraint is loose, then a higher risk weight has a small cost. For a bank, whose capital exceeds the statuary capital by 3%, the additional financing cost is 30 basis points; at 10% of capital above the statuary limit, the cost difference declines to approximately 5 basis points.

Quantitatively, these numbers are reasonable. In 2009, a time period outside of the estimation window, the typical bank originator of a jumbo loan had an excess capital ratio of roughly 7%. According to our model, this corresponds to a roughly 3.1% marginal cost. At the same time, the typical bank origination of a conforming loan had an excess capital ratio of roughly 6.7%, which corresponds to roughly a 2.5% marginal cost. This implies a conforming-jumbo marginal cost, which is roughly in line with the observed rate spread in Figure 1.

Last, the model suggests that originating refinancing mortgages is less costly than originating mortgages for purchase, approximately 15-20 basis points. In refinancing, lenders benefit from many on-the-ground activities having already taken place at the time of purchase, such as a title check, structural examination, negotiations between buyer and seller, saving costs.

VI. Counterfactual Policy Analysis

In this section, we use the estimated model to study the consequences of several policy changes. We study the changes that policies have on overall lending. One important aspect that our model allows us to study is the extent of redistribution from these policies. As we highlight, several policies result in changes in market structure, funneling borrowers, and therefore profits, from banks to shadow banks, and vice versa. Banking profits, as well as the extent of loans held on the balance sheets of banks have important implications for bank stability. Second, the policies have a differential impact across borrowers of different incomes, changing the level of inequality. Last, but critical, our counterfactuals highlight the importance of accounting for shadow banks in analyzing banking and mortgage market policies.

VI.A Changes to Bank Capital Requirements

We first study the consequences of changing capital requirement. The level of the capital requirement is one of the main tools used by policy makers to regulate banks. The capital requirement was 4% in 2010 and increased in several increments to 6% in 2015. Taking the 2015 market as given, we counterfactually study the impact of the capital requirement being eliminated, set at 4.5%, 7.5%, 9%, 12%, and 30%. Table 9 shows the results.

Increasing capital requirements tightens the capital constraint, increasing banks' cost of lending on the balance sheet. As we show below, lowering capital requirements would primarily affect the share of mortgages held on bank balance sheets, but would otherwise have little effect on mortgage origination. Raising capital requirements, on the other hand, would decrease the share of mortgage on bank balance sheets, but also lead to substantial changes in mortgage origination. This additional stability in the banking sector would come at a cost of substantially fewer jumbo mortgages, which would partially be offset with more conforming originations. The decline of the jumbo market would be mostly felt by higher income individuals. In other words, tightening capital requirements trades-off bank stability with welfare of high income consumers, and bank profits.

Mortgage Origination and Redistribution

The effect of changing capital requirements has an asymmetric impact on mortgage origination. Even eliminating capital requirements would result in very modest changes in the origination of mortgages. The total volume would increase by $24 billion to $1,787 billion, with a slight increase in jumbo lending relative to conforming mortgages. The market structure of lending would not change much either with a 2 basis point decline in the interest rate. Both high income borrowers and banks benefit from loosening capital requirements, but the benefits are small, with consumer surplus increasing by less than 1% and bank profits by 2% if capital requirements fall to 4.5%.

Increasing capital requirements, on the other hand, does change mortgage originations. The largest impact is on the jumbo market, which services high income and high house price markets. As capital requirements increase, banks start retreating from jumbo mortgages. Consider the capital requirement of 9%. Jumbo lending decreases by $152 billion, or 41%. The large decrease in the supply of jumbo mortgages results in an 53 basis point increase in jumbo rates, while the average rate remains unchanged, resulting in a large increase in the jumbo spread. A substantial amount of borrowers who would have borrowed jumbo still obtain mortgages: $65 billion worth of mortgages shift to conforming market. The rest of the borrowers, exit the mortgage market completely, resulting in a $87 billion decrease in mortgage lending. Banks manage to capture approximately $31 billion of this additional conforming mortgages, and shadow banks $34 billion. One reason why banks cannot capture a large share of the switchers is because financing those conforming mortgages, which were retained on the balance sheet becomes more expensive.

The primary losers of higher capital requirements are banks and high income borrowers. Given the capital requirement of 9%, high income borrowers lose $34 billion (8%) of consumer surplus. These losses have to be weighed against possible welfare gains of moving risk from bank balance sheets (see, for example, Egan et al (2017)).

Bank Stability

There are two dimensions through which capital requirements affect bank stability: holding mortgage risk on bank balance sheets, and bank profits. Even a small reduction in capital requirements would results in a large increase in the share of loans held on the bank balance sheets. Reducing capital requirements to 4.5% would expand the balance sheet holdings of mortgages by 50% ($350 billion annually). Conversely, the primary consequence of increasing capital requirements is a large decline in on-balance sheet lending. As capital requirements increase and balance sheet financing becomes significantly more expensive, the share of balance-sheet financed lending drops from 41% to 14%, banks' balance sheet holdings of mortgages by 68%. Offsetting somewhat the decrease in risk is also a decrease in expected bank profits, which decline with tighter capital requirements.

As capital requirements tighten, banks switch their business model substantially, from portfolio lending to originate-to-distribute. Thus, even a moderate increase in capital requirements substantially decreases mortgage risk on bank balance sheets, decreasing the risk born by banks. This risk is instead shifted to GSEs, and indirectly taxpayers, who insure securitized mortgages.

VI.B Changes to Conforming Loan Limits

We next consider changing the conforming loan limits. This current policy sets the reach of GSE financing in the mortgage market, and does so differentially across markets. This policy has been actively changed since the beginning of the crisis, with the explicit purpose of intervening in the mortgage market. Prior to 2008, GSE mortgages were limited to a $417,000 cap. As we illustrate in Figure 1, at the beginning of the crisis the jumbo market experienced a contraction, which was particularly relevant for high housing cost markets. In order to increase lending in these areas, their GSE loan limit was increased to $729,750. Since 2015, the conforming loan limits is $417,000 in most counties. The policy of higher limits has persisted, since then, although the limit for high cost areas was reduced most recently in 2015 to $625,000.

Changing the limit allows us to understand the impact of GSEs on the mortgage market at the extensive margin, shifting loans from jumbo to conforming. Second, because the policy caps loan amounts, its consequences potentially differ substantially across markets with different house prices, and households with different mortgage demand. We consider effectively eliminating GSE financing altogether by lowering the conforming limit by 99%, as well as expanding the role of GSEs to the whole market by removing the limit. We also change the limit amounts to by +/- 25%. Last, we explore the effect of changing the policy to its pre-crisis version with a nationwide limit of $417,000 limit, and setting the limit nationwide to the $625,000 limit. These results are shown in Table 10.

The effect of removing GSE financing is to sharply reduce lending, and to make all lending that *does* take place to be non-conforming and hence financed on bank balance sheet. Relative to the baseline, total lending is roughly 75% lower, with consumer welfare being 70% lower. In other words, a large part of the U.S. mortgage market is critically dependent on GSE financing. Somewhat surprisingly, bank profits decline only moderately, falling by 4%. In effect, when *all* lending must go through banks, banks are able to charge significantly higher markups because they possesses a large amount of market power.

We next discuss the converse change, expanding GSEs coverage to the whole mortgage market. This (somewhat extreme) counterfactual highlights the re-distributive impact of expanding GSE coverage because of the changed market structure. Banks are not eliminated, but have a slightly lower market share of 50%. On-balance sheet lending also persists, but shrinks from about $750 to $400 billion. Intuitively, balance sheet capacity from subsidized deposits confirms a financing advantage on banks, which they mainly direct at the jumbo market, but can use in conforming lending. Raising conforming limits to encourage originate-to-distribute activity is not sufficient to eliminate mortgage risk from bank balance sheets. Despite larger lending volumes, bank profits contract by almost $40 billion annually, because mortgage rates significantly decrease. The largest beneficiaries of this policy are high income borrowers, whose borrowing and consumer surplus increase by about 60%. This illustrates the large benefit these households derive from being able to borrow at the close to conforming rates, and loans of optimal size.

The broad consequences of increasing and decreasing conforming loan limits are confirmed in more moderate counterfactuals. One interest fact is that bank profits are non-monotonic in the conforming limit. Both bank profits and total lender profits follow an inverse-U pattern in the conforming loan limit: Bank profits increase initially as loan volumes increase, but then decrease significantly as larger and larger loan sizes become eligible for GSE financing and the high-markup jumbo loan share declines. Consumer welfare, on the other hand, increases monotonically in the GSE limit.

Finally, it is interesting to consider the two scenarios of unifying conforming loan limits across counties. Column (6) considers setting all limits to the $417,000 lower limit; Column (7) considers setting all limits to the $625,000 higher limit. While lowering the limit decreases consumer welfare overall and raising the limit increases consumer welfare overall, these gains are not evenly distributed. In particular, leveling down to $417,000 has essentially no impact on low-income MSA welfare or lending volume, while it significantly reduces high-income MSA welfare and lending volume. Likewise, leveling up to $625,000 has essentially no impact on low-income MSA welfare or lending volume and significantly increases high-income MSA welfare and lending volume.

To summarize, the jumbo loan limit has significant effects not only on overall lending volumes and lender market shares, but on the distribution of welfare and profits in the mortgage market. Extending jumbo limits beyond their current level further increases consumer welfare, but these gains are primarily felt in the highest-income MSAs, as is the impact of the current policy of having higher limits in high-cost MSAs. The consequences of this policy for the distribution of mortgage risk in the economy are relatively limited, with banks retaining substantial amounts of mortgages on their balance sheets.

VI.C Quantitative Easing and GSE Market Intervention

One of the major policies during the last financial crisis was the sequence of policies referred to as of quantitative easing (QE), during which the Federal Reserve purchased large amount of GSE guaranteed mortgages, hoping to decrease the rates at which borrows were able to access mortgages, and expand mortgage lending. Estimates of the impact vary across different QE operations, decreasing mortgage rates between 20-100bp. We model QE as a change in the GSE financing costs, which was the intent of the policy. We also experiment with increasing GSE rates to better understand the implications of the policy. These results are shown in Table 11.

One can compare the QE intervention with that of relaxing capital requirements, since QE was used in part to encourage lending by banks, which had experienced a contraction in capital. Both policy interventions result in more mortgages, but impact different parts of the mortgage market, have markedly different consequences for how mortgage risk is allocated in the economy, and impact different parts of the mortgage market.

