The Limits of Shadow Banks

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This Version: AUGUST 2019

Abstract

We study which types of activities migrate to the shadow banks, why migration occurs in some sectors, and not others, and the quantitative importance of this migration. These questions are explored in the $10 trillion US residential mortgage market, in which shadow banks account for about half of new lending. Using micro data, we document a large degree of market segmentation in shadow bank penetration. They substitute for traditional —deposit taking—banks in easily securitized lending, but are limited from engaging in activities requiring on-balance sheet financing. Banks adjust their financing and lending activities to balance sheet shocks, and behave more like shadow banks following negative shocks. Motivated by this evidence, we build a structural model. Banks and shadow banks compete for borrowers. Banks face regulatory constraints, but benefit from the ability to engage in balance sheet lending. Like shadow banks, banks can choose to access the securitization market. To evaluate distributional consequences, we model a rich demand system with income and house price differences across borrowers. The model is estimated using spatial pricing rules and bunching at the regulatory threshold for identification. We study the quantitative consequences of capital requirements, access to secondary loan market, and unconventional monetary policy on lending volume and pricing, bank stability and the distribution of consumer surplus across rich and poor households. Migration of lending activity to shadow banks and endogenous changes in bank balance sheet retention *both* significantly shape the overall policy response. Consequently, disruptions in securitization market rather than capital requirements have the largest quantitative impact on aggregate lending volume and pricing. We conclude that a complete policy analysis must incorporate the industrial organization of the credit market and the equilibrium interaction of banks and shadow banks.

Keywords: Shadow Banks, Balance Sheet Capacity, Market Segmentation, Capital Requirements, Lending, Mortgages, GSEs, Unconventional Monetary Policy

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Section I: Introduction

Policy makers and researchers have commonly viewed deposit taking institutions—traditional banks—as the main supplier of loans to households and firms. Therefore, traditional banks have been the main focus of regulation and supervision in financial intermediation. A substantial migration of financial activity to the less regulated, shadow banking sector, however, has challenged this view.[1] For instance, following the increase in bank regulation after the financial crisis, the shadow bank loan origination share more than doubled in the $10 trillion US residential mortgage market with shadow banks now accounting for the majority of new lending (Buchak et al. 2018). When considering regulatory changes, policy makers therefore now need to account for the "*shadow bank migration margin*" of adjustment.[2]

In this paper, we document that shadow bank migration occurs primarily for activities which do not require on-balance sheet financing. Banks, by virtue of deposit financing, retain an advantage in balance-sheet intensive activities. However, there is another margin on which traditional lenders can adjust in response to regulation. We document that traditional banks adjust their business model when faced with these shocks, switching from on-balance sheet lending to off-balance sheet lending. We call this margin of adjustment the "*balance sheet retention margin.*" We posit that to quantitatively understand migration of intermediation activity and risks between banks and shadow banks, one needs to account for their interaction in markets—the industrial organization of financial intermediation—as well as the changing business models of banks. We then demonstrate that the two margins are central to understanding consequences of policies such as capital requirements and monetary policy with respect to the equilibrium quantity, price, and distribution of credit as well as bank stability.

We explore the limits of shadow banking in two main residential mortgage market segments in the US: the conforming market and the jumbo market for two broad reasons. First, these two segments account for the vast majority of the $17.8 trillion[3] residential mortgages originated during our sample period (2007 to 2016). Second, intermediaries originating conforming mortgages do not depend as much on balance sheets since these loans are eligible for purchase by Government Sponsored Enterprises (GSEs). Jumbo mortgages, on the other hand, are not eligible for GSE support and are therefore more difficult to securitize: the vast majority of jumbo loans are retained on the lenders' balance sheets. This institutional difference allows us to study the role that balance sheet capacity of banks plays in shaping the migration of activity from banks to shadow banks.

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[1] See Gennaioli, Shleifer, and Vishny (2013), Ordonez (2018), and Moriera and Savov (2017) for models of shadow banking and Greenwood and Scharfstein (2013) and Adrian and Ashcraft (2016) for a comprehensive review.

[2] For instance, the banking regulation proposal of the Minneapolis Federal Reserve, "The Minneapolis Plan," discusses taxing activity which migrates to shadow banking following higher capital requirements, https://www.minneapolisfed.org/publications/special-studies/endingtbtf/final-proposal/summary-of-the-minneapolis-plan-to-end-too-big-to-fail

[3] Mortgage bankers association estimates for 1-4 family homes [accessed August 12, 2019] https://www.mba.org/Documents/Research/Historical%20Mortgage%20Origination%20Estimates.xlsx,

We begin by documenting large swings in the share of balance sheet intensive (jumbo) mortgage originations during this period. The share of jumbo originations declined precipitously—29% to 10%—from 2007 to 2009 relative to securitizeable (conforming) mortgages, only to reverse back to 30% by 2016. These market swings coincided with a dramatic migration of mortgage origination activity to shadow banks (Buchak et al. 2018). We document that the migration was limited to the conforming sector, where shadow banks gained 30pp of market share from 2008 to 2015. In balance sheet intensive jumbo mortgages, shadow banks did not gain market share: traditional banks' market share persisted well above 80%, despite large declines in the quantity they lent.

We argue that different that the market segmentation arises because traditional banks and shadow banks differ in their ability to extend balance-sheet-intensive (jumbo) and securitizeable (conforming) mortgages. Specifically, we argue that the comparative advantage of traditional banks in the jumbo market arises from their ability to hold these loans on their balance sheets. To separate this explanation from alternatives, we exploit the fact that the ability to securitize a mortgage has a sharp size cutoff. Any mortgage that exceeds the conforming loan size limit becomes a jumbo mortgage and is much more difficult to securitize. We also exploit this institutional feature in our structural estimation.

Most alternative explanations for the comparative advantage of banks suggest that this advantage would increase continuously with mortgage size. For example, if richer borrowers prefer borrowing from banks, one would imagine that borrowers' demand for banking services would increase continuously with mortgage size, as one transitions from conforming to jumbo. Instead, we find a 10 percentage point (pp) sharp increase in banks' market share at the conforming limit. Moreover, balance sheet capacity is the likely cause of market segmentation as opposed to other regulatory differences between banks and shadow banks. When we look within the banking sector itself, holding regulation fixed, and compare better capitalized banks with larger balance sheet capacity to less well capitalized banks, we find that the market share of well capitalized banks jumps by over 10% at the conforming limit. These results are consistent with the view that the limited balance sheet capacity of shadow banks prevents migration of balance sheet intensive activities to the shadow banking sector.

The behavior of mortgage prices is also consistent with our hypothesis. While jumbo loans are generally more expensive, the relative price differential experiences a significant variation during our sample period. Periods during which jumbo origination quantity is low are periods of high jumbo spreads (relative to conforming), and vice versa. Moreover, the jumbo spread evolves with the aggregate relative capitalization of lenders in the jumbo and conforming sector. The contemporaneous decrease in quantity and increase in price suggests supply shocks, specifically, changes in the balance sheet capacity of jumbo lenders, were an important determinant of aggregate mortgage prices.

Last, we also show that banks themselves face an important margin of adjustment to balance sheet capacity shocks, the balance sheet retention margin. Banks adjust to a decline in capitalization—balance sheet capacity—by retaining a smaller fraction of their loans and turning their attention to

loans that are harder to securitize. In other words, 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. Together, these facts provide a consistent view of the role of banks and shadow banks in the mortgage market, which we then formally and quantitatively analyze in a model.

Motivated by this evidence, we build and estimate a model of the US residential mortgage market. The goal of the model is to quantitatively understand how the industrial organization of financial intermediation, i.e., shadow bank migration margin, and the business models of banks, i.e., balance sheet retention margin, shape the equilibrium distribution of credit. In other words, which intermediaries originate which types of mortgages, at which interest rates. We then use the estimated model to quantitatively analyze the consequences of capital requirements, access to secondary loan market, and unconventional monetary policy on lending volume and pricing, bank stability, and the distribution of consumer surplus across rich and poor households.

On the supply side, banks' advantage lies in originating loans on their balance sheet, and their balance sheet capacity is limited by their capitalization. Banks adjust their business model on the balance sheet retention margin: with increased capitalization the cost of balance sheet intensive activities declines. Shadow banks, on the other hand, benefit from a lower regulatory burden and compete with banks in originating loans that can be easily securitized. This specialization implies that shocks and interventions, which affect only one type of lender, spill over to other lenders along two broad margins we discussed: the shadow bank migration margin between banks and shadow banks and the balance sheet retention margin within banks.

Because markets are segregated, policy interventions have redistributive consequences. For example, if capital requirements decrease the supply of on-balance sheet lending—jumbo mortgages—and increase the supply of conforming mortgages, this policy is costlier for rich consumers. We capture the redistributive consequences and accommodate realistic consumer substitution patterns by allowing rich heterogeneity on the demand side within a modified discrete choice framework (Berry et al., 1995; Nevo, 2000). Consumers with heterogeneous preferences over price, quality, and mortgage size choose among a menu of mortgages offered by various types of originators. We depart from discrete choice models by also allowing consumers to *choose* their mortgage size, and consequently, decide whether they want a conforming or jumbo mortgage.

We separately estimate demand and supply parameters. To identify standard demand parameters, we need to instrument for price endogeneity. We exploit the fact that for political economy reasons, in some geographic areas the financing cost of a conforming mortgage is higher than in other areas, which is unrelated to mortgage demand (see Hurst et al., 2016, for extensive documentation of that fact). Second, we exploit bunching at the confirming-jumbo cutoff to help us estimate consumer preferences over mortgage size. Intuitively, consumers who bunch at the conforming loan limit choose a smaller than ideal mortgage. The higher the disutility from taking on a smaller than ideal

mortgage, the less bunching we observe. Having estimated demand, we estimate supply side parameters using firm price setting and financing decisions.

Our model captures the salient features of the data, such as the market shares of banks and shadow banks, as well as pricing of mortgages. The model estimates also match the extent of bunching at the conforming discontinuity across markets. Moreover, we observe several market level conforming loan limit changes during our sample period, and find that our model can replicate the actual equilibrium response to these changes quite well. Consistent with the literature, we find that consumers are very price elastic, with lower price elasticity in the jumbo market. Since this market faces less competition from shadow banks, it is a source of rents for banks.

On the supply side, our estimates suggest that financing jumbo mortgages is more expensive than financing conforming mortgages, even when the latter are held on the balance sheet, but the difference declines with bank capitalization and declines to less than 5 basis points (bps) for very well capitalized banks. Last, we find that post 2012 increases in the regulatory burden of traditional banks substantially constrained banks' origination. In particular, non-capital-requirement related regulatory constraints, such as risk of enforcement actions and lawsuits, provided a large advantage to shadow banks and contributed more to shadow bank migration following the crisis than the increased capital requirements.

We next use our estimated model to consider three policy relevant counterfactuals: changing capital requirements; unconventional monetary policy such as Quantitative Easing; and changing the access to a secondary loan market through the GSE conforming loan limit. These policies 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.

One overarching insight from the counterfactuals is that both adjustments on the shadow bank migration margin and the balance sheet retention margin are critical to understanding quantitative consequences of policies. For example, we show that the tradeoff between bank stability and lending is much less severe than anticipated by models that focus only on balance sheet lending. Our model predicts that increasing bank capital requirements from current levels to 9% reduces bank *balance sheet* lending by 2/3rd but *overall* mortgage lending declines by only 2.5%. The critical margin of adjustment in this case is the balance sheet retention margin: *total bank* lending declines by only 9.5% as banks move their lending from retention to selling. Accounting for migration of lending to shadow banks shaves off another 7%. Both margins are equally important in quantitatively shaping responses to other policies. A model of financial intermediation must therefore account for both of these margins when evaluating policies.

The second general insight is that, given the importance of these two margins, the overall adjustment depends on whether policy interventions target traditional banks or secondary markets. When tighter regulation only target traditional banks as is the case with increased capital requirements, solely focusing on bank balance sheets overstates the adverse effect of such polices on overall lending volume. The adjustment on the shadow bank migration margin and the balance

sheet retention margin work to offset the adverse impact. For policies which tighten the secondary loan market, such as increasing GSE financing costs, the balance sheet retention margin still offsets some of the adverse effect through an increase in on-balance sheet lending. The shadow bank migration margin, however, exacerbates the effect: lending contracts for shadow banks, leading to a large overall decline in lending. For example, in the case of unconventional monetary policy that raises GSE financing costs by 100 basis points, bank lending actually *increases* by $52 billion, while shadow bank lending *decreases* by $300 billion. Ignoring the role of shadow banks would yield not only the wrong magnitude of the aggregate effect, but also the wrong direction.

The third insight is that interventions to achieve bank stability differ in their redistributive consequences. For example, increasing capital requirements achieves bank stability by decreasing on-balance-sheet lending, i.e. reducing jumbo mortgages. Therefore, the cost of bank stability is mainly borne by higher income borrowers. An expansion of GSE funding increases the appeal of securitization, also shifting loans from bank balance sheets and increases bank stability. It does so while expanding lending and benefiting consumers across the income spectrum, but comes at the cost of taxpayers subsidizing GSE lending.

These insights generate implications for regulation that go beyond the US market. For instance, the BASEL regulatory framework proposes a uniform treatment of capital requirements across countries. Consider the case of U.K. that does not have a large and liquid secondary market for mortgages. Our analysis suggests that increasing capital requirements in the U.K. would result in a substantially higher contraction in lending due to absence of bank retention margin. More generally, regulatory policy response in different economies need to consider the two margins highlighted.

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. Our results suggest that banks' choice of business model depends on both their capitalization and their equilibrium interaction with shadow banks. 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. Thus, a complete policy analysis must incorporate the industrial organization of the credit market and the equilibrium interaction of banks and shadow banks.

II: Institutional Setting and Data

II.A US Residential Mortgage Market

The residential mortgage market is the largest consumer finance market in the US. As of 2018 there have been 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.

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

The two main groups of mortgage originators in the US are 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, retain very few loans and engage almost exclusively in the originate-to-distribute model (see Buchak et al. 2018). Finally, banks face 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 extensive compliance and rules.[4]

The nature of lenders in the mortgage market changed substantially from 2008 to 2015. Buchak et al. (2018) document a decline in traditional bank originations and the growth of shadow banks, with the shadow bank market share growing from less than 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. (2018) provide evidence that both the increasing regulatory burden faced by traditional banks and growth of technology can account for a substantial part of this trend.

II.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 eligible for the securitization with the participation of government sponsored enterprises (GSEs), while jumbo loans are not. GSEs allow for a substantially easier securitization

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

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, 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. Consequently, these mortgages are significantly more difficult to securitize and the vast majority are retained on the balance sheets.

II.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.[5] 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

[5] 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.

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 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.

II.C Lender Classification

We classify lenders as in Buchak et al. (2018).[6] 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." (see Buchak et al. 2018).

Section III: Empirical Analysis

We begin by presenting a set of empirical facts regarding recent changes in the price, quantity, and composition of mortgage credit, and the accompanying changes in the industrial organization of the market. These facts motivate our analysis and model, shedding light on the drivers of the comparative advantage of banks and shadow banks.

We focus our analysis on two main residential mortgage market segments in the US: the conforming loan market and the jumbo loan market. These two segments account for more than 80% of all US residential mortgages (based on HMDA) originated during our sample period (2007-2016). The data used in our analysis are similar to that used in the literature (e.g., Buchak et al. 2018). Table 1 shows summary statistics for the main datasets used in our analysis.

[6] A complete lender classification is available at https://sites.google.com/view/fintech-and-shadow-banks.

III.A Aggregate Facts

We start by documenting several aggregate facts. We first show three related trends: as the capitalization of the banking sector declines from 2007 to 2009, we observe a decline in the share of jumbo mortgage originations and an increase in the relative price of jumbo mortgage. From 2009 onwards these trends reverse: as the capitalization of the banking sector increases, jumbo mortgage originations increase and the relative price of jumbo mortgages declines. We then investigate two margins of adjustment in the structure of the intermediation sector, which have accompanied these trends, the migration to shadow banks and banks' choices of retaining loans they originate or selling them in the secondary market. Because aggregate facts are always subject to multiple possible interpretations, we turn to micro evidence in Section III.B.

III.A.1 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.

III.A.2 Relative Product Pricing: Conforming and Jumbo Interest Rate Spread

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.

III.A.3 Balance Sheet Capacity of the Banking Sector, Product Pricing and Quantity

The aggregate changes in price and quantity of jumbo mortgages suggest that supply shocks are at least partially responsible for the observed patterns. We next show that changes in the capitalization of the banking sector are a candidate source of these supply shocks. Panel (a) of Figure 2 illustrates that the banking sector capitalization originally declined, bottoming out in 2009, and then began increasing. Moreover, Panels (b) and (c) point to a strong positive association

between bank capitalization and quantity of jumbo originations. Overall, these patterns along with our prior findings indicate suggest that as traditional bank capitalization declines, the amount of on-balance sheet lending declines and their relative pricing increases. In other words, these aggregate facts are consistent with the idea that a decline in the balance sheet capacity of the banking sector serves as a supply shock to on-balance sheet lending, at least relative to lending, which can be securitized.

III.A.3 Margins of Adjustment: "Shadow Bank Migration" and "Balance Sheet Retention"

We next investigate two margins of adjustment that took place in the financial intermediation sector during this period. First, consistent with prior work, we find a dramatic migration of residential mortgages to shadow banks during the 2011 to 2016 period (Buchak et al, 2018). Central to this paper, the migration of shadow banks did not take place in the jumbo market. Bank market share in the jumbo market has remained roughly constant, varying between 85% to 95%. This contrasts with the conforming market, in which bank market share in this market has declined from slightly under 80% in 2007 to about 50% in 2016 (Figure 3 Panel (a)). 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.

We next document that traditional banks adjusted their business model during this period. One possible way to interpret the facts above is that traditional banks *uniformly* contracted their lending, but shadow banks chose to only expand in the conforming market. Here we show that this is not the case. Traditional banks differentially shifted lending in the jumbo and conforming markets(Panel (b) of Figure 3). As bank capitalization decreased from 2007 to 2009, they shifted their originations away from mortgages held on their balance sheet (jumbo) towards mortgages they could securitize (conforming), with the share of jumbo mortgages declining from 30% to 10%. As bank capitalization increased, and conforming loan originations began migrating to shadow banks, they shifted their originations back to on balance sheet lending, with jumbo mortgages comprising more than 40% of their originations by 2016. In other words, banks appear to adjust to capitalization and other regulatory shocks by switching between the classic banking model (originating portfolio loans) and the originate-to-distribute model (shadow bank model). We call this margin that banks can adjust on "the balance sheet retention margin."

III.A.5 Summary of 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 balance sheets of lenders. Since shadow banks do not have much balance sheet capacity, they mainly 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 towards originating to distribute. 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.

III.B. Micro Evidence

The aggregate trends we document illustrate large movements in the mortgage market in dimensions of market structure, type of origination activity, quantity, type, and distribution of credit. In this section, we provide micro-level evidence, which narrows down the potential interpretations of the forces driving the aggregate data.

III.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 market segmentation. One alternative explanation of why traditional banks retain a large market share in the jumbo market is that wealthy borrowers who are more likely to take up mortgages have larger demand for other banking services. As we discussed in Section II, 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. Thus, 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 a loan being retained on balance sheet indeed discretely jumps at the conforming loan limit. As Figure 4 Panel (a) shows, the fraction of loans retained on the lenders' balance sheet discontinuously jumps from about 25% just below the conforming loan limit to about 70% just above the conforming loan limit.

To test weather banks specialize in large loans or in conforming loans, we confirm that their market share discretely increases at the conforming loan limit in Panel (b) of Figure 4. Banks' market share of loans just below the cutoff is roughly 65%, whereas bank market share above the cutoff is roughly 80%. The results suggest that banks have a comparative advantage in originating jumbo loans because these loans are difficult to sell.

We next more formally test whether balance sheet financing share and bank market shares discretely jump at the conforming loan limit discontinuity. We focus on mortgages within 1% of the conforming cutoff and estimate the extent of the discontinuity at the conforming loan limit using the following regression discontinuity specification:

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

Where $Bank_{ilt}$ are {0,1} indicator variables for whether the loan *i* in census tract *l* originated in year *t* 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 2 Panel (a) shows that loans directly above the conforming loan limit experience about 50% absolute increase in the share of loans financed on the balance sheet. Increasing the bandwidth above 1% produces similar results, as shown in columns (2)-(4). In 2015, the most recent year in our sample with a complete data coverage, this association is even stronger: the share of loans financed on the balance sheet jumps by about 47% to 62% above the conforming loan limit (columns (5) to (8)).

Table 2 Panel (b) 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%. Increasing the bandwidth above 1% produces similar results, as shown in columns (2)-(4). The results around the discontinuity illustrate that traditional banks specialize in originating mortgages, which have to be held on the balance sheet, not simply mortgages, which are large.

III.B.2 Within Bank Analysis: Balance Sheet Capacity, and the Balance Sheet Retention Margin

In the previous section, we look at the market segmentation between banks to shadow banks. In this section, we look within banks. We do so for two reasons. First, we use within bank analysis to show that balance sheet capacity of is driving their comparative advantage in the jumbo market, rather than other regulatory differences. Second, we provide micro evidence for the balance sheet retention margin within banks, which we document in the aggregate data.

Market Segmentation and Balance Sheet Capacity: Conforming Loan Limit Discontinuity

Our findings above 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. 2018). 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.

We again study originations above and below 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. Figure 4 Panel (c) 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 roughly 40% of loans. Discontinuously at the cutoff, however, well-capitalized banks market share jumps, and they account for nearly 50% of originations even though they comprise only one quarter of lenders by definition.

We formally test for the discontinuity in Table 3. First, Panel (a) of Table 3 confirms that within the sample restricted to only banks the fraction of loans financed on the balance sheet significantly jumps above the conforming loan limit. Results in Table 3 Panel (b) confirm that the fraction of loans originated by the well capitalized banks substantially increases at 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.

Balance Sheet Retention Margin

In the aggregate data we document that banks' shift away from originating balance sheet intensive loans (jumbo), and towards loans they can sell (conforming) when their capitalization declines. Here, we provide micro evidence of the balance sheet retention margin.

Figure 5 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 between bank capitalization and the share of loans they choose to retain versus sell. One potential reason is that banks who are 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. 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' change their business models with changes to their balance sheet capacity. 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.

We more formally investigate whether traditional banks are more likely to retain a larger share of originated mortgages on their balance sheet if they are better capitalized using the following specification:

$$Held_{bt} = \beta CR_{bt} + \gamma_t + \gamma_b + X'_{bt}\Gamma + \epsilon_{bt} \qquad (2)$$

Where $Held_{bt}$ is the percentage of loans held on the balance sheet by bank b in year t; CR_{bt} is a bank's capital ratio 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. These specifications are estimated for both levels and changes in these variables.

Table 4 shows that banks that experience a 1pp increase in their capital ratio increase the share of originations held on their balance sheets by about 4.5pp (Column 2). Columns (3) and (4) show that across banks, better capitalized banks originate more jumbo loans, but that this effect disappears within banks. Columns (5) and (6) show that the within bank balance sheet retention margin occurs on the dimension of conforming loans. In other words, as banks capitalization changes, they change what share of conforming loans they choose to securitize or keep on the balance sheet. This is consistent with the fact that because secondary market for jumbo loans is limited, banks are largely unable to adjust whether they sell or retain these loans. In contrast, with conforming loans we find a large effect of capitalization on financing. This is consistent with banks able to access external financing for conforming, but not jumbo loans. These effects hold both across and within banks, suggesting that banks vary their business model on conforming side in response to changes in their own capitalization. [7]

III.B.3 Relative Product Pricing

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 6 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 6). 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.

III.B.4 Consumer "Bunching" at the Conforming Loan Cutoff

As we document, jumbo mortgages are generally more expensive than conforming mortgages at the conforming loan limit. A consumer who would, all else equal, prefer a jumbo mortgage may

[7] Mian and Sufi (2018) show that in the run-up to the financial crisis, the expansion of the global shadow banking market reduced the cost of lenders relying on non-core deposit liability financing. One possibility is that our results, where poorly capitalized banks shift towards originations relying on lower-cost financing from non-balance sheet sources (e.g., originate to distribute), are driven by the fact that these poorly capitalized banks have a high share of non-core deposit financing. We redid the earlier analysis, including controls at the bank-year level for the non-core deposit financing share and the core deposit financing share. The results are shown in Table A5 in the Appendix. Our main results on capital ratios are robust to the inclusion of these controls, which suggests that bank capitalization is an important driver of our findings.

therefore prefer to choose a cheaper conforming mortgage instead. Presumably such consumers would choose the largest possible mortgage that is still conforming. Consistent with this idea, the literature has found significant bunching—a mass of borrowers right below the conforming loan cutoff (e.g., DeFusco and Paciorek 2017). We confirm this fact in Figure 7, Panel (a). In addition we document that larger mortgages are on average taken out by people with larger incomes, there is a mass of higher income individuals below the conforming loan limit (Panel b). As the model later formalizes, the income bunching at the discontinuity informs us about which types of borrowers (by income) are willing to take up a smaller mortgages in exchange for lower rates. As we discuss later, our model uses micro moments related to this "bunching" around the conforming limit discontinuity to estimate the model.

III.C Summary

We find that shadow banks have gained significant market share, during the period of tightening regulatory constraints faced by traditional banks, but these gains have been concentrated in the originate-to-distribute 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 a 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 conforming market. Such market segmentation and potential endogenous substitutability between banks and shadow banks implies that assessing the quantitative impact of shocks and interventions on lending volume, prices, bank stability, and borrowers is non-trivial. We next turn to a structural model that allows us to make such assessments.

Section IV: 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. Our model builds on Buchak et al. (2018), but is substantially richer on several dimensions on both demand and supply side. Most importantly, our model accounts for the market segmentation between products, which can be securitized and those that cannot

(conforming and jumbo mortgages) both on the demand and supply side. We briefly discuss some salient features of supply and demand side before describing the model in detail.

On the supply side we explicitly model different financing choices across intermediaries. 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.[8] These financial intermediaries engage in two activities, loan origination and financing. Intermediaries can finance mortgages two different ways: portfolio (balance-sheet) 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. We also allow banks to face regulatory pressures beyond capital requirements. These can arise from legal or regulatory enforcement actions, or the anticipation of future actions on the part of the regulators or prosecutors. These regulatory pressures constrain banks' lending activity even if banks are well capitalized.

Following the current 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.[9] Shadow banks can only originate-to-distribute. With this set-up, our model generates endogenous market segmentation between traditional and shadow banks and within the traditional banking sector between well and poorly capitalized banks. In Section V.D, we relax this assumption and study the consequences of jumbo mortgage securitization.

On the demand side, we build a rich discrete choice framework, with an application to the mortgage market. Importantly, we allow preferences of borrowers to be correlated with their income and house prices. These differences in preferences, especially for larger mortgages, play a critical role in studying the distributional aspects of policies.

IV.A Demand

A market c in year t is defined at the MSA-loan purpose level. For example, a market may be borrowers in New York City attempting to refinance their mortgages. Each market has $i = 1, \dots, I_{ct}$ consumers, with an ideal mortgage size, F_i, and $j = 1, \dots, J$ lenders.[10]

[8] During our estimation period all traditional banks are classified as non-fintech (see Buchak et al. 2018).
[9] 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 balance sheet lending as a competitive outcome with a corner solution.
[10] Market size for new originations is defined as 10% of households in a given market in a year under the assumption that households remain in place for roughly 10 years. The market size for refinances is the total number of households with mortgages.

Lenders can offer up to two types of products, conforming and jumbo mortgages. Conforming mortgage amounts that are available to an individual borrower, $\overline{F_{ict}}$, have to satisfy two constraints. First, the amount must be below the market-specific conforming loan limit $\overline{F_{ct}}$, which is $417,000 in most markets during our estimation period. Second, the loan has to satisfy the individual-specific LTV constraint, where $\overline{LTV} \times P_i$ is the LTV constraint times the borrower's house price. Then the individual's maximum conforming loan size $\overline{F_{ict}}$ is the minimum of the market level conforming level, and the LTV constraint:

$$\overline{F_{ict}} = \min\{\overline{F_{ct}}, \overline{LTV} \times P_i\} \tag{D.1}$$

Any mortgage that does not satisfy these two conditions is a jumbo mortgage. Jumbo mortgages must also satisfy the LTV constraint, i,e, the chosen mortgage size $F_i^* \leq \overline{LTV} \times P_i$. 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 the limits described above.

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

$$\begin{aligned} u_{ijctg} = & \underbrace{-\alpha_i r_{jctg}}_{rate}. \\ & \underbrace{-\beta_i (I(F_i^* < F_i)}_{size} \\ & \underbrace{+ \underbrace{\gamma_i I\left(F_i^* < \overline{F_{ict}}\right)}_{conforming\ convenience} + \underbrace{q_{jt} + \xi_{jct} + \epsilon_{ijctg}}_{lender\ service}}_{service\ and\ convenience} \end{aligned} \tag{D.2}$$

A consumer's utility declines in the mortgage rate $\alpha_i r_{jctg}$, with α_i measuring the consumer specific sensitivity to interest rates.

Borrower i's mortgage amount F_i^* can be smaller than her ideal mortgage size, F_i. If that is the case, she suffers a disutility $\beta_i I(F_i^* < F_i)$,[11] where the borrower specific coefficient β_i measures the extent of disutility, and I is the indicator function. This can occur because the borrowers ideal mortgage is a jumbo $F_i > \overline{F_{ict}}$, but the borrower chooses a mortgage under the conforming limit $I\left(F_i^* < \overline{F_{ict}}\right) I\left(F_i > \overline{F_{ict}}\right)$, or because a binding LTV constraints prevents the borrower from obtaining their ideal jumbo mortgage $I\left(F_i^* > \overline{F_{ict}}\right) I(F_i > \overline{LTV} \times P_i)$.

Consumers also value mortgages on dimensions other than size and price. For example, conforming mortgage approval and administrative procedures differ from those of jumbo mortgages. We allow consumers to have different preferences over these non-rate attributes of

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

conforming mortgages, captured by γ_i. It measures a consumer's relative preference for a conforming loan over a jumbo loan. Consumers also value lender's convenience and/or service quality. Intuitively, consumers like to borrow from fintech shadow banks such as Quicken, because they offer a convenient way to interact online. $q_{jt} + \xi_{jct}$ measures convenience differences between lender, where q_{jt} is observed by the researcher, and ξ_{jct} is not. q_{jt} is the year-lender type invariant quality difference.[12] Last, borrowers' preferences over lenders differ idiosyncratically, which is captured in the i.i.d. T1EV borrower specific utility shock ϵ_{ijctg}. For example, some borrowers prefer to borrow from JPMorgan Chase over Quicken, because they have a bank account with the former, making it easier to transact.

The ideal mortgage size, interest rate sensitivity, the relative preference for conforming loan, as well as the cost of departing from the ideal mortgage size are consumer specific. Consumers' preferences are drawn from a distribution, where the distribution is a function of income and house prices in a market. Specifically, let $\mathrm{B}_i \equiv (\alpha_i, \beta_i, \gamma_i, F_i)'$ describe consumer preferences, then

$$\mathrm{B}_i = \overline{\mathrm{B}} + \Pi(D_{ict} - \overline{D}) + \Sigma\nu_i \qquad \text{(D.3)}$$

$\overline{\mathrm{B}}$ is the vector of mean consumer preferences, Π maps demeaned consumer demographic characteristics such as income and house prices $(D_{ict} - \overline{D})$ 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 ideal mortgage size. The demand parameters to be estimated are then $\theta_d = (\overline{\mathrm{B}}, \Pi, \Sigma)$.