The main effect of QE is to increase conforming mortgage lending volumes significantly: even a 25 basis point decrease in rates leads to approximately $110 billion of new mortgage originations. Because these rates apply to conforming loans only and not to jumbo loans, the impact on jumbo loans is minimal. The impact is larger for lower income borrowers, increasing their surplus by 17%, relative to 9% for high income borrowers. In other words, shocks to bank capital disproportionately fall on higher income borrowers, and QE largely helps lower income borrowers.

In addition to expanding the conforming mortgage market, QE also changes the incentive to keeping loans on the balance sheet. In fact, conforming loans comprise half of balance sheet lending in the baseline ($370 billion). Even a slight decline in GSE funding costs creates large enough incentives to more these loans from the balance sheet to be securitized. In other words, QE shifts conforming loans off the balance sheet even on the intensive margin. QE also expands bank profits, increasing them by 10% for a 25bp decrease in GSE rates. This differs from capital requirements, which shift also shift loans from the balance sheet, but do so by contracting lending and bank profits.

We next study an increase in GSE funding costs, which is not a mirror image of the decrease. For example, increasing GSE funding costs has large effects on bank market shares; in case of a 100bp increase bank market share climbs to 74%. Lending volumes overall decrease by 20%, and balance sheet financing share increases substantially, from 42% to 74%. This is consistent with a significant substitution away from GSE financing and towards bank balance sheet financing, which manifests as large distributional changes and more muted total volume changes. In other words, once GSE financing costs increase, the cheap on-balance sheet funding of banks gives them a large comparative advantage. Shadow bank volume shrinks substantially, by almost half.

Bank profits initially decline as GSE costs increase, because lending volumes decrease overall. However, for larger increases in GSE costs, borrowers substitute more and more towards jumbo loans, and bank profits increase by a small amount in absolute terms. When considering bank profits as a share of total profits and consumer welfare, the increase from the baseline to the +100bps scenario, bank share of profits increases by roughly 11% and bank share of overall welfare increases by roughly 6%. Profit share of profit plus welfare increases by roughly 1%, meaning that non-bank profit share decreases significantly.

Finally, while overall interest rates vary monotonically with changes in GSE financing costs, the ability to substitute towards banks, which themselves can substitute towards balance sheet financing, means that the changes in interest rates are somewhat asymmetric around the baseline case. As GSE rates decrease, nearly all financing moves towards GSEs, and consequently interest rates vary essentially one-to-one with GSE rates as GSE rates decease: A 100 basis point decrease in GSE financing costs corresponds roughly to a 90bp decrease in average interest rates, from 3.92% in the baseline case to 2.82% in the -100bp case. Contrast this near one-to-one correspondence the effect of a 100bps increase. A 100bp increase in GSE financing costs raises average interest rates by less than 40 basis points. This reflects the presence of bank financing substitutes as GSE financing becomes very expensive.

VI.D Counterfactual Policy Analysis: Importance of Shadow Banks

Frequently, policy analysis of banking or mortgage market regulation is restricted to banks. One reason is data availability. Because regulators are provided data from banks, which they regulate, it is natural to analyze policy using those data. Second, because the focus of the analysis is the banking sector, it is natural to analyze models which focus on the behavior of banks. When banks are the sole participants in the market, or when there is little interaction between banks and other lenders, then this restriction may be fairly innocuous. In this section we briefly describe some of the issues that can arise when one does not account for shadow banks in the policy analysis of the mortgage market.

Consider the effect of tightening capital requirements, a policy that is directly targeted at banks. As our analysis above reveals, focusing on banks leads to significantly overstating the consequences for mortgage lending. Consider increasing capital requirements to 9%. Our model suggests that the overall volume of mortgage lending would decline by 5%, while focusing on bank lending would suggest a decline of 11%. In other words, instead of responding like banks, and shrinking their lending, shadow banks actually increase their lending in the conforming market. Second, the model suggests that the impact is limited to the jumbo market, which, in aggregate, presents a smaller share of the market.

One might conclude that omitting shadow banks is problematic, because it *overestimates* the impact of that a given policy can have on the mortgage market. Ignoring the differences between banks and shadow banks, and solely focusing on bank data can also severely *underestimate* the effect of policies. For example, consider increasing the cost of GSE funding by 100 basis points. Even this seemingly large policy change has practically no effect on the amount of mortgages originated by banks: the amount of jumbo and conforming lending by banks remains practically unchanged. The overall lending in the conforming market, on the other hand, declines substantially, by over $300 billion. In other words, focusing on banks ignores the large contraction in shadow banking, which is dependent on GSE funding. Banks can adjust by moving these conforming loans on the balance sheet, and offsetting these costs by charging higher interest rates. The contraction in quantity and increase in lending rates lead to a $50 billion consumer surplus loss. In other words, focusing the analysis only on banks significantly underestimates the impact of increasing GSE funding, because banks can adjust to these shocks, while shadow banks cannot.

Overall, this analysis suggests that a complete policy analysis of the mortgage sector critically requires analyzing simultaneously the impact of the policy on banks and shadow banks, and accounting for their equilibrium interaction. The strategic response of the shadow bank sector plays an important role in the *nature* and *magnitude* of such effects, accounting for more than 70 percent of the aggregate response in some cases.

Section VII: Conclusion

In this paper we document large changes in the market structure of the U.S. mortgage market from 2007 to 2016. The market experiences large changes over time in which type of mortgages were originated, by which financial intermediaries, and at which prices. We link these changes to the balance sheet capacity of the banking sector, and its interaction with the shadow banking sector. The consistent view, which emerges from our result is one of market segmentation driven by comparative advantage. Traditional banks hold a comparative advantage in originating loans to wealthier parts of the population; this advantage arises because deposits financing reduces the cost of holding jumbo loans on the balance sheet. This advantage is limited by capital requirements. As these requirements tighten, or banks loose capital, their comparative advantage shrinks, and they have to originate-to-distribute in the conforming market, in which they compete with shadow banks. Because of additional regulation that comes with deposit taking, traditional banks are at a regulatory disadvantage when it comes to originate-to-distribute banking. This disadvantage has been increasing since 2012, leading to larger growth in shadow banking.

Motivated by this evidence, we recognize the importance of shadow banks and alternative bank business models in a new structural credit market framework that allows us to rethink regulation and policy of banking. We then use this framework to assess the effects of alternative polices, including changes in bank capital requirements, government credit subsidies, and unconventional monetary policy. We find that all of these factors lead to significant changes in the equilibrium quantity, pricing, and distribution of mortgage credit. Importantly, a strategic response of the shadow bank sector play an important role in the nature and magnitude of these effects, accounting for more than 70 percent of the aggregate response in some cases. Ignoring the differences between banks and shadow banks, and solely focusing on bank data can both severely underestimate or overestimate the effects depending on a specific policy. Finally, interventions which affect only one type of lender have significant redistribution consequences.

Our findings have a number of implications. First, they suggest that a complete policy analysis of the lending market critically requires analyzing simultaneously the impact of the policy on banks and shadow banks, and accounting for their equilibrium interaction. In particular, our paper highlights the fact that banking regulation determines market structure through the equilibrium interaction with shadow banks. Any regulation, which affects a part of the intermediation market, spills over to other markets through competition, and affect which products are offered by which firms, as well as equilibrium prices. Because of market segmentation, policies have distributional consequences, which are determined in equilibrium. Therefore, policy and regulatory changes cannot be considered without a full view of the market equilibrium. This observation does not only apply to the residential mortgage market, the focus our study, but to any credit market with a large presence or possible entry of shadow banks.

Second, our results suggests that traditional policy tools including capital ratios and other bank capital regulatory requirements may be of limited effectiveness and have unintended consequences. This observation suggests that future policy and regulations may want to develop tools also targeting the shadow bank sector.

Third, our paper highlights that the line between traditional and shadow banks from a functional perspective is not clearly determined, but is driven by the capitalization of banks, and the banking sector. Well capitalized banks indeed behave as traditional models of banking suggest: they take deposits, and use them to make loans, which they hold to maturity. Poorly capitalized banks, on the other hand, do not have balance sheet capacity, and behave like shadow banks, originating loans and selling them off. The ability to do so allows these banks to originate loans despite depressed capital, offsetting some of the effect of capital tightening.

More broadly, our paper suggests that one has to take a broad view of government insurance subsidies and regulation, if one is to understand their impact on the financial intermediation system. On the one hand, traditional banks exploit cheap insured deposit financing that their franchise gives them access to. On the other, shadow banks, and poorly capitalized banks lean predominantly use GSE insured mortgages. Our results suggest that as subsidies for banks in one sector decline, for example, because of restrictive capital requirements, they more to the other source of subsidies. We believe that better understanding the web of subsidies and regulations that pervades the financial system, how they interact in equilibrium, and their impact on systematic risk and welfare is a fruitful area for future research.

References

Acharya, Viral V., Matthew Richardson, Stijn Van Nieuwerburgh, and Lawrence J. White. 2011, Guaranteed to fail: Fannie Mae, Freddie Mac, and the debacle of mortgage finance. *Princeton University Press*.

Adrian, Tobias, and Adam B. Ashcraft, 2016, “Shadow banking: A review of the literature." In Banking Crises, pp. 282-315. *Palgrave Macmillan UK.*

Agarwal, Sumit, David Lucca, Amit Seru, and Francesco Trebbi, 2014, Inconsistent regulators: Evidence from banking, *Quarterly Journal of Economics* 129, 889-938.

Agarwal, Sumit, Gene Amromin, Itzhak Ben-David, Souphala Chomsisengphet, Tomasz Piskorski, Amit Seru, 2017, Policy Intervention in Debt Renegotiation: Evidence from Home Affordable Modification Program, *Journal of Political Economy* 125, 654-712.

Agarwal, Sumit, Gene Amromin, Souphala Chomsisengphet, Tomasz Piskorski, Amit Seru, and Vincent Yao, 2015, Mortgage refinancing, consumer spending, and competition: Evidence from the home affordable refinancing program, NBER working paper 21512.

Benetton, Matteo, 2018, Leverage regulation and market structure: An empirical model of the UK mortgage market, working paper.

Berndt, Antje, and Anurag Gupta, 2009, Moral hazard and adverse selection in the originate-to-distribute model of bank credit, *Journal of Monetary Economics* 56, 725-743.

Bhutta, Neil, 2012, GSE activity and mortgage supply in lower-income and minority neighborhoods: The effect of the affordable housing goals, *Journal of Real Estate Finance and Economics* 45, 238-261.

Bord, Vitaly M., and João AC Santos, 2012, The Rise of the Originate-to-Distribute Model and the Role of Banks in Financial Intermediation, *Economic Policy Review* 21.