Consumers choose the mortgage that maximizes their utility by choosing between offered mortgages, subject to an LTV constraint. If they do not choose a mortgage they choose an outside good with a fixed utility, u_{i0}. In other words, given product characteristics for each mortgage offered in the market $jctg$ (including interest rate, mortgage type, lender type, statutory size limits, and service quality), and demand parameters θ_d, the set of borrower characteristics (including product-borrower match utilities $\epsilon_{ijc\cdot}$), such that borrowers with these characteristics in market ct choose a mortgage of type g from lender j is:

$$A_{jctg}(r_{\cdot ct}, g_{\cdot ct}, \bar{F}_{ct}, q_{\cdot t}, \xi_{\cdot ct}; \theta_d) = \left\{ \left(D_i, \epsilon_{i0ctg}, \dots, \epsilon_{ijctg}\right) \mid u_{ijctg} \geq u_{ikctl}, \forall k, l \right\} \qquad \text{(D.4)}$$

$A_{jctg}(\cdot)$ denotes the set of demographic characteristics, D_i, and idiosyncratic shocks $\epsilon_{i\cdot ctg}$ such that given loan characteristics $(r_{\cdot ct}, g_{\cdot ct}, \bar{F}_{ct}, q_{\cdot t}, \xi_{\cdot ct})$ and parameters θ_d, consumers with those demographics and preference shocks obtain more utility from choosing the loan from lender j of type g, u_{ijctg}, than from all other lenders and loan types, u_{ikctl} among loans satisfying the

[12] Because of large changes in the quality of fintech providers over time, we allow the quality of fintech shadow banks to evolve over time as well.

borrower specific LTV constraint. Integrating over demographics and shocks yields the market share of mortgage lender j offering product g in market ct:

$$s_{jctg}(r_{\cdot ct}, g_{\cdot ct}, \bar{F}_{ct}, q_{\cdot t}, \xi_{\cdot ct}; \theta_d) = \int_{A_{jctg}} \frac{\exp\left(u_{ijctg}(\mathrm{B}_i)\right)}{\sum_{k,l}\exp\left(u_{ikctl}(\mathrm{B}_i)\right)} dB(B_i) \qquad \text{(D.5)}$$

Note that the size of mortgages a consumer chooses is implicitly captured in expression D.4. If a consumer prefers a jumbo-sized mortgage, and chooses a jumbo mortgage, she does so at the ideal size or at the LTV constraint. If, instead, this consumer chooses a conforming mortgage, she will choose the largest conforming mortgage possible subject to the LTV constraint, which implies bunching at the conforming loan limit.

IV.B Mortgage Supply

There are N_{bct} banks, N_{nct} non-fintech shadow banks, and N_{fct} fintech shadow banks in market *ct*. Lenders choose simultaneously which mortgages to originate across all markets, and how to finance them. A lender *j* who originates m_{jctg} dollars of mortgage type *g* in market *ct* has to decide how many to retain as portfolio loans on the balance sheet, m^b_{jctg}, and finances the remainder through GSE securitization $m_{jctg} - m^b_{jctg}$. Jumbo mortgages cannot be securitized, and are held on the balance sheet, $m_{jctNC} = m^b_{jctNC}$. Each bank has only one balance sheet across markets in which it participates. Denote by $m^b_{jg} = \sum_{ct} m^b_{jctg}$ 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.

IV.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 *ct* is

$$\sum_g m_{jctg} w_{jg} \qquad \text{(S.1)}$$

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.

IV.B.2 Financing and Regulatory Burden

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 $\sigma_t^{GSE} = \sigma_t^b + \sigma^{GSE}$. Here σ_t^b represents the underlying financing costs of funding absent any costs arising from intermediation and captures the current interest rate environment in the macroeconomy. σ^{GSE} captures additional costs coming from the lender using GSE financing, which can include the guarantee fee (g-fee) charged by the GSEs for coverage of projected credit losses from borrower defaults in the securitized pools. In other words, when the firm originates-to-distribute a mortgage, it earns the spread on the mortgage rate, minus the financing and non-financing origination costs, $r_{jctg} - \sigma_t^{GSE} - w_{jg}$ 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 (see extension in Section V.D).

Costs of Portfolio Lending

The cost of portfolio lending depends on the composition of the lenders balance sheet, and the amount of equity capital e_{jt}. 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_{jto}^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_{jt}. The amount of equity and the asset composition of the balance sheet jointly determine the cost of portfolio lending for an intermediary. While these quantities are fixed in the baseline model, we allow for costly equity issuance, as well as liquidating of non-mortgage assets in Section V.D.

A lender's risk-adjusted capital ratio, ρ_{jt}, depends on the banks equity capital e_{jt}, and banks' risk weighted assets $\xi_o m_{jto}^b + \sum_{ctg} \xi_g m_{jctg}^b$:

$$\rho_{jt} = \frac{e_{jt}}{\xi_o m_{jto}^b + \sum_{ctg} \xi_g m_{jctg}^b} \tag{S.2}$$

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:

$$\sigma_{jt}^{p} = \sigma_{t}^{b} + \sigma^{b1}\left(\rho_{jt} - \bar{\rho}\right)^{-\phi} \tag{S.3}$$

The closer a banks risk-adjusted capital ratio is to the statutory requirement, i.e. the smaller is $\left(\rho_{jt} - \bar{\rho}\right)$, the larger is the cost of portfolio loan financing, with ϕ 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 (see, Corbae and D'Erasmo (2019)). We assume that shadow banks' capitalization ρ_{jt} is so low that portfolio lending is prohibitively expensive $\rho_{jt} = \bar{\rho}$. This assumption captures in reduced form the notion that shadow banks do not have access to a subsidized deposit funding and must use external financing instead.

Regulatory Burden

Banks face regulatory pressures beyond capital requirements. These regulatory pressures constrain banks' lending activity even if banks are well capitalized. Rather than changing costs of lending, which we model directly, regulatory burdens may also reduce traditional banks' activity on the extensive margin. For example, risk constrains, fear of enforcement or lawsuits may sometimes prevent a traditional bank from lending to a given borrower altogether (Buchak et al. 2018). We capture this type of regulatory burden through parameter $1/\zeta_{tg}$.

For banks the probability of lending to a specific borrower of mortgage *g* in market *ct* is scaled by a factor ζ_{tg}. A higher $1/\zeta_{tg}$ (lower ζ_{tg}) captures a relatively constrained bank; a lower $1/\zeta_{tg}$ (higher ζ_{tg}) captures a relatively unconstrained bank. These shocks are i.i.d. across lender-borrower pairs, which accounts for the uncertainty that a bank faces with respect to which loans may ex post be subject to these issues.

IV.B.2 Choosing Mortgage Rates and Financing

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 $\boldsymbol{r_{jt}}$ the set of prices of all products, conforming and jumbo, across all markets, $\boldsymbol{r_{jt}} = \{r_{jctg}: \forall c, g\}$. 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_{jctC}^{b}, and how many to securitize, $m_{jt}^{GSE} = \sum_{c}\left(m_{jctC} - m_{jctC}^{b}\right)$. Then the lenders choose interest rates, and the amount of conforming mortgages to hold on the balance sheet by maximizing the following profits:

$$max_{\boldsymbol{r_{jt}}, m_{jctC}^{b}} \underbrace{\sum_{ctg} r_{jctg} m_{jctg}}_{rate\ income} - \underbrace{\sum_{ctg} m_{jctg} w_{jg}}_{origination\ cost} - \underbrace{\left(m_{jt}^{GSE}\sigma_{t}^{GSE} + \sum_{ctg}\left(m_{jctg}^{b}\right)\sigma_{jt}^{p} \right)}_{financing\ cost} \tag{S.4}$$

The first term labeled *rate income* is the yearly income that the lender earns from the loans that it has made, equal to the sum of interest rates times mortgage volumes across all loan types and markets. The second term labeled *origination cost* is the costs the lender occurs in originating the loans, such as the wages of mortgage brokers, advertising, and administrative expense. The third term labeled *financing cost* is the financing cost of the mortgage, reflecting the costs of either GSE or balance sheet financing, depending on the lender's optimal financing cost.

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. Market shares are also affected by regulatory constraints. In other words, the amount of mortgages originated, m_{jctg}, is implicitly a function of both the interest rates of the lender $\boldsymbol{r_{jt}}$, other lenders $\boldsymbol{r_{-jt}}$, and the regulatory burden parameter ζ_{tg}, which we omit for ease of notation.

IV.B.3. 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 decide how many of the mortgages to hold on the balance sheet.

IV.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.

We compute risk adjusted interest rates in a market by projecting out FICO and LTV[13] differences. We then project each loan's actual interest rate to its predicted interest rate differences so that each loan in the market has the market-wide average FICO score of roughly 760. This adjustment insures that across markets and lenders, we are comparing interest rates of similarly risky borrowers. Next, we aggregate from the loan level to the time and market level by taking the average of these residualized interest rates across product and lender types.

We obtain the number of unique lenders (N_{bct}, N_{fct}, and N_{nct}) by taking the median number of lenders per census tract within the MSA. This captures the typical number of loan offerings from

[13] For jumbo data, we include only FICO because LTV is missing for many observations. To ensure this adjustment is not material, we compare residualized jumbo interest rates using both FICO and LTV where LTV is available to those using FICO only and find a correlation of 99.9% among the samples.

each type of lender that a borrower faces. Market size is defined as one tenth of the total number of households in the case of new originations, under the assumption that one tenth of households are potentially in the market for a new home per year, and as the total number of outstanding mortgages in the case of refinances.

IV.C.1 Demand Estimation

Our estimation roughly follows Berry et al (1995), and Nevo (2000) with several differences. The first important difference is borrowers choose loan quantity, in addition to choosing whether to take up a mortgage. In other words, while Berry et al (1995) is a discrete choice model, our model is discrete-continuous. Therefore, in addition to estimating standard preferences over interest rates (governed by α_i), and non-price attributes of mortgages (governed by γ_i and $q_{jt} + \xi_{jct}$) we have to estimate the preferences over mortgage size. These are governed by a borrowers (unobserved) ideal mortgage size F_i, and the disutility of choosing a mortgage, which is too small, β_i. The most significant departure from the standard Berry et al (1995) and Nevo (2000) style estimation is the use of the discontinuity at the conforming loan limit in addition to aggregate data. In other words, we introduce bunching style identification into a structural model.

To identify consumer preferences, we need to instrument for prices. We exploit an institutional feature of how GSEs set interest rates of conforming mortgages. Hurst et al. (2016) show that, for political economy reasons, mortgage pricing for GSE loans does not adjust for spatial risk. In other words, in some areas, the financing cost of a conforming mortgage is higher than in other areas, which is unrelated to mortgage demand (see Hurst et al., 2016, for extensive documentation of that fact). Accordingly, we use the variation in mortgage pricing across regions to obtain relative variation in conforming and jumbo interest rates that is driven by GSE constraints and not by borrower demand.

In addition to aggregate data, we also exploit several micro-level data moments. First, we use the mean and standard deviation of realized loan sizes for jumbo and conforming loans within a market. Second, we use two moments around the conforming limit discontinuity. First, we use the market share of borrowers who obtain conforming loans exactly at the conforming loan limit (see Figure 7 Panel a). The second moment we match is the income difference between borrowers exactly at the conforming loan limit and those nearby (see Figure 7 Panel b).

Identification Discussion:

While all moments jointly identify the parameters of the model, as in Berry et al (1995) and Nevo (2000), the aggregate market shares allow us to identify the distribution of preferences over interest rates and non-price attributes of mortgages, once we instrument for price. The price variation induced by the GSE cost shocks allows us to identify the price sensitivity for consumers, α_i. Variation in market shares for a given interest rate across lenders allows us to estimate consumer preferences over non-price attributes, $q_{jt} + \xi_{jct}$. Intuitively, if Quicken has a larger market share for mortgages for a given interest rate, it must be because consumers value Quicken's convenient mortgage screening and documentation system.

Jointly with the aggregate moments, the micro moments allow us to estimate the preferences over other parameters of the model. Intuitively, consumers who choose a jumbo mortgage, choose the mortgage at their ideal size (subject to LTV constraint). Similarly, consumers who choose a conforming mortgage below the conforming limit, choose a mortgage at their ideal size (subject to LTV constraint). Intuitively, the mean and standard deviation of realized loan sizes for jumbo and conforming loans within a market are very informative about the distribution of ideal loan sizes, F_i, once we account for the behavior at the discontinuity.

The parameter β_i, governs behavior at the discontinuity, and consequently the distribution of loan sizes around the discontinuity are highly informative in identifying these parameters. Recall that a consumer choosing a smaller than ideal mortgage yields a disutility β_i. Consider a consumer whose ideal mortgage size is greater than the conforming limit. She has three choices: obtain a jumbo mortgage of the ideal size, obtain a conforming mortgage that is too small, perhaps at a lower rate, or exit the market entirely. When β_i is large, she will be unlikely to take a smaller conforming loan, unless the interest rate differential and her price sensitivity is large. In contrast, when β_i, is small she is more likely to take a conforming mortgage exactly at the conforming loan cutoff. In consequence, all else equal, β_i governs the amount of bunching at the conforming loan cutoff. Large β_i leads to less bunching and small β_i leads to more bunching. Consequently, the average level of β_i is identified off of the observed bunching in the data, and β_i's covariance with wage and house price is identified by how bunching varies with wage and house prices in the data.

Besides taking a smaller conforming loan, the consumer has the option to obtain a jumbo loan or exit the market entirely. If γ_i is high, holding the conforming market share fixed, then jumbo loans are highly inconvenient and the consumer is more likely to exit the market entirely rather than obtain a jumbo loan. In contrast, when γ_i is low, jumbo loans is are relatively convenient, and the consumer is more likely to remain in the market. That is, γ_i governs the missing mass of borrowers whose ideal loan size is jumbo but because jumbo loans are inconvenient and conforming loans are too small, decide to exit the market entirely. Observe from Figure 7 Panel (a) that indeed, the density of mortgages drops discontinuously above the conforming loan limit beyond simply the bunching at the conforming loan limit and that there is a missing mass of jumbo borrowers. That is, consumers value the convenience of conforming mortgages. Put another way, holding market size constant on the extensive margin, γ_i governs the relative market shares of conforming and jumbo mortgages, with a high γ_i leading to relatively more conforming loans. Consequently, the average level of γ_i is identified off of the relative market shares of conforming and jumbo loans holding overall market shares fixed, while γ_i's covariance with wage and house price is identified based on how these relative market shares vary with wage and house prices in the data.

The last micro moment we match is the income difference between borrowers exactly at the conforming loan limit and those nearby (see Figure 7 Panel b). Intuitively, the larger the income spike at the discontinuity, the more sensitive less sensitive the higher income population is to talking a mortgage, which is smaller than ideal. This moment aids in identifying the correlation

between income and preferences for a jumbo mortgage, i.e., the structure of the correlation in the random coefficients.

Model Fit: Targeted Moments and Simulated Responses to Real Policy Changes

We estimate the model over the period 2010-2015. The results are shown in Tables 5, 6, and 7. Broadly, the model matches market shares of conforming and jumbo mortgages by different lenders for given mortgage prices, as well as the micro moments, such as the bunching at the conforming limit. By construction, the model fits market shares data. The model also fits the size distribution of mortgages in the data quite well. Figure 8 shows the bunching at the conforming loan limit generated by our model, both the average amount of bunching, as well as differences in bunching across markets. 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. The model overestimates the extent of bunching in the markets with most bunching. Intuitively, these markets with highest demand for jumbo mortgages. This is likely due approximating the desired loan size with a log normal distribution. Markets, in which desired loan sizes are large are then also high variance, so the log-normal distribution will put a lot of mass to the right.