Buchak, Greg, Gregor Matvos, Tomasz Piskorski, and Amit Seru, 2017, Fintech, Regulatory Arbitrage, and the Rise of Shadow Banks, forthcoming in the *Journal of Financial Economics*.

Cox, Natalie, 2017, Pricing, Selection, and Welfare in the Student Loan Market: Evidence from Borrower Repayment Decisions, working paper.

Di Maggio, M., A. Kermani, C. Palmer, 2016, How Quantitative Easing Works: Evidence on the Refinancing Channel, working paper.

Di Maggio, M., A. Kermani, B. Keys, T. Piskorski, R. Ramcharan, A. Seru, V. Yao, 2017, Interest Rate Pass-Through: Mortgage Rates, Household Consumption and Voluntary Deleveraging, *American Economic Review* 107, 3550-88.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, 2017, The Deposits Channel of Monetary

Policy, *Quarterly Journal of Economics* 132, 1819-1876.

Elenev Vadim, Tim Landvoigt, and Stijn Van Nieuwerburgh, 2016, Phasing Out the GSEs, *Journal of Monetary Economics* 81, 111-132.

Erickson, T., Whited, T.M., 2002. Two-step GMM estimation of the errors-in-variables model using high-order moments. *Econometric Theory* 18, 776–799.

Fligstein, Neil, and Alexander F. Roehrkasse, 2016, The Causes of Fraud in the Financial Crisis of 2007 to 2009: Evidence from the Mortgage-Backed Securities Industry, *American Sociological Review* 81, 617-643.

Fuster, Andreas, Lo, Stephanie and Willen, Paul, 2017, The Time-Varying Price of Financial Intermediation in the Mortgage Market, Federal Reserve Bank of New York, Staff Report No. 805.

Fuster, Andreas, Matthew C. Plosser, Philip Schnabl, James I. Vickery, 2018, The Role of Technology in Mortgage Lending, working paper.

Gete, Pedro, and Michael Rehrer, 2017, Nonbanks and Lending Standards in Mortgage Markets. The Spillovers from Liquidity Regulation, working paper.

Gennaioli, Nicola, Andrei Shleifer, and Robert W. Vishny, 2013, A Model of Shadow Banking, *Journal of Finance* 68, 1331–1363.

Granja, João, and Christian Leuz. The Death of a Regulator: Strict Supervision, Bank Lending and Business Activity. No. w24168. National Bureau of Economic Research, 2017.

Granja, João, Gregor Matvos, and Amit Seru, 2014, Selling failed banks, forthcoming in the *Journal of Finance.*

Greenwood, Robin, and David Scharfstein, 2013, The growth of finance, *Journal of Economic Perspectives* 27, 3-28.

Haughwout, Andrew, Ebiere Okah, and Joseph Tracy, 2016, Second chances: Subprime mortgage modification and redefault, *Journal of Money, Credit and Banking* 48, 771-793.

Hurst, Erik, Benjamin J. Keys, Amit Seru, and Joseph Vavra, 2016, Regional redistribution through the US mortgage market, *American Economic Review* 106, 2982-3028.

Keys, Benjamin J., Tanmoy Mukherjee, Amit Seru, and Vikrant Vig, 2010, Did securitization lead to lax screening? Evidence from subprime loans, *Quarterly Journal of Economics* 125, 307-362.

Keys, Benjamin J., Tomasz Piskorski, Amit Seru, and Vikrant Vig, 2013, Mortgage financing in the housing boom and bust. In *Housing and Financial Crisis*, edited by Edward L. Glaeser and Todd Sinai, 143-204, University of Chicago Press

Koijen, Ralph S.J. and Motohiro Yogo, 2016, Shadow Insurance, *Econometrica* 84, 1265-1287.

Lucca, David, Amit Seru, and Francesco Trebbi, 2014, The revolving door and worker flows in banking regulation, *Journal of Monetary Economics* 65, 17-32.

Mayer, Christopher, Edward Morrison, Tomasz Piskorski, and Arpit Gupta, 2014, Mortgage modification and strategic behavior: Evidence from a legal settlement with Countrywide, *American Economic Review* 104, 2830-2857.

Mian, Atif, and Amir Sufi, 2009, The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis, *Quarterly Journal of Economics* 124, 1449-96.

Ordonez Guillermo, 2018, Sustainable Shadow Banking, American Economic Journal: Macroeconomics, 10(1), 1-25.

Piskorski, Tomasz, Amit Seru, and Vikrant Vig, 2010, Securitization and distressed loan renegotiation: Evidence from the subprime mortgage crisis, *Journal of Financial Economics* 97, 369-397.

Piskorski, Tomasz, Amit Seru, James Witkin, 2015, Asset quality misrepresentation by financial intermediaries: Evidence from the RMBS market, *Journal of Finance* 70, 2635-2678.

Purnanandam, Amiyatosh, 2011, Originate-to-distribute model and the subprime mortgage crisis." *Review of Financial Studies* 24, 1881-1915.

Rajan, Uday, Amit Seru, and Vikrant Vig, 2015, The failure of models that predict failure: Distance, incentives, and defaults, *Journal of Financial Economics* 115, 237-260.

Stanton, Richard, Nancy Wallace, and Jonathan Walden, 2014, The industrial organization of the U.S. residential mortgage market, *Annual Review of Financial Economics* 6, 259-288.

Stanton, Richard, Nancy Wallace, and Jonathan Walden, 2017, Mortgage loan-flow networks and financial norms, forthcoming in the *Review of Financial Studies*.

Table 1: Origination and Financing of Conforming Loans---Banks versus Shadow Banks

This table shows the regression discontinuity of financing source and originator type around the conforming loan limit. Panel A considers balance sheet lending versus outside financing. The left-hand side variable is an indicator for whether the loan is financed on balance sheet or sold to an affiliate institution. Panel B considers bank originators versus shadow bank originators. The left-hand side variable is an indicator for whether the originator is a traditional bank. In both panels, columns (1)-(4) use the 2007-2015 sample; (5)-(8) use 2015 originations only. Columns (1)-(4) and (5)-(8) consider discontinuity widths from +/-1%, 5%, 10%, and 25% around the conforming loan limit. Controls include log loan amount, log applicant income, dummy variables for applicant race, ethnicity, sex, loan type, loan purpose, occupancy, and property type, and census tract-year fixed effects. Standard errors in parentheses are clustered at the lender-year level.

Panel A: Balance Sheet Financing

	2007-2015 Sample				2015 Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Discontinuity Width	+/- 1%	+/- 5%	+/- 10%	+/- 25%	+/- 1%	+/- 5%	+/- 10%	+/- 25%
Non-Conforming	0.503***	0.452***	0.440***	0.424***	0.628***	0.542***	0.507***	0.469***
	(0.026)	(0.020)	(0.019)	(0.017)	(0.046)	(0.039)	(0.033)	(0.030)
Loan-Level Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tract-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,152,391	2,136,598	3,249,506	7,679,499	104,713	216,897	348,413	850,795
R^2	0.271	0.259	0.254	0.228	0.359	0.335	0.322	0.287

Panel B: Originator Type = Bank

	2007-2015 Sample				2015 Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Discontinuity Width	+/- 1%	+/- 5%	+/- 10%	+/- 25%	+/- 1%	+/- 5%	+/- 10%	+/- 25%
Non-Conforming	0.245***	0.217***	0.203***	0.183***	0.384***	0.328***	0.301***	0.266***
	(0.020)	(0.015)	(0.014)	(0.012)	(0.030)	(0.029)	(0.027)	(0.026)
Loan-Level Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tract-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,152,391	2,136,598	3,249,506	7,679,499	104,713	216,897	348,413	850,795
R^2	0.308	0.259	0.231	0.200	0.314	0.259	0.230	0.196

Table 2: Balance Sheet Retention

This table shows the results of specifications, which consider the source of traditional bank financing for originated mortgages. Observations are at the bank-year level. Left-hand side variables are the percentage of originated loans retained on balance sheet within the calendar year for the given lender. Data are from HMA and the Federal Reserve call reports. Columns (1) and (2) are in levels, Columns (3) and (4) are in differences. Right-hand-side variables are in levels for columns (1) and (2) and in differences for columns (2) and (4). All columns have year fixed effects; Columns (2) and (4) additionally include lender fixed effects. Standard errors in parenthesis.

	Specification:			
	% Held (Levels)		% Held (Changes)	
	(1)	(2)	(3)	(4)
Capital Ratio	3.166***	4.467***	1.949***	2.407***
	(0.349)	(0.521)	(0.466)	(0.537)
Log(Originations)	-0.155***	-0.232***	-0.112***	-0.139***
	(0.015)	(0.027)	(0.025)	(0.027)
Log(Unique CTs)	0.046***	0.154***	0.083**	0.081*
	(0.016)	(0.040)	(0.040)	(0.043)
Log(Avg Loan Income)	0.481***	0.627***	0.651***	0.619***
	(0.050)	(0.072)	(0.057)	(0.059)
Log(Avg Loan Size)	-0.335***	-0.258***	-0.047	-0.035
	(0.028)	(0.041)	(0.040)	(0.043)
Log(Bank Assets)	0.037***	0.004	0.016**	0.014*
	(0.005)	(0.008)	(0.008)	(0.009)
Deps/Total Liabilities	-0.446***	-0.241*	-0.297**	-0.259**
	(0.064)	(0.124)	(0.117)	(0.128)
Year FE	Y	Y	Y	Y
Lender FE	N	Y	N	Y
N	1,224	1,224	1,223	1,223
R^2	0.422	0.702	0.269	0.284

Table 3: Origination and Financing of Conforming Loans---Bank Capitalization

This table shows the regression discontinuity of financing source and originator type around the conforming loan limit. Panel A considers balance sheet lending versus outside financing. The left-hand side variable is an indicator for whether the loan is financed on balance sheet or sold to an affiliate institution. Panel B considers bank originators versus shadow bank originators. The left-hand side variable is an indicator for whether the originator is well-capitalized. In both panels, columns (1)-(4) use the 2007-2015 sample; (5)-(8) use 2015 originations only. Columns (1)-(4) and (5)-(8) consider discontinuity widths from +/-1%, 5%, 10%, and 25% around the conforming loan limit. Controls include log loan amount, log applicant income, dummy variables for applicant race, ethnicity, sex, loan type, loan purpose, occupancy, and property type, and census tract-year fixed effects. Standard errors in parentheses are clustered at the lender-year level.

Panel A: Balance Sheet Financing

	2007-2015 Sample				2015 Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Discontinuity Width	+/- 1%	+/- 5%	+/- 10%	+/- 25%	+/- 1%	+/- 5%	+/- 10%	+/- 25%
Non-Conforming	0.566***	0.515***	0.508***	0.499***	0.666***	0.587***	0.532***	0.477***
	(0.037)	(0.026)	(0.025)	(0.024)	(0.068)	(0.045)	(0.033)	(0.024)
Loan-Level Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tract-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	313,788	580,777	883,273	2,047,329	24,923	57,114	97,493	237,146
R^2	0.442	0.409	0.396	0.352	0.627	0.561	0.522	0.469

Panel B: Originator Type = Well-Capitalized Bank

	2007-2015 Sample				2015 Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Discontinuity Width	+/- 1%	+/- 5%	+/- 10%	+/- 25%	+/- 1%	+/- 5%	+/- 10%	+/- 25%
Non-Conforming	0.087*	0.102***	0.106***	0.099***	0.138	0.151*	0.165**	0.169***
	(0.044)	(0.033)	(0.031)	(0.025)	(0.110)	(0.082)	(0.073)	(0.059)
Loan-Level Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tract-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	313,788	580,777	883,273	2,047,329	24,923	57,114	97,493	237,146
R^2	0.521	0.445	0.393	0.322	0.541	0.379	0.302	0.219

Table 4: The Margin of Balance Sheet Adjustment

This table shows the results of specifications, which study the determination of bank origination financing and product mix, with three additional left-hand-side variables. The regression is at the lender-year level among traditional banks. The left-hand side variable for columns (1) and (2) is % of originations not sold within the calendar year of origination. For columns (3) and (4) the left-hand side variable is percent of originated loans that are jumbo (non-conforming). For columns (5) and (6) the left-hand side variable is % jumbo originations not sold within the calendar year. For (7) and (8) the left-hand side variable is % conforming originations not sold within the calendar year. Columns (1), (3), (5), (7) have year fixed effects. Columns (2), (4), (6), and (8) additionally have lender fixed effects. Standard errors are in parenthesis.

	Dependent variable:							
	% Held		% Jumbo		% Held (Jumbo)		% Held (Conforming)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CR	3.679***	4.818***	0.192**	-0.178*	0.319	-0.454	3.783***	5.176***
	(0.366)	(0.539)	(0.083)	(0.092)	(0.214)	(0.302)	(0.377)	(0.564)
Log(orig)	-0.153***	-0.247***	-0.023***	-0.033***	-0.074***	-0.079***	-0.144***	-0.232***
	(0.016)	(0.028)	(0.004)	(0.005)	(0.010)	(0.015)	(0.017)	(0.029)
Log(CT)	0.011	0.172***	0.010***	0.005	-0.050***	0.015	0.007	0.168***
	(0.016)	(0.041)	(0.004)	(0.007)	(0.012)	(0.022)	(0.017)	(0.043)
Log(Assets)	0.045***	0.004	0.007***	0.001	0.050***	0.001	0.041***	0.004
	(0.005)	(0.008)	(0.001)	(0.001)	(0.003)	(0.005)	(0.005)	(0.009)
Log(Dep/Liab)	-0.356***	-0.172	-0.011	0.156***	-0.228***	-0.271***	-0.368***	-0.254*
	(0.067)	(0.128)	(0.015)	(0.022)	(0.035)	(0.086)	(0.069)	(0.134)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Lender FE	N	Y	N	Y	N	Y	N	Y
Observations	1,226	1,226	1,226	1,226	1,206	1,206	1,226	1,226
R^2	0.359	0.730	0.299	0.836	0.196	0.770	0.361	0.719

Table 5: Supply of Bank Credit and the Borrowing Decisions

Column (1) of both panels shows the first stage regression of bank market share on post times OTS share. Column (2) shows the reduced form regression of bunching share on post times OTS share. Column (3) is the OLS regression of bunched on bank market share. Column (4) is the IV regression of bunched on bank market share instrumented with post times OTS. Panel A uses a narrower bandwidth to define bunched loan sizes, while Panel B uses a wider bandwidth. All columns have year and county fixed effects. Standard errors are in parenthesis.

Panel A: +/- (0.990, 1.001) Bandwidth

	Dependent variable:			
	% Bank	% At Cutoff		
	(1) OLS	(2) OLS	(3) OLS	(4) IV
Post x OTS Share	-0.200***	0.027***	-	-
	(0.009)	(0.002)	-	-
% Bank	-	-	-0.006***	-0.137***
	-	-	(0.001)	(0.013)
Year & County FE	Y	Y	Y	Y
Observations	32,110	32,110	32,110	32,110
R^2	0.902	0.628	0.626	0.516

Panel B: +/- (0.995, 1.001) Bandwidth

	Dependent variable:			
	% Bank	% At Cutoff		
	(1) OLS	(2) OLS	(3) OLS	(4) IV
Post x OTS Share	-0.200***	0.022***	-	-
	(0.009)	(0.002)	-	-
% Bank	-	-	-0.005***	-0.111***
	-	-	(0.002)	(0.013)
Year & County FE	Y	Y	Y	Y
Observations	32,110	32,110	32,110	32,110
R^2	0.902	0.649	0.648	0.588

Table 6: Changes in Conforming Loan Limits and Mortgage Market Outcomes

This table shows the results of regressions at the year-county level. All columns include year and county fixed effects. *Limit Increase* is the percentage increase in the conforming loan limit in a county between 2007 and year *t*. Column (1) regresses jumbo share on this increase. Column (2) regresses the bunched loan share on this increase. Column (3) is the reduced form of bank market share on the limit increase. Column (4) is the OLS of bank share on jumbo origination share. Column (5) is the IV of bank share on jumbo share instrumented with conforming loan limit increases. Standard errors are in parentheses.

	Jumbo Share	Cutoff Share	Bank Share		
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV
Limit Increase	-0.356***	-0.051***	-0.029***	-	-
	(0.003)	(0.001)	(0.003)	-	-
Jumbo Share	-	-	-	0.223***	0.083***
	-	-	-	(0.005)	(0.008)
Year FE	Y	Y	Y	Y	Y
County FE	Y	Y	Y	Y	Y
Observations	32,147	32,147	32,147	32,147	32,147
R^2	0.874	0.696	0.901	0.908	0.905

Table 7: Structural Estimation – Demand Parameters

This table shows the estimated demand parameters. Consumer preferences are given by the equation $\mathrm{B}_i = \overline{\mathrm{B}} + \Pi(D_{ic} - \overline{D}) + \Sigma v_i$, where $\overline{\mathrm{B}}$ is the vector of parameter means, Π is the mapping between demographic characteristics, and Σ scales random shocks. Panels (a), (b), and (c) show the results for $\overline{\mathrm{B}}$, Π, and Σ, respectively.

Panel A: Mean Preference Parameters

	$\overline{\mathrm{B}}$	
Parameter	Estimate	Description
$\bar{\alpha}$	0.67	Price
$\bar{\beta}$	2.89	Disutility from smaller loan
$\bar{\gamma}$	-2.38	Conforming preference
$\log \bar{F}$	12.09	Log loan size

Panel B: Demographic-Preference Relationships

		Π	
Parameter	Estimate (logIncome)	Estimate (logPrice)	Description
α_i	-0.12	-0.03	Price Elasticity
β	0.13	-0.19	Disutility from smaller loan
γ	0.33	0.46	Conforming preference
$\log F_i$	0.32	0.47	Log loan size

Panel C: Shocks

	Σ	
Parameter	Estimate	Description
σ_{α}^2	0.06	Price Elasticity
σ_{β}^2	0.17	Disutility from smaller loan
σ_{γ}^2	0.10	Conforming preference
$\sigma_{\log F}^2$	0.41	Log loan size

Table 8: Structural Estimation – Supply Parameters

This table shows the estimated supply parameters. Panel (a) shows the linear parameters that enter the initial origination costs. Panel (b) shows the non-linear parameters that determine the financing cost.

Panel A: Initial Origination Costs

Capital costs			Labor Costs		
Parameter	Estimate	Description	Parameter	Estimate	Description
$r_{d,2010}$	2.79	Capital cost (2010)	w_n^b	0.00	Bank, new (baseline)
$r_{d,2011}$	2.82	Capital cost (2011)	w_r^b	-0.16	Bank, refi
$r_{d,2012}$	2.19	Capital cost (2012)	w_n^n	0.06	Non-fintech, new
$r_{d,2013}$	2.56	Capital cost (2013)	w_r^n	-0.18	Non-fintech, refi
$r_{d,2014}$	2.71	Capital cost (2014)	w_n^f	0.09	Fintech, new
$r_{d,2015}$	2.39	Capital cost (2015)	w_r^f	-0.06	Fintech, refi

Panel B: Financing Costs

Parameter	Estimate	Description
σ	0.04	External financing cost
r_e^1	0.01	Internal coefficient on capital adequacy
ϕ	1.46	Shape parameter for capital adequacy

Table 9: Counterfactual Analysis – Capital Requirements

This table shows the impact of raising capital requirements. Rows show the predicted impact of the counterfactual change on various outcomes. "Lending" and "Welfare" rows are normalized to the baseline level.

	Changes to Capital Requirements						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	None	4.5%	6% (Baseline)	7.5%	9%	12%	30%
Market Shares and Lending Volumes							
Market Share (Bank)	63%	62%	62%	61%	58%	53%	51%
Bank Market Share of Conforming	52%	52%	51%	51%	51%	51%	51%
Market Share (Jumbo)	22%	22%	21%	19%	13%	2%	0%
Balance Sheet Financing Share	63%	61%	41%	26%	14%	3%	0%
Lending Volume ($b)	1,787	1,776	1,763	1,736	1,675	1,587	1,570
Lending (High Income Market) ($b)	896	890	883	863	823	768	755
Lending (Low Income Market) ($b)	129	128	128	126	125	121	121
Interest Rates and Markups							
Interest Rates (Average)	3.85	3.86	3.87	3.88	3.87	3.86	3.86
Interest Rates (Jumbo)	4.31	4.37	4.46	4.71	4.99	9.36	(No Loans)
Interest Rates (High Income Market)	3.91	3.92	3.93	3.94	3.93	3.92	3.91
Interest Rates (Low Income Market)	3.76	3.77	3.78	3.79	3.78	3.78	3.78
Markup (Average)	1.55	1.55	1.54	1.54	1.54	1.53	1.53
Markup (Bank)	1.63	1.63	1.63	1.62	1.59	1.55	1.53
Markup (Non-bank)	1.53	1.53	1.53	1.53	1.53	1.53	1.53
Profits and Consumer Welfare							
Overall Lender Profits ($b)	215	213	211	202	183	156	150
Bank Profits ($b)	142	140	137	129	110	83	77
Non-bank Profits ($b)	73	73	73	74	74	74	74
Consumer Welfare ($b)	296	294	292	288	279	267	264
Consumer Welfare (High Income Market) ($b)	154	153	151	149	142	135	133
Consumer Welfare (Low Income Market) ($b)	19	19	19	19	19	18	18
Consumer Welfare (High Income Borrower) ($b)	452	448	444	428	410	370	360
Consumer Welfare (Low Income Borrower) ($b)	164	163	162	162	161	161	161

Table 10: Counterfactual Analysis – Conforming Loan Limit

This table shows the impact of altering the conforming loan limit. Column (1) shows the impact of removing GSE financing altogether; Column (2) shows the impact of reducing the limit by 25%; Column (3) shows the 2015 baseline scenario; Column (4) shows the impact of increasing the limit by 25%; Column (5) shows the impact of removing the limit altogether, so that all loans are eligible for GSE financing. Column (6) shows the impact of setting all limits to the lower national limit of $417,000. Column (7) shows the impact of setting all limits to the higher national limit of $625,000. Rows show the predicted impact of the counterfactual change on various outcomes. "Lending" and "Welfare" rows are normalized to the baseline level.