We also examine the fit of the model by confronting it with actual policy changes. We exploit changes to conforming loan limits over time in the US mortgage market between 2007 and 2016. We compute market outcomes using our model estimates, and compare model predicted changes to those from the data. The main variables of interest at the level of county and origination year are jumbo origination share (*%Jumbo*), bank origination share (*%Bank*), and the mass of borrowers at conforming limit cutoff (*%AtCutoff*). The main explanatory variable captures the change in conforming limit in a given county in a given year. It is measures as the percentage difference between the conforming loan limit in year *t* in county *c*, and the conforming loan limit in 2007 for the same county *c*:

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

The origination amount 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 8 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. This is roughly in line with what the model suggests in Table 11, which shows that a 1% increase in the conforming loan limit decreases jumbo market share by roughly 0.31%. 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. This is broadly consistent with what the model suggests in Table 11, which finds that a 1% increase in the jumbo loan limit leads to roughly a 0.08% decrease in bank market share around the current limit.[14]

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 $\bar{\alpha} = 1.14$ implies a price elasticity of roughly 4.4. This estimate is close to DeFusco and Paciorek (2017), who estimate the elasticity from the conforming loan discontinuity using a different approach. The estimate of $\sigma_\alpha^2 = .07$ suggests moderate borrower differences in price elasticity, ranging from 4 to 5.12 for borrowers two standard deviations below the mean, and borrowers with two standard deviations above the mean in price sensitivity. Second, for a given level of income borrowers who buy more expensive houses are less price elastic with respect to mortgages. This makes sense: customers who are willing to purchase a larger house are also more willing to also pay a higher interest rate. Conditional on the house price, on the other hand, higher income households are more price elastic. In other words, the household, which bought a more frugal home relative to its income is also more price elastic when choosing a mortgage. Overall, since jumbo mortgages cater to 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.

Ideal mortgage size

The preference over mortgage size is a central driver of consumers choosing jumbo versus conforming mortgages. The ideal mortgage size is larger for wealthier individuals, with an elasticity of 0.38: as income rises by 1%, the desired mortgage size increases by 0.38%. This estimate is close to the heuristic that household debt should not exceed 30% of household income. Desired loan size also increases with house prices, with an elasticity of approximately 0.39.

[14] We also assess if there is a change in bank market share as more jumbo loans are originated by using the following specification $BankShare_{ct} = \beta JumboShare_{ct} + \gamma_c + \gamma_t + \epsilon_{ct}$. The results in Table 8 Column (4) find a positive and significant association between bank share and jumbo share. This coefficient, here estimated as roughly 0.25, is roughly in line with the relationship suggested in the model from Tables 9, 10, and 11, which finds that bank share increase by roughly 0.50 percentage points per percent increase in jumbo market share. Note that variation in jumbo share from the regression above obtains from all sources, such as variation in demand, supply and policy variation, whereas the cross-validating variation in the model comes entirely from policy variation where one would expect a stronger relationship between jumbo share and bank share.

Consumer may not be able to borrow at their ideal size due to LTV constraints, or because they choose a cheaper and more convenient conforming mortgage, rather than the jumbo sized mortgage they would ideally want.

When borrowers depart from their ideal mortgage size, they find this departure costly. This parameter is 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. For borrowers who would otherwise prefer a jumbo mortgage, we estimate a mean disutility of taking a smaller loan to be $\bar{\beta} = 5.79$, which is equivalent to roughly a 5.1% higher interest rate. Because consumers are on average quite price elastic, the fact that may still take a more expensive jumbo mortgage, implies that those borrowers value the additional funds provided by a jumbo mortgage. Taking out a smaller conforming mortgage may prevent the borrower from purchasing a home, or result in purchasing a substantially smaller home than they would want.

Next, 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. Finally, we find a positive and substantial preference for conforming loans overall as opposed to jumbo loans, possibly reflecting the costs of qualifying for and obtaining a jumbo loan (e.g., increased screening and loan documentation requirements and additional time and effort needed to obtain a jumbo loan relative to conforming loan). The preference for conforming mortgages explains the substantially smaller market share of jumbo mortgages relative to the house price distribution.

IV.C.2 Supply Estimation and Results

To estimate the supply-side parameters, which govern intermediaries' behavior, we use the revealed preferences of intermediaries in 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, and the costs of originate-to-distribute. Intuitively, using demand estimates, we can compute the mark-ups that intermediaries earn. We use the lenders' pricing decisions, combined with these mark-ups to infer the costs of lending. For example, if an intermediary is charging higher prices for a given mark-up, this implies that the intermediary is facing higher lending costs, which the lender passes on to consumers. Recall that for a bank, the cost of portfolio lending depends on its current capital ratio ρ_j, the statutory capital requirement $\bar{\rho}$, other parameters such as the risk weights, ξ_g and ξ_j, and the type of mortgage. To the extent that low capitalization indeed causes a higher cost of portfolio lending, the model implies how these higher costs should be passed through to different types of mortgages given estimated demand. Table 6 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. Since mortgage demand is quite price elastic, the markups are quite moderate, at 1.6%. With that in mind, the baseline costs of originating and financing a mortgage varies from 4.2% – 4.6%. This number represents the cost of financing and originating a new purchase mortgage if a bank were flush with capital. As banks' capitalization declines, their financing costs rise. To better understand the different costs of mortgages, Figure 9 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 aspects are worth discussing.

First, well capitalized banks have a cost advantage over poorly capitalized banks, because they can lend with lower-cost balance sheet financing. Moreover, even poorly capitalized banks have a cost advantage over shadow banks. While both can finance mortgages through GSEs, the model estimates that banks' origination costs are lower. 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.[15] 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 statutory capital by 3%, the additional financing cost is approximately 50bps; at 10% of capital above the statutory limit, the cost difference declines to approximately 5bps.

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 4.5% 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 4.35% marginal cost. This implies a negative conforming-jumbo marginal cost spread which is roughly in line with patterns in Panel (c) of Figure 1.

Finally, the model suggests that originating refinancing mortgages is less costly than originating mortgages for purchase by approximately 5-10 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, which reduces costs.

IV.C.3 Bank Regulatory Burden and Fintech Quality

Table 7 shows two primary reasons why banks have been losing market share during this period: an increase in the regulatory burden from 2012 onwards and the entrance of new fintech competitors. A part of the reason why banks have lost market share during the period is an increase

[15] Exposures to US government-sponsored enterprises receive 20% risk weights; exposure to first-lien mortgages on owner-occupied single family houses receive a 50% risk weight. See https://www.mercatus.org/system/files/mercatus-barth-primer-capital-standards-v1.pdf

in capital requirements, which has increased their costs of funding, as we discuss above. On the other hand, the period following the crisis has been profitable, increasing banks' capitalization offsetting some of this increase. Despite that, banks have lost substantial market share in the conforming market. Table 7 shows why.

The regulatory burden measures the non-capital requirement related regulatory constraints faced by the banking sector relative to shadow banks, such as risk of enforcement actions and lawsuits, which constrain bank origination. The estimates show that the banking sector regulatory burden even declined a bit, but then starts increasing from 2012 onwards. This is the period of implementation of the Dodd-Frank Act, the establishment of the Consumer Financial Protection Bureau, and increased mortgage lawsuit activity targeted at traditional banks. These results are consistent with those of Buchak et al. (2018) who estimate the regulatory burden in a simpler model, but on a longer sample. The substantial changes in the regulatory burden emphasize that the singular focus on capital requirements misses a large degree of regulatory and enforcement changes in the banking sector following the crisis.

The second reason that banks have been losing market share over the period is the entrance of new fintech lenders. These fintech lenders entered on the promise of providing a better user experience, with a more consumer convenient online interface. Table 7 suggests that it took fintech until 2013 to achieve that, and they were only successful in the market for mortgage refinancing. Prior to 2012, our model suggests that consumers' on average preferred to originate a refinancing mortgage from a non-fintech shadow bank, but by 2015, consumers substantially prefer the fintech experience in this sector. In the market for new originations, i.e. the consumer is purchasing a house, fintech are at a disadvantage: consumers on average prefer non-fintech shadow banks over the whole sample, although by 2012, the disadvantage has decreased significantly. This result is consistent with the idea that the online origination is not well-suited to originating new mortgages, which require on-the-ground activities, such as a structural examination or a new appraisal.

Section V: Counterfactual Policy Analysis

In this section, we use the estimated model to study the consequences of several policy changes. Our baseline scenario is based on 2015 lending volumes, as reported in HMDA, together with 2015 regulatory policies.[16] We evaluate the effects of policies on the amount, distribution, and pricing of loans, as well as the resulting market structure. In doing so we assess the quantitative importance of the balance sheet retention and shadow bank retention margins in these effects. We analyze the consequences of policy changes along two dimensions. The first is mortgage origination and redistribution, which analyzes the policy from the perspective of potential borrowers: how many mortgages of each type are originated, at which prices, and to which borrowers. The second dimension is implications for bank stability. Because policies impact bank

[16] Note that our baseline shadow bank market share (39%) is the fraction of loans originated by shadow banks in the combined conforming and jumbo issuance volume. Accounting for mortgages insured by the Federal Housing Administration, a loan segment where shadow banks originated about 75% loans in 2015, increases the overall shadow bank market share to about 50% (see Buchak et al. 2018).

profits and balance sheet loan retention, they have implications for bank stability. Moreover, the policies have a differential impact across borrowers of different incomes, changing the level of inequality.

V.A Changes to Bank Capital Requirements

We first study the consequences of changing capital requirements. The level of the capital requirement is one of the main tools used by policy makers to regulate banks. Our motivating facts in Section III.B suggest that when traditional banks face a higher regulatory capital constraint, they will reduce lending on balance sheet. On the other hand, the impact will be lessened because banks will adjust on the balance sheet retention margin, keeping fewer of the originated loans on the balance sheet. Moreover, shadow banks will step into the gap and provide some loans as well. The extent of shadow bank migration in response to capital requirements is now acknowledged as an important margin to consider in policy proposals.[17] Our counterfactual allows us to quantify the magnitude of the adjustment along these margins. Taking the 2015 market as given, we counterfactually study the impact of increasing and decreasing capital requirements relative to the 6% baseline. Table 9 and Figure 10 shows the results.

Increasing capital requirements tightens the capital constraint, increasing banks' cost of lending on the balance sheet. Broadly, capital requirements increase stability in the banking sector at a cost of substantially fewer jumbo mortgages. The decline is partially offset by banks originating conforming loans that they do not retain on the balance sheet. The expansion of shadow bank lending also offsets some of the decline in 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. The effect is asymmetric. As we show below, lowering capital requirements primarily operates on the balance sheet retention margin: it increases 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, operates both on the balance sheet retention margin, and the shadow bank migration margin. It decreases the share of mortgages on bank balance sheets, but increases the number of loans originated by shadow banks.

Mortgage Origination and Redistribution

The effect of changing capital requirements has an asymmetric impact on mortgage origination. Cutting capital requirements by half, to 3%, would result in very modest changes in the origination of mortgages. The total volume would increase by $16 billion to $1,779 billion, driven primarily by increases in jumbo lending. The market structure of lending would be relatively unchanged, except about 15 basis point decline in jumbo interest rates. Both high income borrowers and banks benefit from loosening capital requirements, but the benefits are small, with consumer surplus

[17] For instance *The Minneapolis Plan* of the Minneapolis Federal Reserve proposes substantially increased capital ratios, above 20%. One of the critical inputs involves projections on the amount of activity that could migrate to the shadow banking sector (https://www.minneapolisfed.org/publications/special-studies/endingtbtf/final-proposal/summary-of-the-minneapolis-plan-to-end-too-big-to-fail).

increasing by $3 billion,[18] and lender profits increasing by $3 billion if capital requirements fall to 3%. These gains in consumer surplus fall primarily to high income individuals, with individuals in the top quartile of income gaining roughly $47 in consumer welfare, compared to $6 for individuals in the bottom quartile of income.

Increasing capital requirements, on the other hand, causes significant changes to mortgage origination. Consider increasing the capital requirement to 9% from 6%. Total mortgage originations decline somewhat, by $54 billion. However, the main effects are on which types of mortgages are originated and how conforming mortgages are financed. In order words, the largest changes are on the bank balance sheet retention margin and the shadow bank migration margin.

In terms of which types of mortgages are originated, the largest impact is on the jumbo market. Jumbo lending decreases by $151 billion, or 40%, relative to the market with capital requirement of 6%. The large decrease in the supply of jumbo mortgages results in a 44 basis point increase in jumbo rates, relative to the baseline jumbo interest rate of 5.05% while the conforming rate remains virtually unchanged at 4.88%, resulting in a large increase in the jumbo spread. These increases in interest rates are driven almost entirely by increases in banks' marginal costs of originating jumbo loans on balance sheet rather than changes in markups, and these marginal costs increase by 46 basis points over the baseline markup of 1.6%.

A substantial number of borrowers who would have obtained jumbo loans still obtain mortgages: $97 billion worth of mortgages shift to the conforming market. Banks and shadow banks each capture approximately $49 billion of these originations, resulting in a 4pp increase in the share of loans originated by shadow banks. This migration away from jumbo lending at banks and towards conforming lending at shadow banks illustrates the importance of the shadow bank migration margin. However, a significant fraction of these borrowers switch to conforming borrowing but remain at banks, or exit the market completely. Their exit results in a $54 billion net decrease in mortgage lending. This incomplete migration towards shadow banks illustrates that tighter capital regulations on the banking sector may not be completely absorbed through the shadow bank migration channel.

Higher capital requirements primarily hurt banks and higher consumers in higher income zip codes where there is a greater demand for jumbo loans. Given the capital requirement of 9%, bank profits decrease by roughly $24 billion, while shadow bank profits are essentially unchanged. As capital requirements increase, banks lose their comparative advantage of financing loans on balance sheet. Total consumer surplus declines by roughly $45 billion, and a typical borrower sees her consumer surplus decline by roughly $1,617 under the 9% capital requirement scenario versus the baseline. Welfare effects differ significantly within the income distribution, with the majority of these declines occurring for borrowers in high-income markets that rely on jumbo lending. The top income quartile markets see consumer surplus decline by roughly $32 billion, while consumer

[18] We compute consumer surplus as a lifetime present-value dollar equivalent measure of *expected utility* (integrated over consumer specific shocks ϵ_{ijctg}), assuming a subjective discount rate of 4.00% over a period of 10 years.

surplus in the bottom income quartile markets declines by only $1 billion. Finally, it is important to note that these losses have to be weighed against possible welfare gains of moving risk from bank balance sheets (e.g., 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 results in a large increase in the share of loans held on the bank balance sheets. Reducing capital requirements to 4.5% expands the balance sheet holdings of mortgages by 54% ($358 billion annually). Conversely, the primary consequence of increasing capital requirements is a large decline in on-balance sheet lending. As capital requirements increase to 9% and balance sheet financing becomes significantly more expensive, the share of balance-sheet financed lending drops from 37% to 14%, and banks' balance sheet holdings of mortgages drop by 63%. In other words, capital requirements operate primarily on the balance sheet retention margin. These large adjustments starkly illustrate the importance of the bank balance sheet retention margin in responding to increases in capital requirements. 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 adjust along the balance sheet retention margin and 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 to taxpayers, who insure securitized mortgages.

V.B Quantitative Easing and GSE Market Intervention

One of the major policies during the last financial crisis was the sequence of policies referred to as 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. Estimates of the impact vary across different QE operations, decreasing mortgage rates between 20-100bp.[19] We model QE as a decrease 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. Such an increase could reflect the reversal of the QE policy or increase in the guarantee fees charged by the GSEs for coverage of projected credit losses from defaults in the securitized pools. The results are shown in Table 10 and Figure 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.

[19] See, among others, Krishnamurthy and Vissing-Jorgensen (2011) and DiMagio, Kermani, and Palmer (2016).

In particular, they have dramatically different distributional consequences across the income spectrum and result in markedly different allocations of mortgage risk in the economy.

Mortgage Origination and Redistribution

The main effect of QE is to decrease conforming loan rates and increase conforming mortgage lending volumes significantly: a 25bp decrease in GSE rates leads to an essentially one-to-one decrease in conforming loan rates and roughly $193 billion of new conforming mortgage origination. Jumbo interest rates are unaffected. Aggregate consumer surplus increases by roughly $35 billion, driven by both increased lending and lower interest rates.

An *increase* in GSE financing costs has a relatively smaller impact on interest rates and on lending volumes because banks' adjust on the balance sheet retention margin. A 25bp increase in rates only leads to a 12bp increase in conforming loan rates. As GSE financing costs increase, banks make significant adjustments along the bank balance sheet retention margin and substitute away from GSE financing and towards cheaper balance sheet financing. In this scenario, conforming mortgage origination declines by only $88 billion, in comparison to the $193 billion increase caused by an equivalent GSE rate decrease. Jumbo origination volumes decrease slightly because the increased conforming loan balance sheet financing crowds out jumbo lending and increases jumbo origination costs slightly. Aggregate consumer surplus declines by roughly $17 billion, with individuals in higher income markets seeing declines of roughly $8 billion, compared to $1 billion in low income markets.