	Changes to Conforming Limit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	-99%	-25%	Baseline	+25%	No Limit	All @ 417k	All @ 625k
Market Shares and Lending Volumes							
Market Share (Bank)	100%	67%	62%	59%	50%	63%	58%
Bank Market Share of Conforming	51%	52%	51%	51%	50%	52%	51%
Market Share (Jumbo)	100%	32%	21%	15%	0%	24%	13%
Balance Sheet Financing Share	100%	49%	41%	37%	26%	45%	36%
Lending Volume ($b)	435	1,500	1,763	1,929	2,250	1,730	2,006
Lending (High Income Market) ($b)	260	746	881	971	1,169	849	1,005
Lending (Low Income Market) ($b)	21	112	128	137	147	128	142
Interest Rates and Markups							
Interest Rates (Average)	4.03	3.85	3.87	3.88	3.88	3.87	3.88
Interest Rates (Jumbo)	4.13	4.37	4.46	4.54	(No Loans)	4.45	4.61
Interest Rates (High Income Market)	4.11	3.92	3.93	3.94	3.88	3.93	3.94
Interest Rates (Low Income Market)	3.91	3.77	3.78	3.79	3.88	3.78	3.79
Markup (Average)	1.65	1.53	1.54	1.55	1.56	1.54	1.56
Markup (Bank)	1.70	1.64	1.63	1.62	1.58	1.64	1.63
Markup (Non-bank)	1.56	1.51	1.53	1.54	1.54	1.53	1.55
Profits and Consumer Welfare							
Overall Lender Profits ($b)	96	196	211	217	200	210	220
Bank Profits ($b)	96	138	137	133	101	140	134
Non-bank Profits ($b)	0	58	73	83	99	70	86
Consumer Welfare ($b)	27	237	292	328	407	283	344
Consumer Welfare (High Income Market) ($b)	16	121	151	172	221	143	179
Consumer Welfare (Low Income Market) ($b)	1	16	19	21	23	19	22
Consumer Welfare (High Income Borrower) ($b)	66	329	445	532	762	426	578
Consumer Welfare (Low Income Borrower) ($b)	8	152	162	166	170	160	166

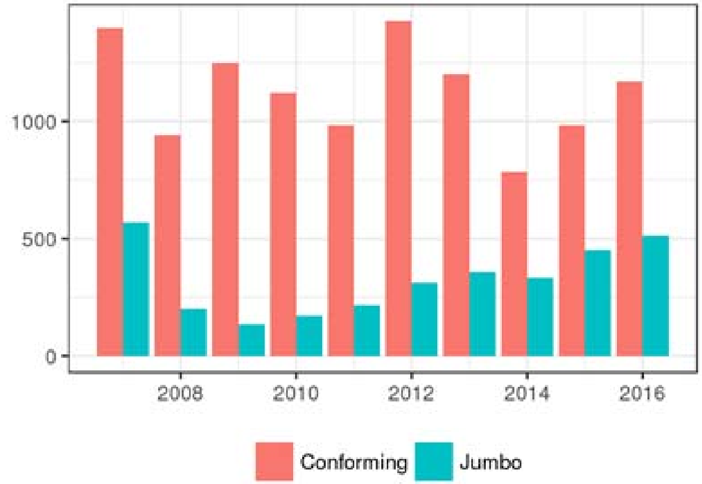
Table 11: Counterfactual Analysis – Conforming Loan Limit

This table shows the impact of raising capital requirements. Columns (1)-(3) show the impact of lowering GSE financing costs by 100, 25, and 10 basis points, respectively. Column (4) shows the 2015 baseline scenario. Columns (5)-(7) show the impact of increasing GSE financing costs by 10, 25, and 100 basis points, respectively. Rows show the predicted impact of the counterfactual change on various outcomes. "Lending" and "Welfare" rows are normalized to the baseline level.

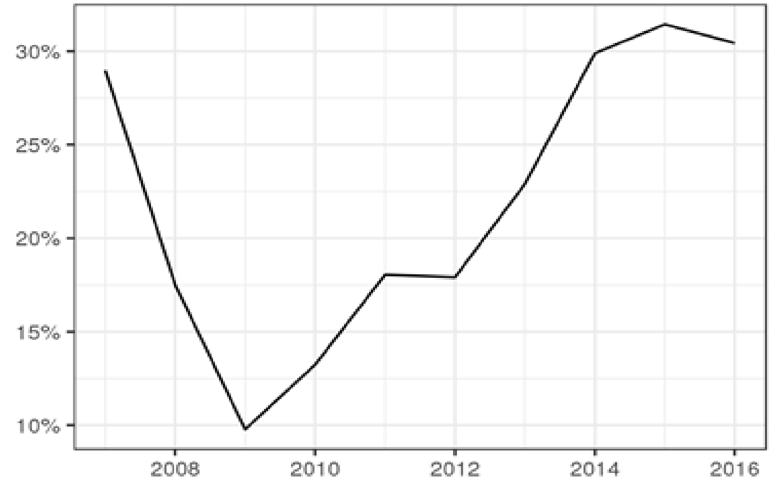
	Changes to GSE Financing Costs						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	-100bps	-25bps	-10bps	Baseline	+10bps	+25bps	+100bps
Market Shares and Lending Volumes							
Market Share (Bank)	59%	61%	61%	62%	63%	65%	74%
Bank Market Share of Conforming	52%	51%	51%	51%	53%	55%	66%
Market Share (Jumbo)	15%	19%	21%	21%	22%	22%	25%
Balance Sheet Financing Share	15%	19%	21%	42%	62%	65%	74%
Lending Volume ($b)	2,591	1,939	1,830	1,763	1,726	1,680	1,491
Lending (High Income Market) ($b)	1,263	961	913	883	865	843	751
Lending (Low Income Market) ($b)	202	143	134	127	124	121	105
Interest Rates and Markups							
Interest Rates (Average)	2.86	3.62	3.77	3.87	3.92	3.98	4.18
Interest Rates (Jumbo)	4.45	4.45	4.46	4.46	4.45	4.45	4.46
Interest Rates (High Income Market)	2.92	3.68	3.83	3.93	3.99	4.05	4.27
Interest Rates (Low Income Market)	2.76	3.53	3.68	3.78	3.83	3.89	4.08
Markup (Average)	1.51	1.54	1.54	1.54	1.55	1.55	1.56
Markup (Bank)	1.58	1.61	1.62	1.63	1.63	1.63	1.63
Markup (Non-bank)	1.50	1.52	1.53	1.53	1.54	1.54	1.57
Profits and Consumer Welfare							
Overall Lender Profits ($b)	285	225	216	211	207	203	185
Bank Profits ($b)	175	144	140	137	137	138	142
Non-bank Profits ($b)	110	82	77	73	70	65	44
Consumer Welfare ($b)	454	325	305	292	285	276	241
Consumer Welfare (High Income Market) ($b)	229	167	158	152	148	144	126
Consumer Welfare (Low Income Market) ($b)	32	22	20	19	18	18	15
Consumer Welfare (High Income Borrower) ($b)	619	481	459	443	433	425	385
Consumer Welfare (Low Income Borrower) ($b)	293	189	172	162	157	150	125

Figure 1: Conforming and Jumbo Loan Markets Origination Volumes and Relative Product Pricing

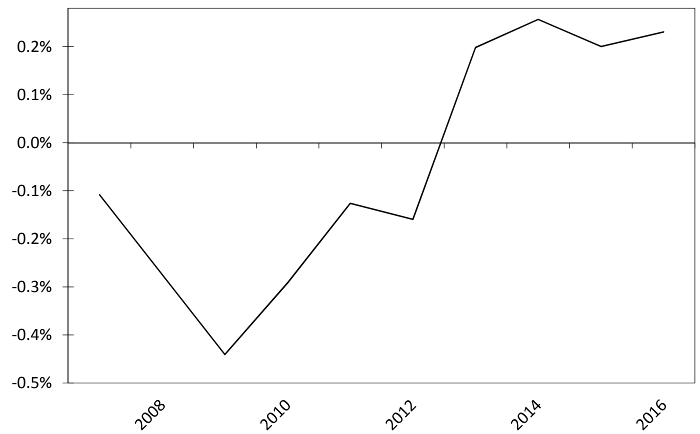
Panel (a) shows aggregate mortgage origination volumes in billions of dollars by conforming and jumbo mortgages. Panel (b) shows jumbo origination share of all conventional (non-FHA/VA/RHS) mortgages by dollars originated. Conforming loans are defined as "conventional" (non-FHA) in HMDA with loan amounts below the conforming loan limit. Panel (c) shows the conforming-jumbo interest rate spread (based on BlackKnight). A negative spread means jumbo loans have higher rates.