This asymmetry in response to rate increases and decreases becomes more apparent in more extreme scenarios. A 100bp decline in GSE financing costs leads to roughly a 100bp decline in conforming interest rates. In contrast, a 100bp increase in GSE financing costs leads to only a 33bp increase in conforming interest rates. This asymmetric response of interest rate reflects the importance of the bank balance sheet retention margin. As they retain more loans on the balance sheet, the sensitivity of mortgage interest rates to GSE rates decreases. Interestingly, as absorb these cost increases through more balance-sheet lending, conforming loan balance sheet retention reduces banks' ability to originate jumbo mortgages, leading to slightly higher jumbo rates and slightly lower volumes. The implications for lending volumes and consumer welfare are similarly asymmetric, with a 100bp decrease leading to origination volume increases of roughly $1,012 billion and consumer surplus gains of $169 billion, compared to origination volume decreases of $249 and welfare losses of $51 billion for a 100bp increase.

Shadow bank market shares are very sensitive to changes in the securitization market: a 100bp increase in the GSE financing costs leads to 13 percentage points decline in the overall shadow bank market share and 16 percentage points decline in the shadow bank share of conforming loans.

Bank Stability

In the baseline scenario, conforming loans comprise roughly 42 percent ($280 billion) of balance sheet lending, but even a slight decline in GSE funding costs creates large enough incentives to move these loans from the balance sheet to be securitized. In other words, banks respond to QE by shifting conforming loans off the balance sheet along the balance sheet retention margin. This

endogenous shift explains why conforming interest rates are so sensitive in particular to *decreases* in GSE financing costs: when GSE financing is cheaper, all conforming originations are GSE financed, and so further changes to GSE rates are passed through roughly one-to-one to conforming loan rates. QE also expands traditional bank profits, increasing them by $8 billion, or roughly 6% for a 25 basis points decrease in GSE rates.

In contrast, banks are able to respond to increases in GSE financing costs by shifting originations onto their balance sheets. In response to the 100bp GSE cost increases, the balance sheet financing share increases substantially, from 37% to 75%, which mutes the effect on rates and aggregate lending volumes. Once GSE financing costs increase, the cheap on-balance sheet funding of banks gives them a large comparative advantage and banks adjust on the balance sheet retention margin. There is also a large migration from shadow banks: shadow bank lending volume shrinks substantially by around 44%. Bank profits are initially unaffected as GSE costs increase because lending volumes decrease overall, which is offset by increases in more profitable balance sheet lending. However, for larger increases in GSE costs, the latter effects dominate as borrowers' substitute more and more towards loans financed on bank balance sheets, and bank profits increase by a small amount.

This counterfactual illustrates how the effects of QE differ substantially from capital requirements. Both increases to capital requirements and decreases to GSE financing costs have the effect of shifting origination off balance sheet and into securitized mortgages. However, an increase in GSE financing cost leads to much larger contraction of aggregate lending volume compared to the increases in capital requirements. This is because an increase in the GSE financing costs directly affects the lending ability of *both* banks and shadow banks and ends up contracting lending substantially. On the other hand, increases in the capital requirements targets only banks. As a result, shadow banks end up alleviating the adverse effect of an increase in the capital requirements on aggregate lending volume by increasing their lending though the migration margin.

V.C Changes to Conforming Loan Limits

We next consider changing conforming loan limits. This policy has been actively changed since the beginning of the crisis, with the explicit purpose of intervening in the mortgage market. During the 2006-2016 period, conforming loans were generally 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, the Economic Stimulus Act of 2008 temporarily increased the conforming loan limit in high-cost areas, pushing it to as much as $729,750. The policy of higher limits has persisted since then, although the limit for high cost areas was subsequently reduced to $625,000.[20] The limit is subject to an ongoing policy debate regarding the potential downsizing of the GSE role by progressively

[20] Due to progressive increases in conforming loan limits from 2017 onwards, by 2019 the conforming loan limit reached $484,350 in most markets and up to $726,525 in high cost areas.

lowering the conforming loan limits.[21] Moreover, because the policy caps loan amounts, its consequences differ substantially across markets with different house prices and households with different mortgage demand. We experiment with several different types of limits, and show the results in Table 11 and Figure 12.

Mortgage Origination and Redistribution

We first consider expanding GSE coverage by increasing the conforming loan limit by 25%. For most markets, this means increasing it from $417,000 to roughly $520,000. This counterfactual highlights the redistributive impact of expanding GSE coverage because of the changed market structure. Total origination volumes increase by roughly $200 billion, with conforming origination volumes increasing by roughly $310 billion, and jumbo originations decreasing by roughly $110 billion. This expansion of GSE coverage leads to increases in shadow bank market share by roughly 4 percentage points.

Increasing conforming loan limits leads to increases in overall and conforming volume, decreases in jumbo volume, and increases in consumer welfare. Consumer surplus increases by roughly $88 billion in the highest income markets, while it increases by only $11 billion in the lowest income markets. Borrowers in high income areas are more sensitive to these increases because they purchase more expensive homes and consequently prefer larger loans.

Finally, it is interesting to consider the two scenarios of unifying conforming loan limits across counties. Column (5) of Table 11 considers setting all limits to the $417,000 lower limit; Column (6) considers setting all limits to the $625,000 higher limit. While lowering the limit decreases lending volumes overall and raising the limit increases lending volumes overall, these gains are not evenly distributed. Decreasing limits in all markets to $417,000 has essentially no impact on low-income area consumer surplus, while it significantly reduces high-income area consumer surplus, decreasing it by roughly $51 billion relative to the baseline scenario. On the other hand, increasing limits across all markets to $625,000 significantly increases high-income consumer surplus among both low- and high-income areas, with the majority of the welfare gains accruing to high income areas and high-income borrowers. Borrowers in high-income areas see consumer welfare increase by $106 billion, while borrowers in low-income areas see consumer welfare increase by only $17 billion.

Bank Stability

While changes to the conforming loan limit mechanically have large impact on conforming loan volumes, interestingly, the impact on loan retention is less direct. Decreasing the conforming loan limit by 25% raises the share of loans financed on balance sheet by 12 percentage points. This increase is driven largely by increased jumbo lending as a share of overall lending, which increases by 12 percentage points. Increasing the conforming loan limit has a muted effect on the share of balance sheet financing, which declines from 36% to 31%. While a substantially greater share of mortgage originations is conforming, banks continue to hold a significant share of these

[21] See, for example: https://www.housingwire.com/articles/27344-affordability-concerns-surface-in-conforming-loan-limit-debate [accessed on October 2, 2018.]

originations on balance sheet rather than selling them. That is, banks' response along the balance sheet retention margin is small even though their ability to securitize more loans increases. Increasing conforming loan limits does impact the distribution of profits between banks and shadow banks, with banks' profits decreasing and those of shadow banks' profits increasing as shadow banks can now originate and distribute to a larger segment of the market where banks once dominated.

Finally, we note an interesting difference between the effects of lowering conforming loan limit (Table 11 and Figure 12) versus increasing capital requirements (Table 9 and Figure 10) on aggregate lending volumes. Both polices decrease aggregate lending volumes. However, in the case of increased capital requirements both shadow bank migration and changes to bank balance sheet retention *alleviate* the adverse effect of policy on the aggregate lending volume. In other words, in the case of tighter capital requirements, solely focusing on bank balance sheet data and models would overstate the adverse effect of such policy on overall lending volume. On the other hand, in the case of lowering the conforming loan limit, the shadow banking sector *amplifies* the adverse impact on aggregate lending volume as this policy also causes a contraction of shadow bank lending.[22]

To summarize, the conforming 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 conforming loan limit beyond their current level further increases consumer surplus, but these gains are primarily felt in the highest-income areas, 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.

V.D Model Extensions: Raising Equity, Asset Sales, and Jumbo Securitization

Our baseline model is already rich, accounting for equilibrium interactions between banks and shadow banks across several markets, as well as allowing banks to adjust their business model on the balance sheet retention margin. Nevertheless, we limit the model complexity to components, which are necessary to match the patterns in the data. In this section, we extend the model on several dimensions. We allow banks to issue equity and sell existing assets, so they can use the generated balance sheet capacity to retain and originate mortgages, giving banks additional margins of adjustment. Second, we investigate whether our conclusions would change if a securitization market for jumbo mortgages were to arise in the future.

Endogenous Balance Sheet Capacity: Bank Equity Issuance and Asset Sales

In the baseline model we assume that issuing loans on the balance sheet becomes increasingly more expensive since banks have fixed balance sheet capacity. We first extend the model to allow

[22] This observation may help explain why lowering the conforming loan limit has much bigger adverse aggregate effect on lending volume compared to raising capital requirements: almost $200 billion reduction due to decline of conforming loan limit by 25% compared to about $16 billion reduction in aggregate lending volume due to increasing capital ratios by 25% (from 6% to 7.5%).

banks to issue equity in order to finance their originations. If a bank wants to keep a mortgage on the balance sheet at a fixed capital ratio, the cost of external funding is a fixed premium over GSE financing costs. This approach nests banks choosing any desired debt-to-equity ratio: If a bank has chosen a certain (arbitrary, not necessarily the current) debt-to-equity ratio, financing an additional mortgage requires only the issuance of enough equity to keep debt-to-equity ratio constant at the same cost.

Another way banks can obtain additional balance sheet capacity is to sell existing assets. Recall that banks hold non-mortgage assets other than mortgages on its balance sheet. In the baseline model, the quantity of these assets is fixed. Since adding mortgages on the balance sheet is increasingly more expensive, the bank could choose to sell its assets and substitute these for mortgages. We assume these other assets have a fixed opportunity cost (return). For ease of modeling, we assume that these assets yield a premium over GSE securitized mortgages that the bank could instead hold.

Intuitively, when a bank is close to its capital requirement, balance sheet lending becomes very expensive. At that point, banks have the option to finance new jumbo originations by raising external financing or selling assets. The advantage of doing this, from the bank's perspective, is that it does not raise the financing costs on its inframarginal assets, and only pays a fixed, linear cost to finance the mortgage. Since equity issuance is more expensive than GSE financing, banks will always finance conforming mortgages through GSE financing or existing balance sheet equity, rather than through new equity issuance.

To understand the effect of endogenous balance sheet capacity, we study the impact of raising capital requirements. We set the cost of issuing external funds and the opportunity cost of holding non-mortgage assets at 25bps above GSE funding. The results are shown in Appendix Table A1. As one would expect, endogenous balance sheet capacity mutes the effects of raising capital requirements. Raising capital requirements to 9% decreases lending volumes by only $1 billion, and increases jumbo interest rates by 7 basis points. The effects on consumer welfare are also muted. The large margin of adjustment occurs on the share of loans that are financed through new equity issuance. With the baseline capital requirements of 6%, roughly 8% of loans are financed through new equity issuance. Increasing capital requirements to 9% increases this to 21%. As shown in Figure A3, when capital requirements are 3%, no jumbo loans are financed through new equity issuance, while when capital requirements at 9%, nearly all jumbo loans are financed through new equity issuance.

Jumbo Mortgage Securitization Market

We conduct our policy analysis using the institutional environment from 2015: while conforming mortgages can either be securitized or held on the balance sheet, there is no securitization market for jumbo mortgages. As our model suggests, if bank balance sheet become significantly impaired the premium on jumbo mortgages rises. If the effect is persistent, one might imagine that a securitization market for jumbo mortgages would arise, as they did pre 2008. We introduce a securitization market for jumbo mortgages by allowing jumbo mortgages to be sold on a secondary

market. Similar to how conforming securitization has a fixed cost, σ_t^{gse}, we assume that jumbo securitization has a fixed cost, σ_t^{jum}.

The introduction of jumbo securitization has two effects. First, traditional banks now face a tradeoff between financing jumbo mortgages on balance sheet versus financing jumbo mortgages through securitization. When bank capital is closer to the capital requirement, on-balance sheet financing costs for jumbo mortgages rise. When these costs are sufficiently high, banks choose to switch to external financing through securitization. Second, the introduction of jumbo securitization allows shadow banks to engage in jumbo loan origination. In other words, shadow banks now compete with traditional banks also in the jumbo lending market.

To understand the effect of introducing jumbo securitization markets, we assume that jumbo securitization would be 25bps more expensive than conforming securitization, since it is not supported by GSE. The results are shown in Appendix Table A2. The introduction of a jumbo securitization market would change the equilibrium even at the baseline 6% capital requirement, with a large market share migration towards shadow banks. Jumbo lending would increase by 46 billion, which would be partially offset by a $32 billion decrease in conforming lending, as some conforming borrowers substitute towards jumbo loans. Shadow banks' origination would increase by $42 billion, $28 billion of which would come at the expense of traditional banks. Shadow banks market share of jumbo loan originations would jump 14%. This market increases consumer welfare by $92 billion, with $54 billion of these gains falling to the highest income markets, while only $5 billion of these gains accrue to the lowest income markets.

After the introduction of jumbo securitization markets, changes to capital requirements have muted effects on overall lending volumes and welfare. In other words, the tradeoff between bank stability and mortgage origination becomes even less severe than our baseline model would suggest. This is because the bank balance sheet retention margin and the shadow bank migration margin now apply to jumbo loans in addition to conforming loans.

Increasing capital requirements to 9% decreases lending volumes by only $5 billion, in comparison to the decrease of $54 billion when there are no jumbo securitization markets. Without jumbo securitization markets, increasing capital requirements increases jumbo origination costs because these mortgages must be retained on balance sheet. With jumbo securitization, in contrast, as higher capital requirements increase balance sheet lending costs, banks can adjust on the retention margin. Figure A4 illustrates these dynamics. Panel (a) shows that while origination volume falls slightly as capital requirements are raised, the effects of higher capital requirements are much smaller. Panel (b) shows that there is a large margin of adjustment along the share of jumbo mortgages that are securitized. With the baseline 6% capital requirement, roughly 50% of jumbo originations are securitized. With a 9% capital requirement, nearly all jumbo loans are financed through securitization. Additionally, shadow banks can now originate jumbo mortgages, and so the shadow bank migration margin functions in all segments of the market.

These three extensions suggest that the importance of the shadow bank migration margin and the balance sheet retention margin play an important role when it comes to policy. The existence of securitization markets, either conforming, jumbo, or both, gives lenders considerable flexibility in mortgage financing. Analyses that overlook this, and focus on, for example, only bank balance sheet lending, miss significant economic forces and lead to misleading policy analyses.

V.E Summary from Counterfactuals.

One overarching insight from the counterfactuals is that both adjustments on the shadow bank migration margin and the balance sheet retention margin are critical to understanding policy consequences. For example, we show that the tradeoff between bank stability and lending is much less severe than anticipated by many models, which focus only on balance sheet lending. Panel (a) of Figure 13, Panel (a) illustrates this visually by showing a change in the aggregate mortgage origination volume (in $ billions) across various bank capital ratio requirements (in %) relative to the baseline scenario. The dotted line shows the aggregate change in the bank balance sheet lending volume [Bank (BS)]. The solid grey line shows the overall change in the bank lending volume including securitized loans [Bank (BS+Sold)], while the solid black line shows the aggregate lending response accounting for both traditional and shadow bank response [Bank (BS+Sold)+Shadow Bank]. Intuitively, the difference between total bank lending response and on-balance sheet bank lending response captures the importance of the balance sheet retention margin, while the difference between aggregate lending response including shadow banks and the total bank lending response captures the importance of the shadow bank migration margin.

As we observe, while higher capital ratios lead to substantial decline in the bank balance sheet lending volume, the overall decline in the bank lending volume is considerably moderated by the ability of the banks to expand off-balance sheet lending through loans sales. The shadow bank migration margin further moderates the adverse impact of bank capital requirements on the aggregate lending volume. For example, our model predicts that increasing bank capital requirements from current levels to 9% (Table 9 and Figure 10) reduces bank balance sheet lending by 2/3rd, but *overall* mortgage lending declines by only 2.5%. One margin of adjustment that is important is the balance sheet retention margin: *total* bank lending declines by only 9.5% as banks adjust their lending from retention to selling. Accounting for migration to shadow banks shaves off another 7%, leaving the net decline to be just 2.5%.