(a) Conforming and jumbo origination volumes ($ billions)



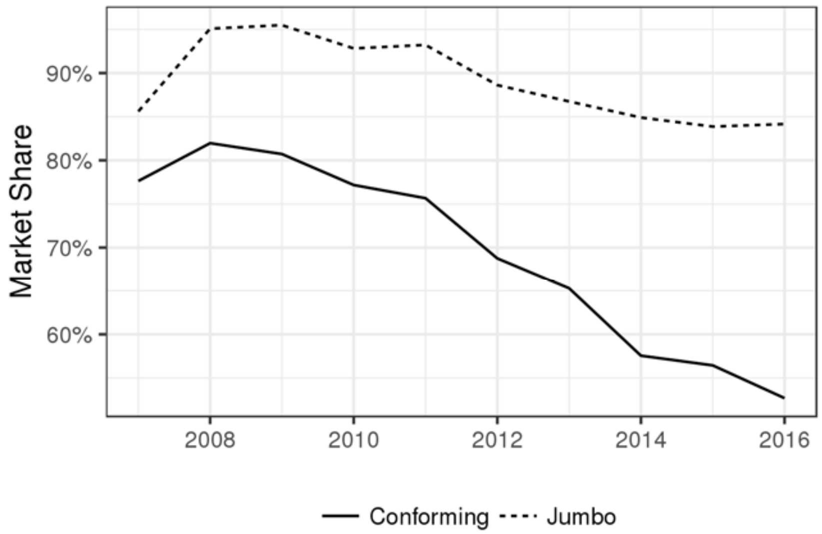
(b) Jumbo market share in total originations



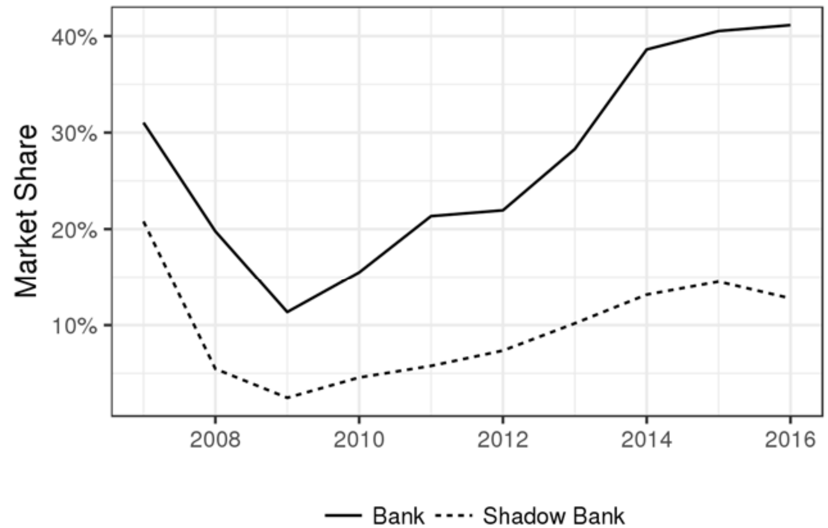
(c) Conforming-jumbo interest rate spread

Figure 2: Traditional and Shadow Bank Market Shares in the Confirming and Jumbo Markets

Panel (a) shows bank market share (by dollars originated) in the confirming (solid) and jumbo (dashed) markets. Panel (b) shows jumbo lending share (by dollars originated) among banks (solid) and shadow banks (dashed). That is, panel (b) shows what percentage of lender originations are jumbo (non-conforming) among banks and shadow banks. Conforming loans are defined as "conventional" (non-FHA) in HMDA with loan amounts below the conforming loan limit.



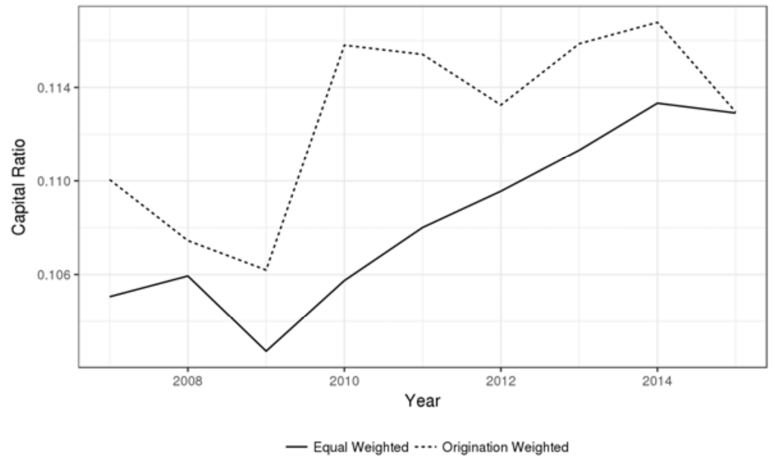
(a) Traditional bank market share



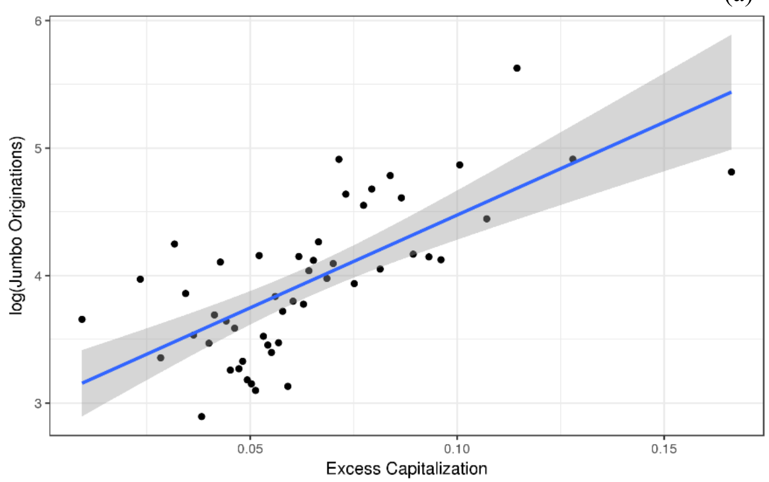
(b) Jumbo loan share of originations

Figure 3: Bank Capital and Jumbo Originations

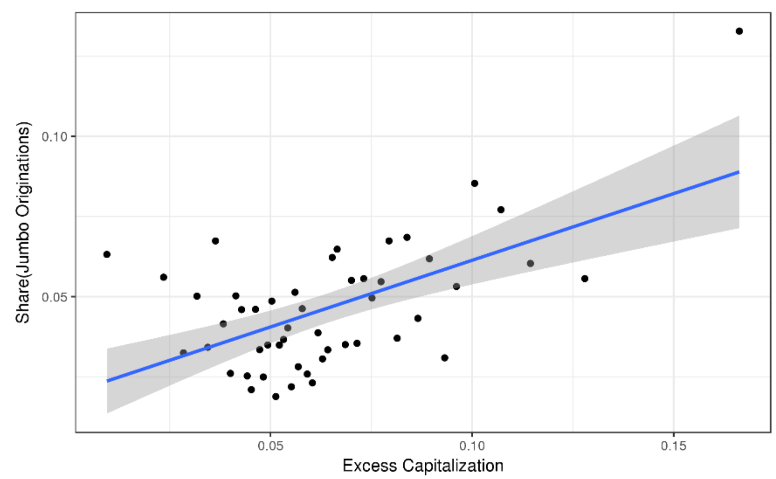
Panel (a) shows bank capital ratios over time. The solid line is the (simple) average across all banks; the dashed line is weighted by mortgage originations. Panel (b) shows a binned scatterplot of log numbers of jumbo originations versus bank capitalization above the statutory limit. Panel (c) shows a binned scatterplot of jumbo share of own bank originations versus bank capitalization above the statutory limit.



(a) Capital ratios over time



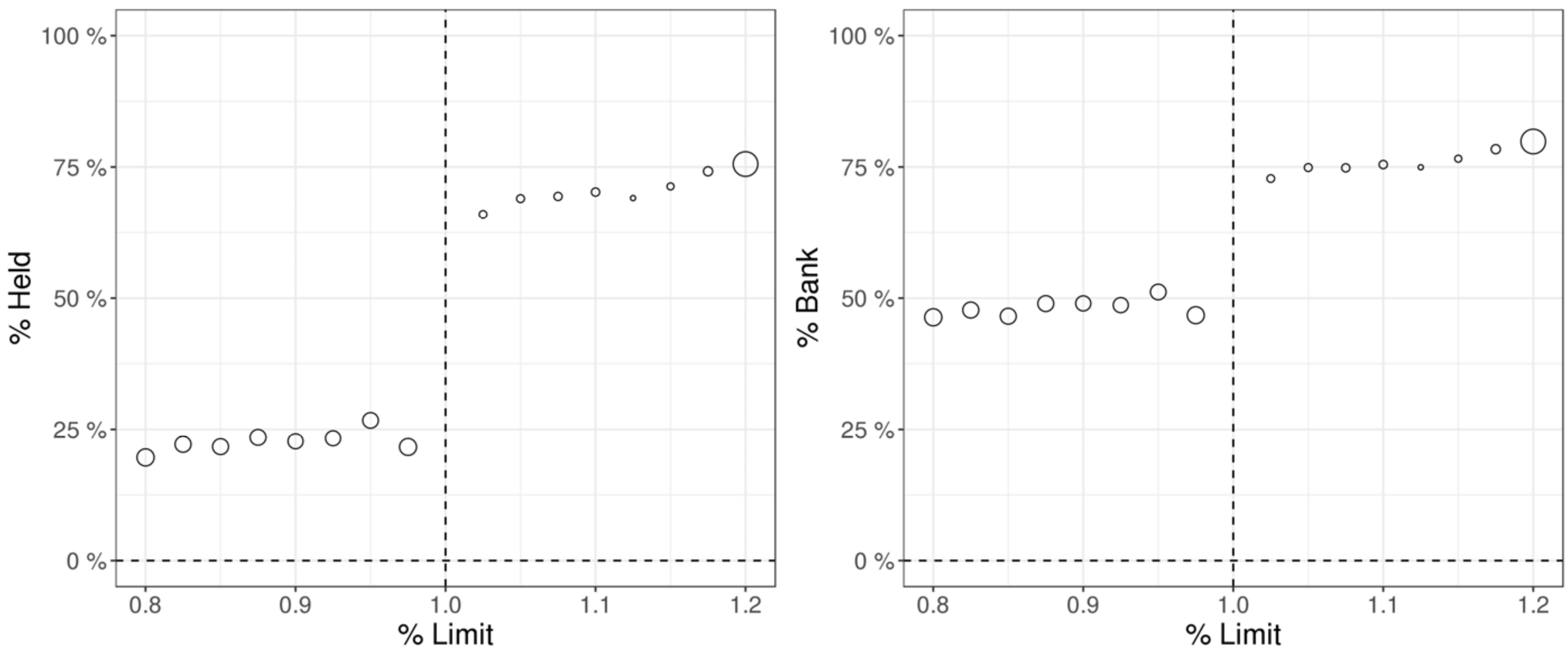
(b) Log(Jumbo Originations) versus excess capitalization



(c) Own jumbo share versus excess capitalization

Figure 4: Balance Sheet Financing and Bank Lending around the Conforming Loan Limit Cutoffs

Panel (a) shows the percentage of originations retained on balance sheet by the loan's percentage of the conforming loan limit. Panel (b) shows the percentage of originations that are done by banks, by conforming loan limit. The time period is 2007-2015. Loan sizes are binned according to 5% buckets, i.e., 91%-95%, 96%-100%, 101%-105%, and so on. Data are from HMDA.