It is clear from this example as well as other counterfactuals that a model of financial intermediation must carefully account for both of these margins when evaluating policies. The overall effects on mortgage origination volume are dominated by whether these margins are active: When they can function, policy effects on lending volumes are muted, but when they cannot function, such effects are much larger. The capital requirements counterfactual illustrates this point clearly: The bank balance sheet retention margin and the shadow bank migration margin function in the conforming loan segment and attenuate the volume effects, but they do not function in the jumbo market, and so the volume effects are larger. When the margins are active in one segment

and not another, it then becomes important to understand substitution patterns across segments which depend crucially on the size preference parameters we identified in the model.

This insight extends well beyond the US market. For instance, the U.K. does not have a large and liquid secondary market for mortgages. Therefore, the impact of financial regulation will differ substantially from the perspective of consumers as well as bank stability. The current BASEL regulatory framework proposes a uniform treatment of capital requirements across countries. Our framework suggests that following this and increasing capital requirements in the UK would result in a substantially higher contraction in overall lending since bank retention margin in absent in UK. Thus, because of the two margins we discussed, the consequences of imposing similar regulations across countries could result in dramatically different responses depending on the nature of the market.

Broadly, which margin of adjustment is most important depends critically on the nature of the loan product and its interaction with the regulatory intervention. In the case of conforming loans, there are three potential sources of financing: bank balance sheets, bank sales to GSEs, and shadow bank sales to GSEs. Increased capital requirements raise costs for balance sheet origination, and push lending towards bank sales to GSEs (the bank balance sheet retention margin) and towards shadow bank sales to GSEs (the shadow bank migration margin). In the case of jumbo loans, however, there is no substitute for bank balance sheet lending and consequently neither margin leads to significant attenuation in volume. Interestingly, expanding or contracting GSE subsidies to a wider range of loan sizes directly alters which loans have access to these two margins of adjustment. Our model suggests that when it is active, the bank balance sheet retention margin is quantitatively more important in attenuating the impacts of regulation, because banks are more flexible in modifying their financing behavior than consumers are in substituting from one lender to another.

The second general insight is that the adjustment depends on whether policy interventions target traditional banks or secondary markets. The concrete examples we analyze are capital requirements versus interventions such as the GSE premium (QE), conforming loan limits, or having a jumbo securitization market. When tighter regulation only target traditional banks as is the case with increased capital requirements, solely focusing on bank balance sheets overstates the adverse effect of such polices on overall lending volume. The adjustment on the shadow bank migration margin and the balance sheet retention margin work to offset the adverse impact. For policies which tighten the secondary market, such as increasing the GSE financing cost or lowering the conforming loan limit, the balance sheet retention margin still offsets some of the adverse effect through an increase in on-balance sheet lending as shown in Figure 13, Panel (b) and (c). The shadow bank migration margin, however, exacerbates the effect: lending contracts for shadow banks, leading to a large overall decline in lending. Ignoring the role of shadow banks can yield

not only the wrong magnitude of the aggregate effect, but also the wrong direction, as shown in Figure 13 Panel (b), comparing the bank to bank plus shadow bank response.[23]

This insight has direct consequences for how empirical researchers approach measuring policy consequences. When financial regulations and policies change, researchers typically use bank data to measure the consequences. Our counterfactuals suggest that drawing quantitative conclusions solely based on bank balance sheet data can be extremely problematic, and difficult to de-bias without an explicit model of bank retention and shadow bank migration margins.

The third insight is that interventions to achieve bank stability differ in their redistributive consequences. For example, increasing capital requirements achieves bank stability by decreasing on-balance-sheet lending, i.e. reducing jumbo mortgages. Therefore, the cost of bank stability is mainly borne by higher income borrower. An expansion of GSE funding increases the appeal of securitization, also shifting loans from bank balance sheets and increases bank stability. It does so while expanding lending and benefiting consumers across the income spectrum, but comes at the cost of taxpayers subsidizing GSE lending.

Section VI: Related Literature and Conclusion

VI.A Related Literature

Our paper is 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 of the originate-to-distribute model and its impact on 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), Rajan 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. (2018) analyze 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 two third and one third of the recent shadow bank growth. Fuster et al. (2018) provide complementary evidence that suggests that fintech lenders adjust supply more elastically than other lenders in response to exogenous mortgage demand shocks, thereby alleviating capacity constraints associated with traditional mortgage lending. Kim et al. (2018) discusses potential liquidity risks faced by shadow bank lenders. Irani et al. (2018) focus on corporate loans and study the role of bank capital regulation in growth of shadow banks. In contrast, this paper focuses particularly on what has driven the

[23] Notably, the equilibrium response of the shadow bank sector is quite important in explaining the aggregate lending response to various policies. For example, lowering the conforming loan limit by 25% results in $294 billion decline in lending (Table 11 and Figure 13, Panel c). The contraction of lending by shadow banks ($207 billion), accounts for 70% of the aggregate lending response.

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 addition, our structural model allows us to assess the role of capital requirements, government credit subsidies, and unconventional monetary policy on the overall distribution of mortgage credit across borrowers as well as on bank stability.

Our paper is also related to the literature on the GSEs.[24] We focus particularly on the role of GSE financing and its interaction with recent regulatory and bank capital changes in explaining growth of shadow banks. We study how market segmentation arises out of GSE financed market interacting with bank balance sheet capacity 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), Agarwal et al. (2014), (2015), (2017) Lucca et. al. (2014), Piskorski et al (2015), Granja et al. (2017), Granja and Leuz (2017), Di Maggio et al. (2016, 2017), Gete and Reher (2017). Our paper focuses, instead, on the growth of shadow banks and their interplay with traditional banks in the aftermath of the crisis.

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.[25] Buchak et al. (2018) 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. We use similar tools to answer fundamentally different questions.

Our paper is also connected to recent quantitative equilibrium models of mortgage and housing markets with heterogonous agents (e.g., Favilukis, Ludvingson, Van Nieuwerburgh 2017; Kaplan, Mitman, and Violante 2016; Greenwald, Landvoigt, and Van Nieuwerburgh 2018; Guren, Krishnamurty, and McQuade 2018). Such models can provide many valuable insights, including the quantitative assessment of various effects. Unlike these papers that use computational tools

[24] 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.

[25] 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.

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 using micro data. Moreover, we focus mainly on implications for credit market outcomes taking into account 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 (e.g., Gennaioli, Shleifer, and Vishny 2013; Adrian and Ashcraft 2016 Moreira and Savov 2017; Ordonez 2018; Begenau and Landvoigt 2018). Among this recent work, Koijen and Yogo (2016) analyze the implications of reinsurance market that allows regulated life insurance companies to move some of their liabilities to shadow reinsurers. Drechsler et al. (2017) and Xiao (2018) 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, thereby affecting the transmission of monetary policy. Unlike these papers that focus on the consequences of deposits flows between traditional and shadow bank sector, we study the consequences of capital requirements, conforming credit limits, and unconventional monetary policy that operate independently from the deposit channel. In doing so, we study the impact of equilibrium interaction of shadow banks with traditional banks on quantity, price, allocation of mortgage credit as well as on bank stability.

VI.B Conclusion

Our findings have a number of implications. First, they suggest that a complete policy analysis of the lending market critically requires simultaneously analyzing the impact of the policy on banks and shadow banks, and accounting for their equilibrium interaction. Any regulation that affects a part of the intermediation market spills over to other markets through competition, and affects which products are offered by which firms, which part of the household income distribution is impacted, as well as equilibrium prices. Therefore, to understand the migration of intermediation activity and the risks between banks and shadow banks, one needs to account for their interaction in markets—the industrial organization of financial intermediation, as well as the changing business models of banks and on versus off-balance sheet lending. Ignoring these interactions can severely alter the predicted consequences of policies with respect to the equilibrium quantity, price, distribution of credit, and bank stability. 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 with off-balance sheet lending options.

Second, 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. Thus, without thinking about banks

responses on the retention margin, deciding to securitize instead of holding loans on the balance-sheet, traditional policy tools, including capital ratios and other bank capital regulatory requirements, may have limited effectiveness. On the other hand, disruptions in secondary loan markets have significant impact on aggregate lending volume and pricing as they adversely affect the ability to lend of both shadow banks and poorly capitalized traditional banks.

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. On the other, shadow banks and poorly capitalized banks predominantly rely on GSE mortgage guarantees. Our results suggest that as subsidies for banks in one sector decline, for example, because of restrictive capital requirements, they tilt their activity toward other sources of tax payer financed subsidies. Understanding the web of subsidies and regulations that pervade the financial system, their equilibrium interactions, and their impact on systematic risk and welfare remains a fruitful area for future research.

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Table 1: Summary Statistics

Table 1 shows summary statistics for the datasets used in the reduced-form section of the paper. The sample is mortgages for single-family homes. Panel (a) shows summary statistics from the HMDA loan-level dataset, used in the regressions for Tables 2 and 3. Panel (b) shows summary statistics from the bank-year level dataset constructed from HMDA and call report data, which is used in the regressions for Table 4.

Panel A: HMDA Loan-Level Summary Dataset, 2010-2015

	All Lenders	Traditional Banks	Shadow Banks
Total Originations	46,431,132	30,943,694	15,487,438
% Retained on Balance Sheet or Affiliate	28%	38%	8%
% Sold to Commercial Bank	10%	5%	18%
% Sold to GSE	49%	50%	45%
% Sold to Other	14%	6%	29%

Panel B: Bank-Year Dataset

	2008	2009	2010	2011	2012	2013	2014	2015
Unique Banks	138	120	149	156	173	168	165	157
Capital Ratio	11%	11%	12%	12%	12%	12%	11%	11%
% Loans Retained on Balance Sheet	59%	54%	46%	35%	29%	29%	41%	42%
% Jumbo Loans	3%	2%	3%	3%	4%	6%	10%	12%
% Jumbo Loans Retained on Balance Sheet	94%	92%	84%	86%	89%	86%	88%	90%
% Conforming Loans Retained on Balance Sheet	58%	53%	46%	34%	26%	26%	36%	35%

Table 2: Financing on Balance Sheet and Originator Type (Bank vs. Shadow Bank) around the Conforming Loan Limit

This table assesses the discontinuity of financing on balance sheet and originator type around the conforming loan limit for all (bank and shadow bank) originations. Panel (a) considers balance sheet lending versus outside financing. The left-hand side variable is an indicator for whether the loan is financed on the balance sheet or sold. 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, Jumbo is an indicator for whether the loan size is above the conforming loan limit in the time-county of origination rendering it ineligible for securitization through GSEs. In both panels, columns (1)-(4) use the all sample, while (5)-(8) use 2015 originations only. Columns (1)-(4) and (5)-(8) consider discontinuity bandwidths 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: Loan Financed on Balance Sheet or Sold?

	All Sample				2015 Originations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth +/-	1%	5%	10%	25%	1%	5%	10%	25%
Jumbo	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tract-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
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: Loan Originated by Bank?

	All Sample				2015 Originations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth +/-	1%	5%	10%	25%	1%	5%	10%	25%
Jumbo	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tract-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
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 3: Financing on Balance Sheet and Capitalization of Traditional Banks around Conforming Loan Limit

This table assesses the discontinuity of financing on balance sheet and capitalization of traditional banks around the conforming loan limit for only traditional bank originations, with shadow bank originations excluded. 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. Panel (b) considers well versus poorly capitalized banks. The left-hand side variable is an indicator for whether the originator is well-capitalized. Banks are defined as well capitalized based if they are in the top quartile of capitalization for the given year. In both panels, Jumbo is an indicator for whether the loan size is above the conforming loan limit in the time-county of origination rending it ineligible for securitization through GSEs. 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: Loan Financed on Balance Sheet or Sold?

	All Sample				2015 Originations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth +/-	1%	5%	10%	25%	1%	5%	10%	25%
Jumbo	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tract-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
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: Loan Originated by a Well Capitalized Bank?

	All Sample				2015 Originations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth +/-	1%	5%	10%	25%	1%	5%	10%	25%
Jumbo	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tract-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
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: Balance Sheet Retention and Bank Capitalization

This table assesses the relationship of bank capitalization and financing of loans on the balance sheet and how it varies with product mix. The regression is at the lender-year level among traditional banks. For columns (1) and (2), the left-hand side variable is percent of all originated loans not sold within the calendar year. For columns (3) and (4), the left-hand side variable is the percent of originated loans that are jumbo (non-conforming). For (5) and (6) the left-hand side variable is percent of conforming originations not sold within the calendar year. Capital ratio is the bank's statutory capital ratio (in percentage). Log(Originations) is the (log) total number of originations for the lender in the given year. Log(Unique CTs) is the (log) number of unique census tracts in which the bank originates mortgages, a measure of geographical spread. Log(Average Loan Income) and Log(Average Loan Size) are the (log) average borrower income and loan size for the loans the banks originates in the year. Log(Bank Assets) is the (log) total bank assets. Deposits / Total Liabilities is the percentage of the bank's liabilities that are deposits. All columns have year fixed effects. Columns (2), (4), (6), and (8) additionally have lender fixed effects. Data are from HMDA and the Federal Reserve call reports. Standard errors are in parentheses.

	% Held (All loans)		% Jumbo		% Held (Conforming)	
	(1)	(2)	(3)	(4)	(5)	(6)
Capital Ratio	3.114	4.506	0.211	-0.136	3.123	4.827
	(0.325)	(0.523)	(0.053)	(0.071)	(0.333)	(0.550)
Log(Originations)	-0.154	-0.231	-0.015	-0.022	-0.149	-0.219
	(0.015)	(0.027)	(0.002)	(0.004)	(0.015)	(0.029)
Log(Unique CTs)	0.038	0.158	-0.004	0.016	0.043	0.144
	(0.015)	(0.040)	(0.002)	(0.005)	(0.015)	(0.042)
Log(Bank Assets)	0.041	0.004	0.005	0.002	0.038	0.003
	(0.005)	(0.008)	(0.001)	(0.001)	(0.005)	(0.008)
Deposits / Total Liabilities	-0.409	-0.279	-0.052	0.165	-0.396	-0.360
	(0.061)	(0.121)	(0.010)	(0.016)	(0.063)	(0.127)
Log(Average Loan Income)	0.450	0.628	0.164	0.130	0.362	0.594
	(0.052)	(0.072)	(0.008)	(0.010)	(0.054)	(0.077)
Log(Average Loan Size)	-0.337	-0.254	0.032	0.067	-0.358	-0.285
	(0.028)	(0.041)	(0.005)	(0.006)	(0.028)	(0.043)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Lender FE	No	Yes	No	Yes	No	Yes
Observations	1,241	1,241	1,241	1,241	1,241	1,241
R^2	0.428	0.751	0.646	0.896	0.436	0.740

Table 5: Structural Estimation − Key Demand Parameters

This table shows the estimated demand parameters. Consumer preferences are given by the equation $B_i = \bar{B} + \Pi(D_{ic} - \bar{D}) + \Sigma\nu_i$, where $\bar{B}$ 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 $\bar{B}$, Π, and Σ, respectively. α is the consumer's price sensitivity, i.e., how much her utility decreases from a 1% higher interest rate. β is the consumer's disutility from obtaining a smaller loan. γ is the consumer's utility from obtaining a conforming loan rather than a jumbo loan, regardless of loan size. A detailed description of the economic meaning of these parameters and how they are estimated can be found in Sections IV.A and IV.C.1, respectively.