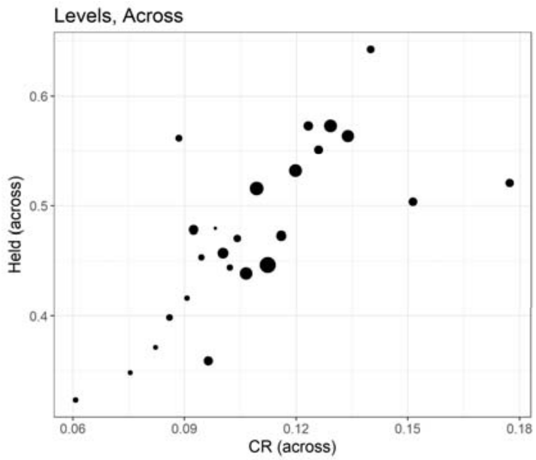


(a) Originations retained on balance sheet

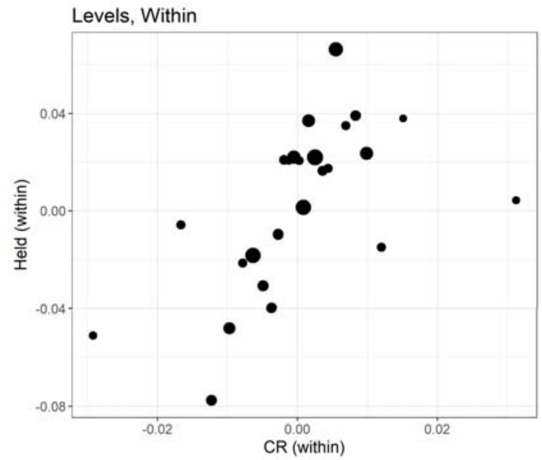
(b) Bank market share

Figure 5: Balance Sheet Financing versus Bank Capital Ratios

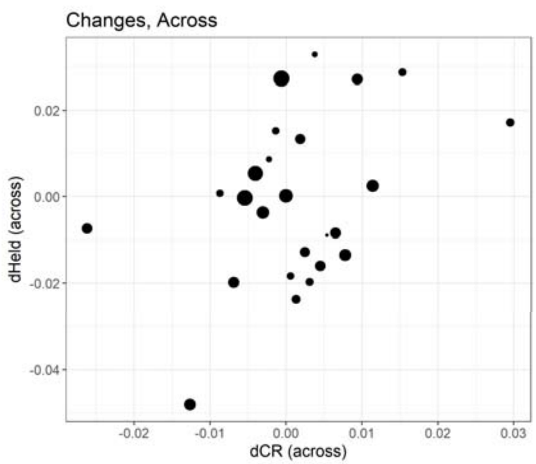
Figure 6 shows binned scatterplots (25 equal-sized bins) of bank percent of loans held on balance sheet versus bank capital ratios. All bins are residualized to the controls as in Table (3). "Within" panels remove bank fixed effects. Panels (a) and (b) show the results in levels and correspond to Table (3) columns (1) and (2), respectively; (c) and (d) show the results in changes and correspond to Table (3) columns (3) and (4), respectively. Panels (a) and (c) are across banks; (b) and (d) are within banks.



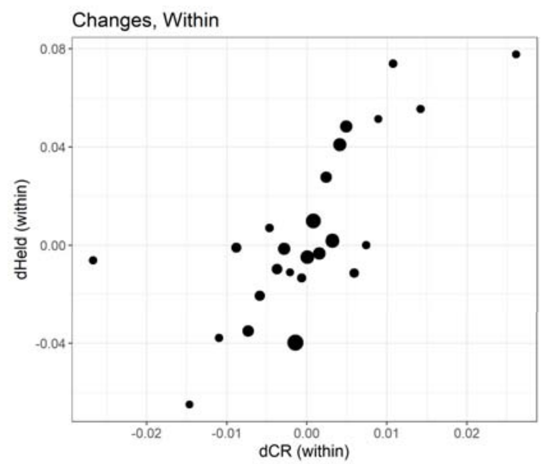
(a) Across banks, levels



(b) Within banks, levels



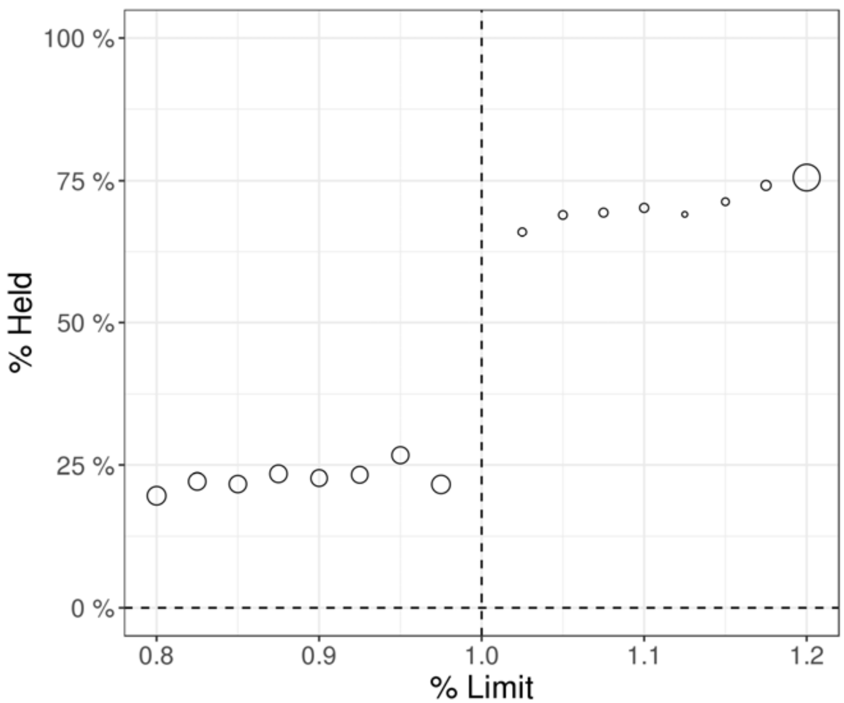
(c) Across banks, changes



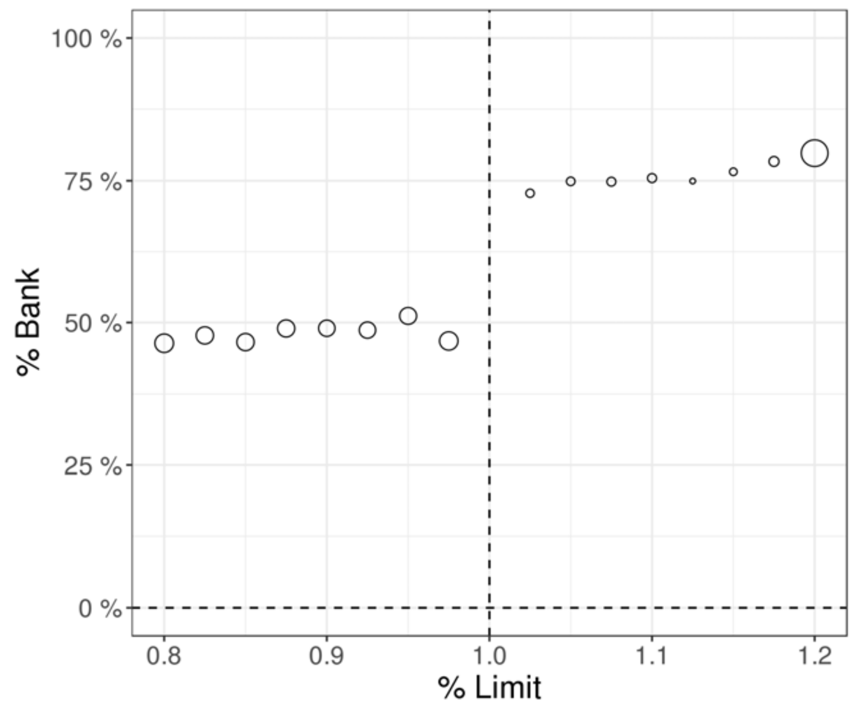
(d) Within banks, changes

Figure 6: Traditional Bank Balance Sheet Condition around the Conforming Loan Limit Cutoffs

Panel (a) shows the percentage of originations retained on balance sheet by the loan's percentage of the conforming loan limit among banks only. Panel (b) shows the percentage of originations that are done by well-capitalized banks, by conforming loan limit. A well-capitalized bank is defined as a bank whose capital ratio is in the top quartile for the given year. The time period is 2007-2015. Loan sizes are binned according to 5% buckets, i.e., 91%-95%, 96%-100%, 101%-105%, and so on. Data are from HMDA.



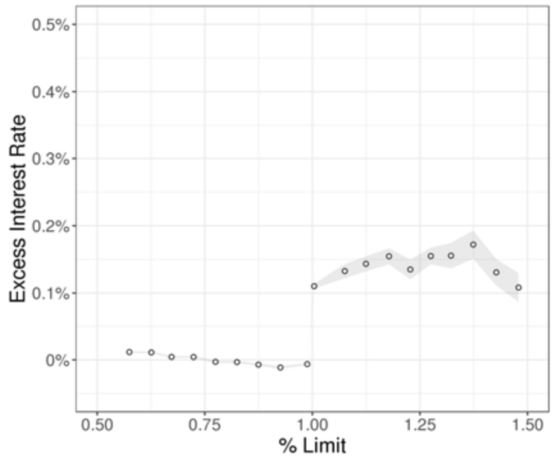
(a) Originations retained on balance sheet



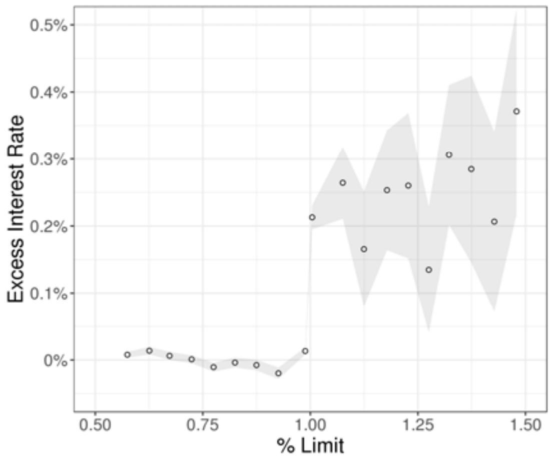
(b) Well-capitalized bank share of all bank

Figure 7: Interest Rates around the Conforming Limit

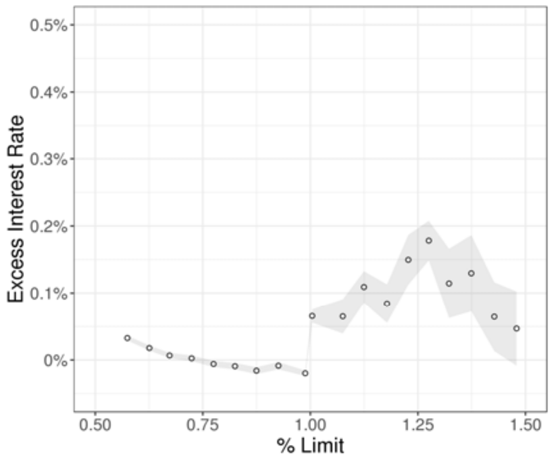
Panel (a), (b), and (c) show the interest rates of FRMs for 2007-2016, 2008, and 2014 respectively, by the loan's percentage of the conforming loan limit. Interest rates are residualized against loan characteristics including purpose, credit score, LTV, and term, and binned into to 4% buckets by size. Shaded regions represent 95% confidence intervals. Data are from BlackKnight.