Panel A: Mean Preference Parameters

$\bar{B}$		
Parameter	Description	Estimate
$\bar{\alpha}$	Price	1.14
$\bar{\beta}$	Disutility from smaller loan	5.79
$\bar{\gamma}$	Conforming convenience	6.91
$\log \bar{F}$	Log loan size	12.22

Panel B: Demographic-Preference Relationships

Π			
Parameter	Description	Estimate (log Income)	Estimate (log Price)
α_i	Price	0.64	-0.57
β_i	Disutility from smaller loan	-1.87	0.73
γ_i	Conforming preference	-3.81	2.30
$\log F_i$	Log loan size	0.38	0.39

Panel C: Shocks

Σ		
Parameter	Description	Estimate
σ_α^2	Price	0.07
σ_β^2	Disutility from smaller loan	1.36
σ_γ^2	Conforming preference	0.05
$\sigma_{\log F}^2$	Log loan size	0.49

Table 6: Structural Estimation – Key Supply Parameters

This table shows the estimated supply parameters. Panels (a) and (b) show financing costs and non-financing costs, respectively. Panel (c) shows the non-linear parameters that determine the financing cost. Financing costs represent financing costs that any lender must pay, regardless of whether it is financed though GSE financing or on balance sheet. Non-financing costs represent differences in origination or labor costs not coming from financing. Non-linear financing costs reflect the tradeoff a bank faces when deciding whether to finance on balance sheet or through GSE financing. A detailed description of the economic meaning of these parameters and how they are identified can be found in Section IV.B and IV.C.2, respectively

Panel A: Financing Costs

Parameter	Year	Estimate
σ^b_{2010}	2010	4.61
σ^b_{2011}	2011	4.02
σ^b_{2012}	2012	3.80
σ^b_{2013}	2013	3.98
σ^b_{2014}	2014	4.19
σ^b_{2015}	2015	4.34

Panel B: Non-financing Costs

Parameter	Description	Estimate
w_{bn}	Bank, purchase (baseline)	0.00
w_{br}	Bank, refinance	-0.05
w_{nn}	Shadow Bank, Non-fintech, purchase	0.21
w_{nr}	Shadow Bank, Non-fintech, refinance	0.11
w_{fn}	Shadow Bank, Fintech, purchase	0.07
w_{fr}	Shadow Bank, Fintech, refinance	0.10

Panel C: Non-linear Financing Costs

Parameter	Description	Estimate
σ^{GSE}	GSE funding cost	0.05
σ^{b1}	Internal coefficient on capital adequacy	0.01
ϕ	Shape parameter for capital adequacy	1.49

Table 7: Structural Estimation – Regulatory Burden and Fintech Quality

This table shows the estimated bank regulatory burden and fintech quality parameters. The regulatory burden reported here is defined as $1/\zeta$, where ζ is the scaling factor on the probability of lending to a specific borrower as discussed in Section IV.B.2. A higher bank regulatory burden parameter captures relatively constrained traditional banks; a lower burden captures relatively constrained traditional banks. An increase in the fintech quality parameter indicates an increase in the perceived quality of services offered by shadow bank fintech lenders relative to other lenders. Fintech quality is relative to non-fintech shadow bank originations of the same type (new origination or refinance).

		Fintech Quality	
Year	Bank Regulatory Burden	New Originations	Refinance
2010	0.55	-1.29	0.53
2011	0.53	-0.88	0.69
2012	0.36	-0.80	1.00
2013	0.60	-0.54	1.21
2014	1.29	-0.33	1.26
2015	1.09	-0.15	1.25

Table 8: Validation of Counterfactual Results using Conforming Loan Limit Changes

This table studies the response of jumbo market share, conforming loan bunching, and bank market share to changes in conforming loan limits at the year-county level. *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. The left-hand side is the county-year level jumbo loan market share in percentage terms. Column (2) regresses the bunched market share of borrowers around the conforming loan cutoff on this increase within a 5% loan-size bandwidth. The left-hand side variable is the county-year level market share of loans falling within 0.10% of the conforming loan limit in percentage terms. 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. The left-hand side variable in columns (3) and (4) is the county-year level bank market share in percentage terms. All columns include year and county fixed effects. Standard errors are in parentheses.

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

Table 9: Counterfactual Analysis – Capital Requirements

This table shows the impact of various capital requirements. Column (1) shows the case a 3% capital requirement. Column (2) for a 4.5% capital requirement. Column (3) for a 6% capital requirement (baseline). Column (4) for a 7.5% capital requirement. Column (5) for a 9% capital requirement. Column (6) for a 12% capital requirement. Rows show the predicted impact of the counterfactual change on various outcomes.

	Capital Requirement					
	(1) 3%	(2) 4.5%	(3) 6% (Baseline)	(4) 7.5%	(5) 9%	(6) 12%
Lending Volumes						
Overall Lending Volume ($b)	1,779	1,770	1,763	1,747	1,709	1,649
Conforming Volume ($b)	1,390	1,385	1,385	1,412	1,482	1,627
Jumbo Volume ($b)	389	386	378	335	227	22
Bank Volume ($b)	1,108	1,098	1,087	1,057	984	852
Loan Financing						
Balance Sheet Lending ($b)	1,108	1,019	661	389	241	24
Share of Loans Financed on Balance Sheet (%)	62%	58%	37%	22%	14%	1%
Share of Conforming Loans Financed on Balance Sheet (%)	52%	46%	20%	4%	1%	0%
Shadow Bank Market Share (%)	38%	38%	38%	40%	42%	48%
Shadow Bank Share of Conforming Loans (%)	48%	49%	49%	49%	49%	49%
Interest Rates (deviation from baseline)						
Conforming Interest Rate (%)	-0.01	-0.01	-	0.00	0.00	0.00
Jumbo Interest Rate (%)	-0.15	-0.11	-	0.30	0.44	1.57
Jumbo - Conforming Spread (%)	-0.14	-0.10	-	0.29	0.44	1.57
Profits and Consumer Welfare (deviation from baseline)						
Overall Lender Profits ($b)	3	2	-	-7	-23	-50
Bank Profits ($b)	3	2	-	-7	-24	-50
Shadow Bank Profits ($b)	0	0	-	0	0	0
Overall Consumer Surplus ($b)	3	2	-	-10	-45	-97
Individual Consumer Surplus ($)	49	43	-	-492	-1,617	-3,810
Overall Consumer Surplus for Top Income Market ($b)	2	1	-	-8	-32	-68
Overall Consumer Surplus for Bottom Income Market ($b)	0	0	-	0	-1	-2
Individual Consumer Surplus for Top Income Quartile ($)	47	30	-	-159	-402	-885
Individual Consumer Surplus for Bottom Income Quartile ($)	6	18	-	-449	-1,665	-4,083

Table 10: Counterfactual Analysis – GSE Financing Costs

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.

	Changes to GSE Financing Costs						
	(1) -100bps	(2) -25bps	(3) -10bps	(4) Baseline	(5) +10bps	(6) +25bps	(7) +100bps
Lending Volumes							
Overall Lending Volume ($b)	2,775	1,960	1,834	1,763	1,717	1,672	1,514
Conforming Volume ($b)	2,381	1,578	1,454	1,385	1,341	1,297	1,145
Jumbo Volume ($b)	394	381	380	378	376	375	369
Bank Volume ($b)	1,623	1,190	1,123	1,088	1,081	1,094	1,140
Loan Financing							
Balance Sheet Lending ($b)	394	381	380	658	1,052	1,087	1,140
Share of Loans Financed on Balance Sheet (%)	14%	19%	21%	37%	61%	65%	75%
Share of Conforming Loans Financed on Balance Sheet (%)	0%	0%	0%	20%	50%	55%	67%
Shadow Bank Market Share (%)	42%	39%	39%	38%	37%	35%	25%
Shadow Bank Share of Conforming Loans (%)	48%	49%	49%	49%	47%	45%	33%
Interest Rates (deviation from baseline)							
Conforming Interest Rate (%)	-1.00	-0.25	-0.10	-	0.06	0.12	0.33
Jumbo Interest Rate (%)	0.01	0.00	0.00	-	0.00	0.01	0.03
Jumbo - Conforming Spread (%)	1.00	0.25	0.10	-	-0.06	-0.11	-0.30
Profits and Consumer Welfare (deviation from baseline)							
Overall Lender Profits ($b)	91	18	7	-	-4	-9	-24
Bank Profits ($b)	45	8	3	-	0	2	9
Shadow Bank Profits ($b)	45	9	4	-	-4	-10	-34
Overall Consumer Surplus ($b)	169	35	13	-	-8	-17	-51
Individual Consumer Surplus ($)	-295	-30	21	-	-48	-125	-536
Overall Consumer Surplus for Top Income Market ($b)	80	16	6	-	-4	-8	-25
Overall Consumer Surplus for Bottom Income Market ($b)	13	3	1	-	-1	-1	-4
Individual Consumer Surplus for Top Income Quartile ($)	2,666	554	219	-	-142	-291	-775
Individual Consumer Surplus for Bottom Income Quartile ($)	-3,919	-763	-256	-	81	122	28

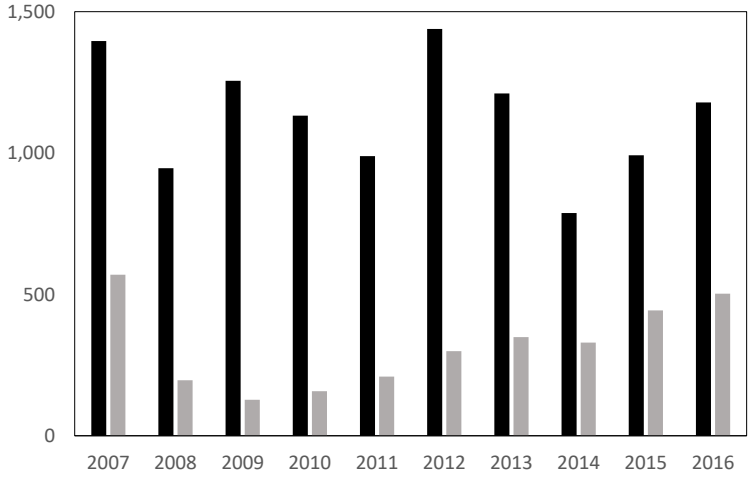
Table 11: Counterfactual Analysis – Conforming Loan Limit

This table shows the impact of altering the conforming loan limit. Column (1) shows the impact of reducing the limit by 25%; Column (2) shows the 2015 baseline scenario; Column (3) shows the impact of increasing the limit by 25%. Column (4) shows the impact of setting all limits to the lower national limit of $417,000. Column (5) 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.

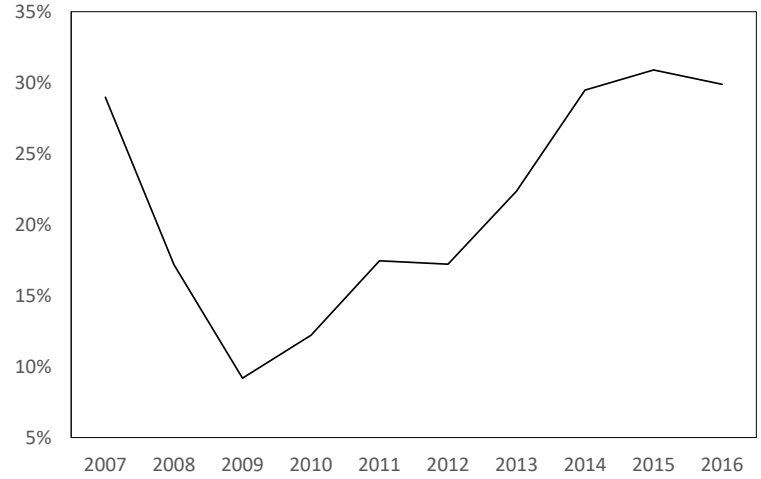
	Changes to Conforming Loan Limit					
	(1) -25%	(2) Baseline	(3) 25%	(4) No Limit	(5) $417k	(6) $625k
Lending Volumes						
Overall Lending Volume ($b)	1,469	1,763	1,965	2,360	1,725	2,062
Conforming Volume ($b)	971	1,385	1,695	2,357	1,316	1,826
Jumbo Volume ($b)	498	378	270	3	410	236
Bank Volume ($b)	999	1,087	1,132	1,184	1,087	1,164
Loan Financing						
Balance Sheet Lending ($b)	703	637	602	452	653	610
Share of Loans Financed on Balance Sheet (%)	48%	36%	31%	19%	38%	30%
Share of Conforming Loans Financed on Balance Sheet (%)	21%	19%	20%	19%	19%	20%
Shadow Bank Market Share (%)	32%	38%	42%	50%	37%	44%
Shadow Bank Share of Conforming Loans (%)	48%	49%	49%	50%	49%	49%
Interest Rates (deviation from baseline)						
Conforming Interest Rate (%)	0.02	-	-0.01	-0.03	0.00	-0.02
Jumbo Interest Rate (%)	-0.01	-	-0.01	-0.01	-0.02	-0.01
Jumbo - Conforming Spread (%)	-0.02	-	0.01	0.02	-0.02	0.01
Profits and Consumer Welfare (deviation from baseline)						
Overall Lender Profits ($b)	-9	-	5	5	0	9
Bank Profits ($b)	8	-	-7	-26	4	-6
Shadow Bank Profits ($b)	-17	-	11	31	-4	15
Overall Consumer Surplus ($b)	-267	-	171	505	-51	241
Individual Consumer Surplus ($)	-4,161	-	2,895	9,228	-958	4,143
Overall Consumer Surplus for Top Income Market ($b)	-136	-	88	265	-51	106
Overall Consumer Surplus for Bottom Income Market ($b)	-18	-	11	30	0	17
Individual Consumer Surplus for Top Income Quartile ($)	-1,850	-	1,541	9,112	-493	2,508
Individual Consumer Surplus for Bottom Income Quartile ($)	-4,183	-	1,519	1,885	-776	1,717

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

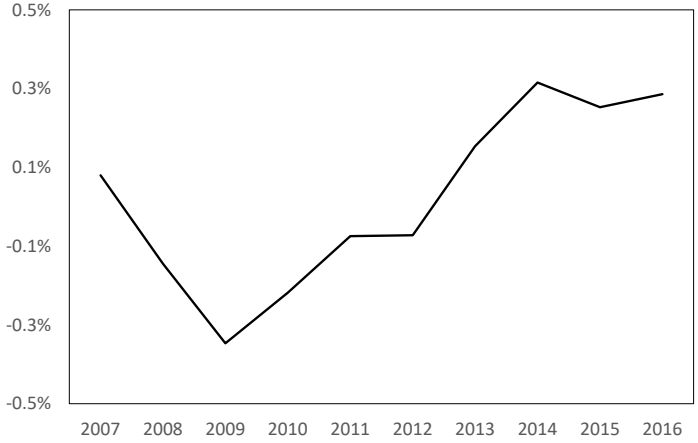
Panel (a) shows aggregate mortgage origination volumes in billions of dollars by conforming and jumbo mortgages. Panel (b) shows jumbo origination share (in %) of all conventional (non-FHA/VA/RHS) mortgages by dollars originated. Conforming loans are defined as "conventional" (non-FHA) in HMDA with loan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



(a) Conforming (black) and jumbo (grey) originations ($ billions)



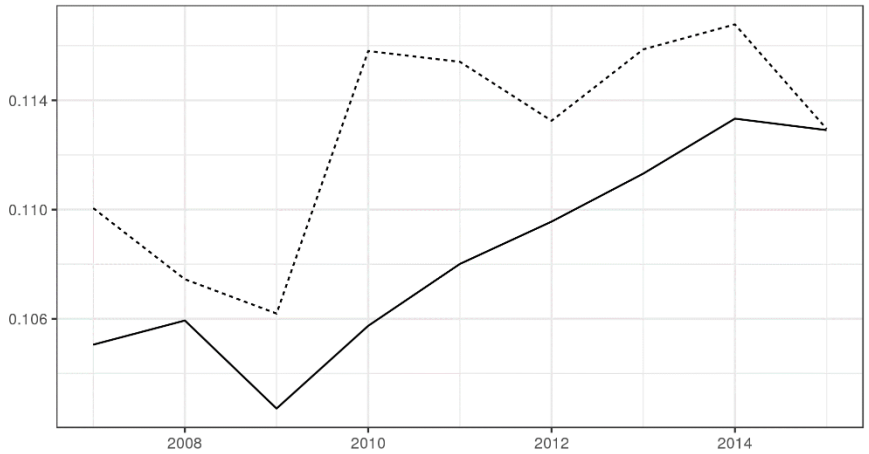
(b) Jumbo market share in total originations