(a) Full sample



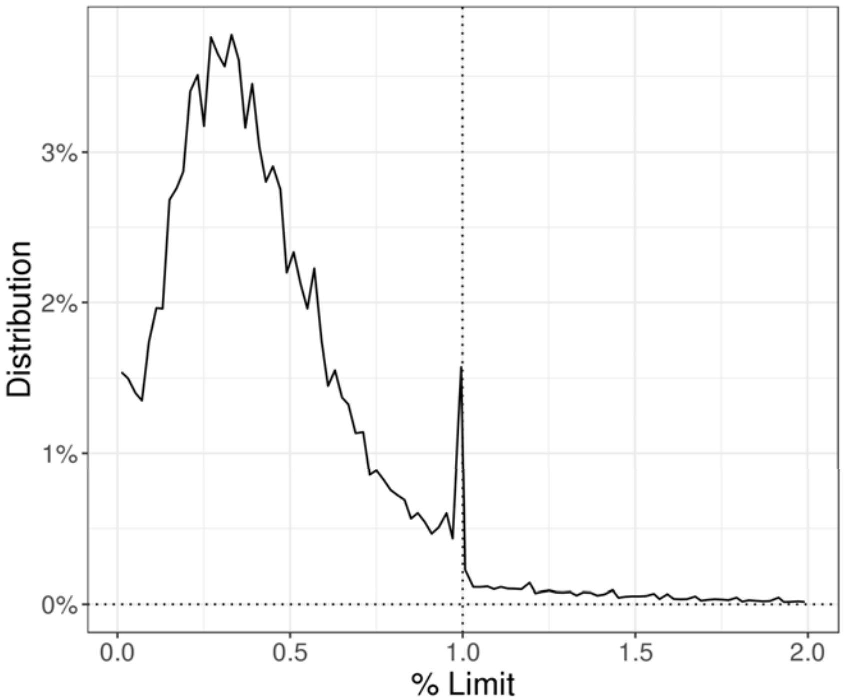
(b) 2008 Sample



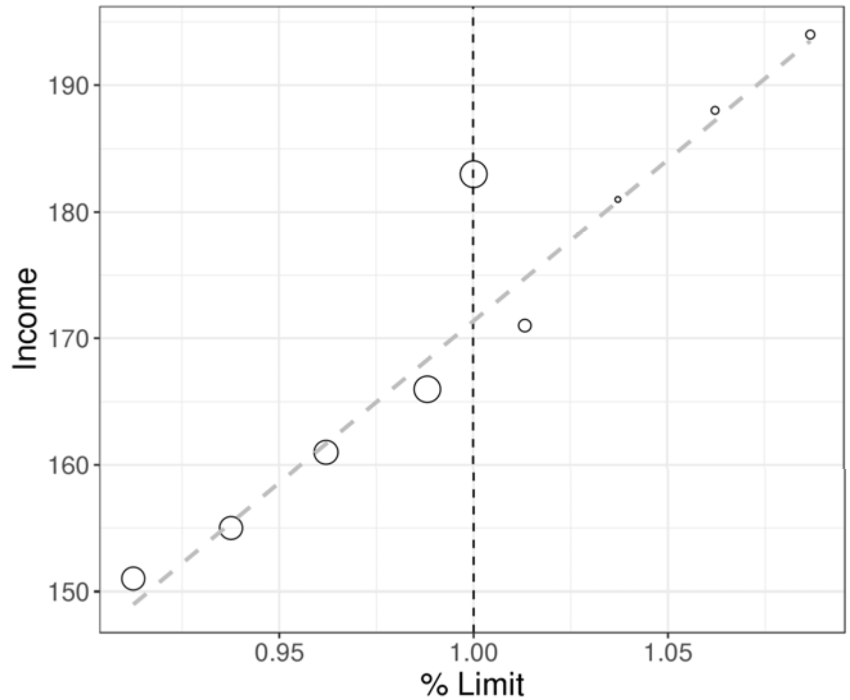
(c) 2014 Sample

Figure 8: Loan Distribution and Borrower Income by Conforming Loan Limits

Panel (a) shows the distribution of loan principal amounts around the conforming loan cutoff. % of Conforming is defined as the loan principal amount divided by the conforming loan limit in the county-year of origination. The cutoff is at 1, shown by a dotted vertical lone. Panel (b) shows borrower binned average income around the conforming loan cutoff. The market size represents the loan volume falling within the bin. Data are from HMDA joined with conforming loan limits.



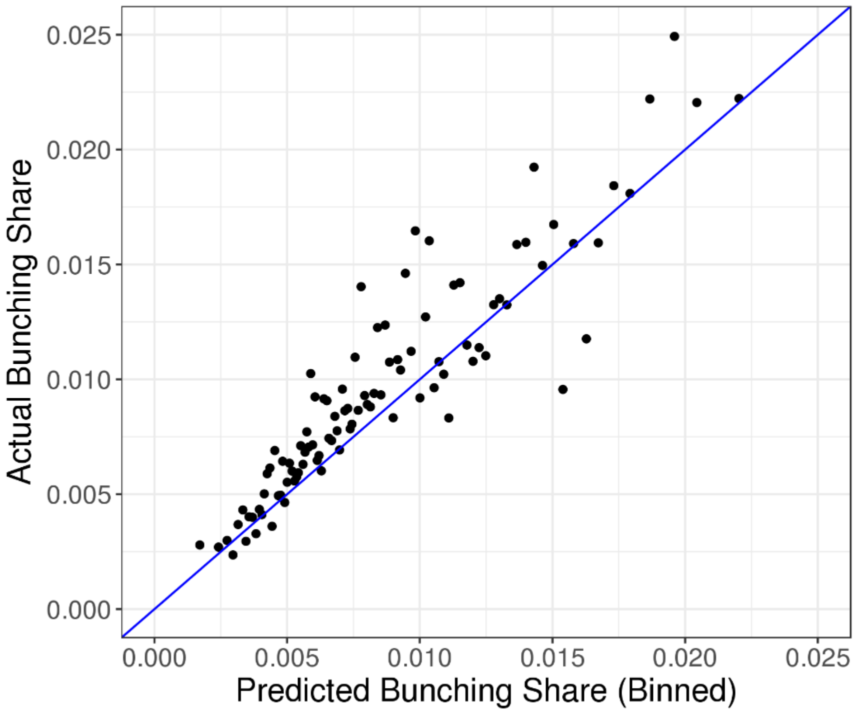
(a) Distribution of Loan Sizes



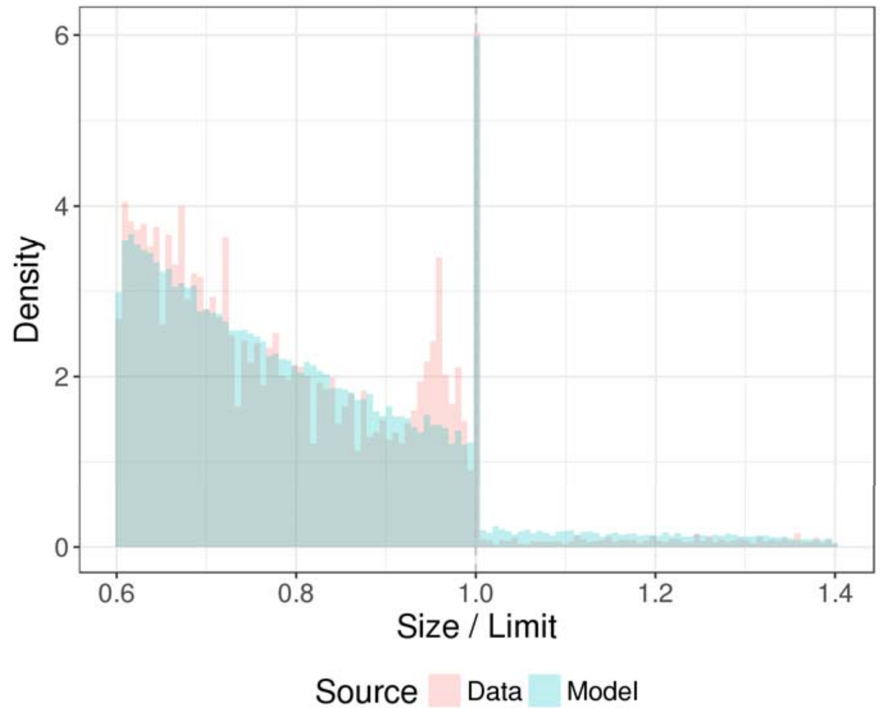
(b) Well-capitalized bank share of all bank

Figure 9: Empirical versus Model Conforming Loan Bunching

This figure shows conforming loan bunching for the model versus empirical bunching across markets. Panel (a) plots binned simulated bunching market share (conditional on being in the market) on the X axis versus empirical bunching market share (conditional on being in the market) on the Y axis. The blue line is the 45 degree line. Panel (b) shows the market-wide simulated and actual loan size distributions around the conforming loan cutoff.



(a) Predicted versus actual bunching



(b) Simulated and empirical size distributions

Figure 10: Marginal Origination Costs

This figure shows model-implied marginal costs as a function of excess bank capitalization, the difference between the bank's capital ratio and the statutory requirement. The red line shows marginal cost for banks originating conforming loans. The green line shows the marginal cost for banks originating jumbo loans. The blue line shows the marginal cost for non-banks originating conforming loans.