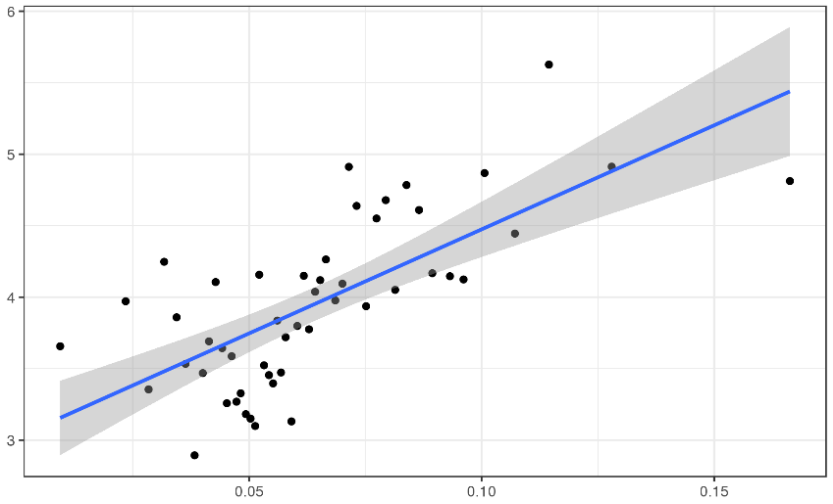
(c) Conforming-jumbo interest rate spread

Figure 2: Bank Capital and Jumbo Originations

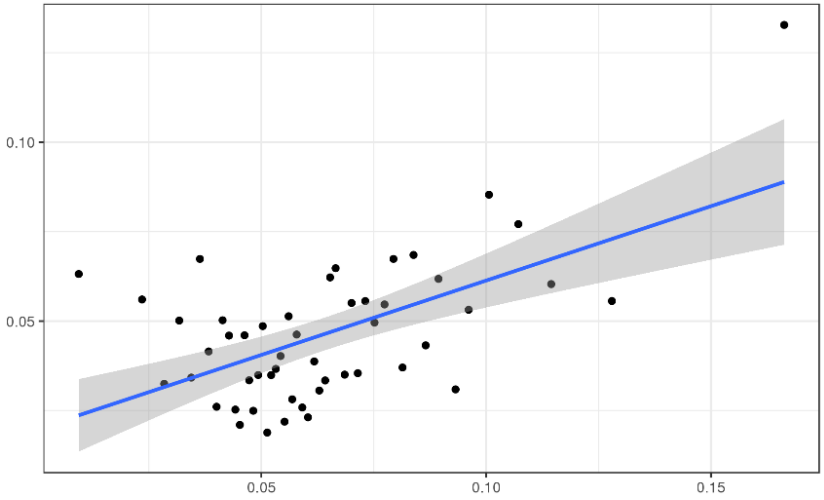
Panel (a) shows bank capital ratios over time. The solid line is the (simple) average across all banks; the dashed line is weighted by mortgage originations. Panel (b) shows a binned scatterplot of log numbers of jumbo originations versus bank capitalization above the statutory limit. Panel (c) shows a binned scatterplot of jumbo share of own bank originations versus bank capitalization above the statutory limit. Gray bands represent 95% confidence intervals.



(a) Equal (black) and origination (grey) weighted capital ratios over time



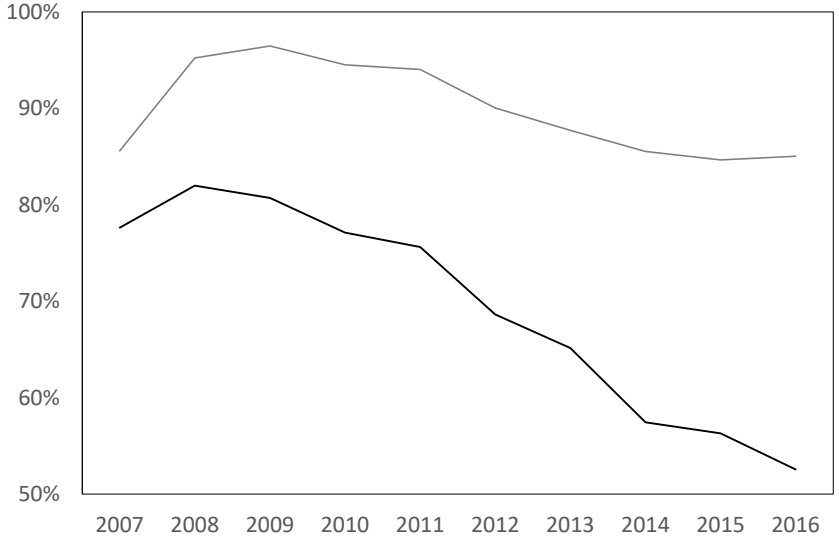
(b) Log(Jumbo Originations) versus excess capitalization



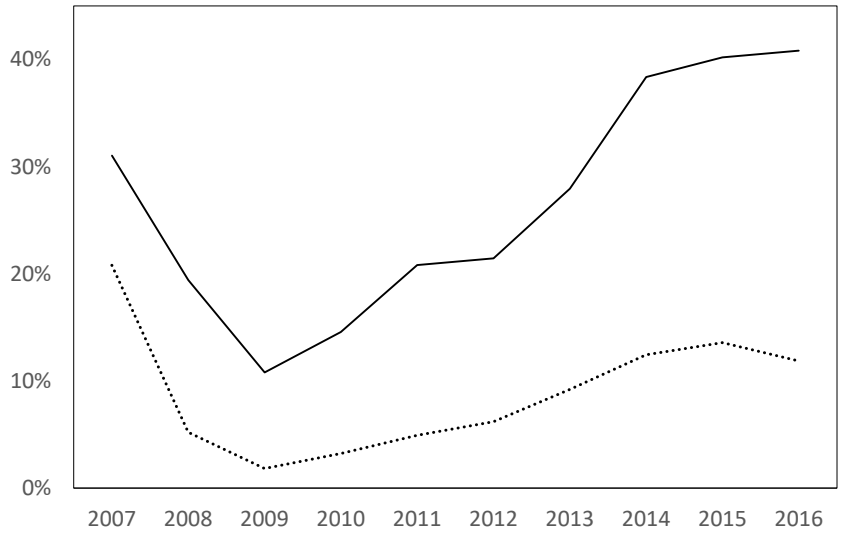
(c) Jumbo origination share versus excess capitalization

Figure 3: Traditional and Shadow Bank Market Shares in the Conforming and Jumbo Markets

Panel (a) shows bank market share (by dollars originated) in the confirming (black) and jumbo (grey) markets. Panel (b) shows jumbo lending share (by dollars originated) among banks (solid) and shadow banks (dotted). 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.



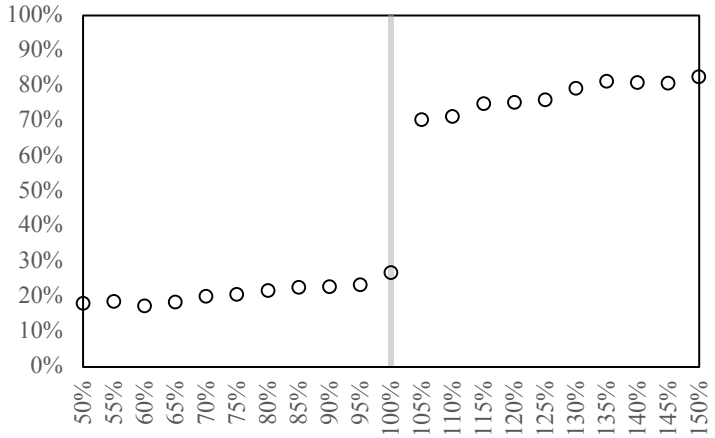
(a) Bank market share among conforming (black) and jumbo (grey) loans



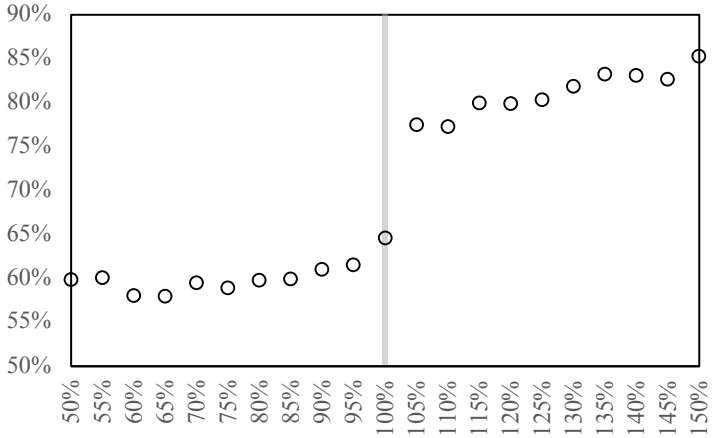
(b) Jumbo share of originations among banks (solid) and shadow banks (dotted)

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

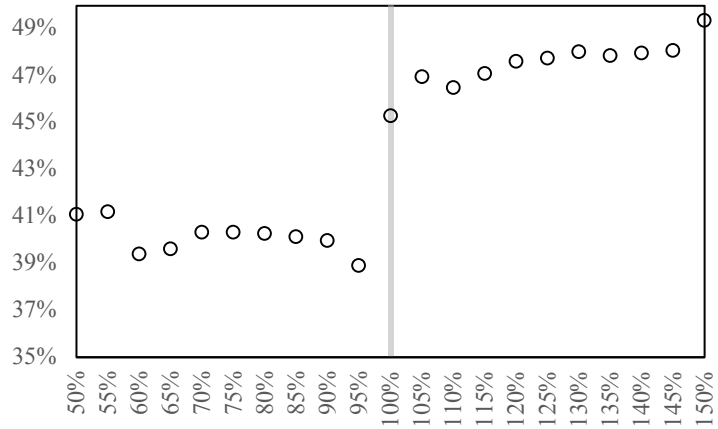
Panel (a) shows the percentage of mortgage originations retained on balance sheet by the loan amount divided by the conforming loan limit in the county-year of origination. The cutoff is at 100%, shown by a dotted vertical line. Panel (b) shows the percentage of originations that are done by banks around the conforming loan limit. Panel (c) shows the percentage of bank originations done by well-capitalized banks, where a bank is well-capitalized if it is in the top quartile of capitalization for the year of origination. Loan sizes are binned as a proportion of the conforming loan limit in 0.05 buckets, i.e., 0.91-0.95, 0.96-1.00, 1.01-1.05, and so on. In Panel (a), a mortgage is retained on balance sheet if it is not sold in the calendar year or sold to an affiliate. Each panel uses HMDA data between 2007 and 2015. Panels (a) and (b) use all originations; Panel (c) uses traditional bank originations only.



(a) Percentage of loans retained on balance sheet



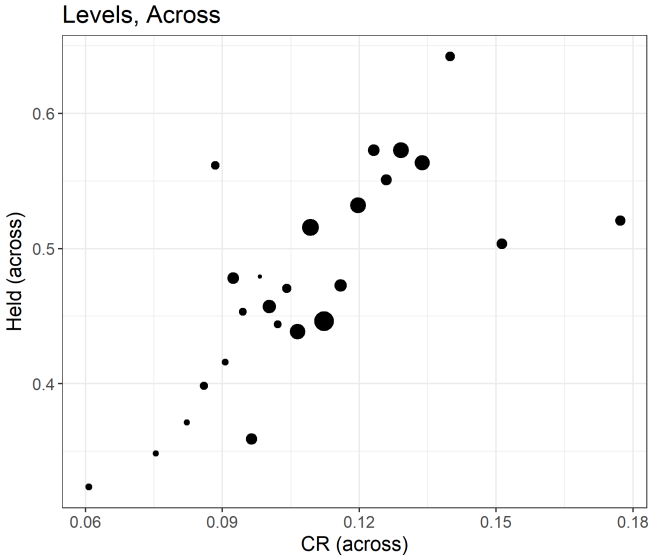
(b) Market share of banks among all lenders



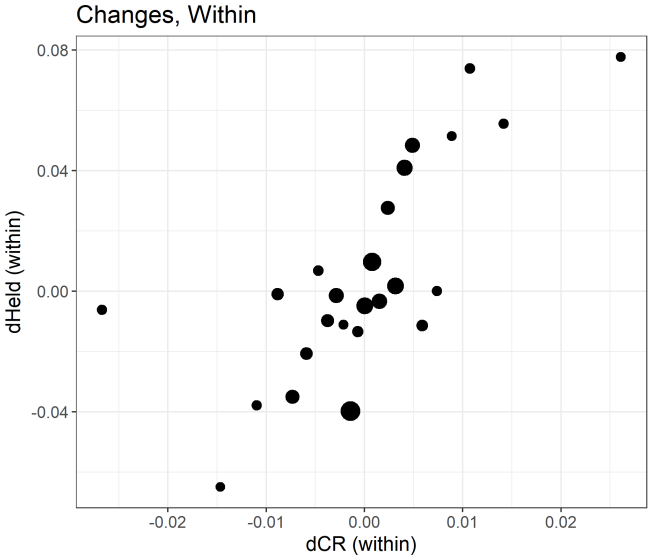
(c) Market share of well-capitalized banks among banks only

Figure 5: Balance Sheet Financing versus Bank Capital Ratios

Figure 5 shows binned scatterplots (25 equal-sized bins) of bank percent of loans held on balance sheet versus bank capital ratios. All bins are residualized using the controls detailed in Table 4. "Within" panels remove bank fixed effects. Panel (a) shows the results in levels and corresponds to Column (1) in Table 4 and Panel (b) show the results in changes and corresponds to Column (2) of Table 4.



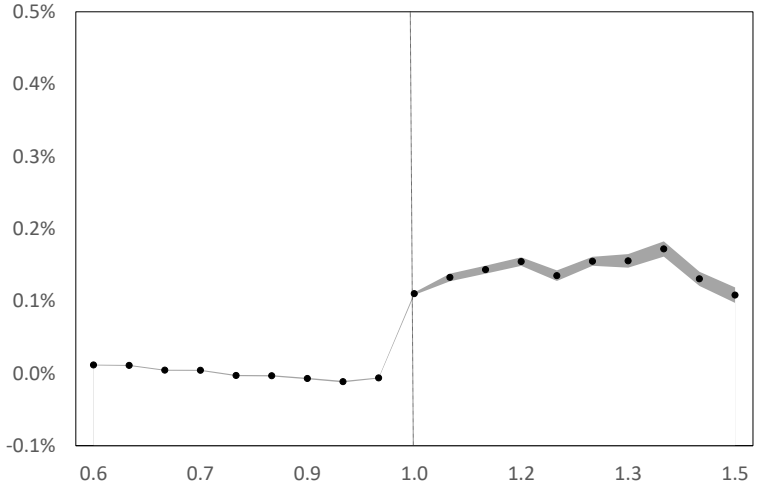
(a) Across banks, levels



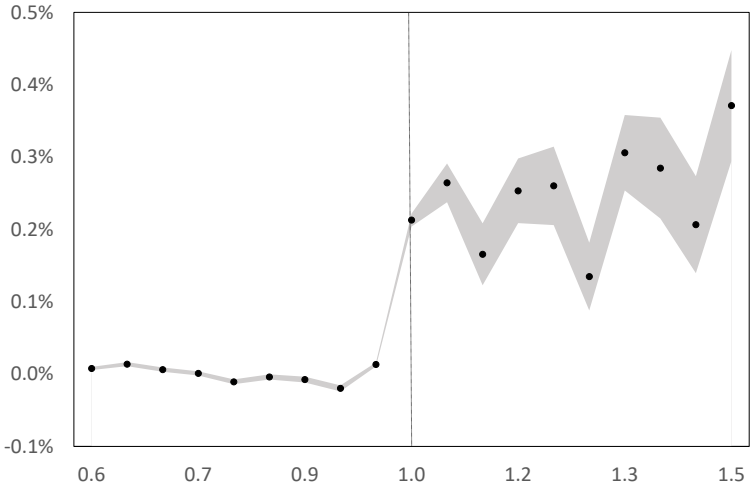
(d) Within banks, changes

Figure 6: Interest Rates around the Conforming Limit

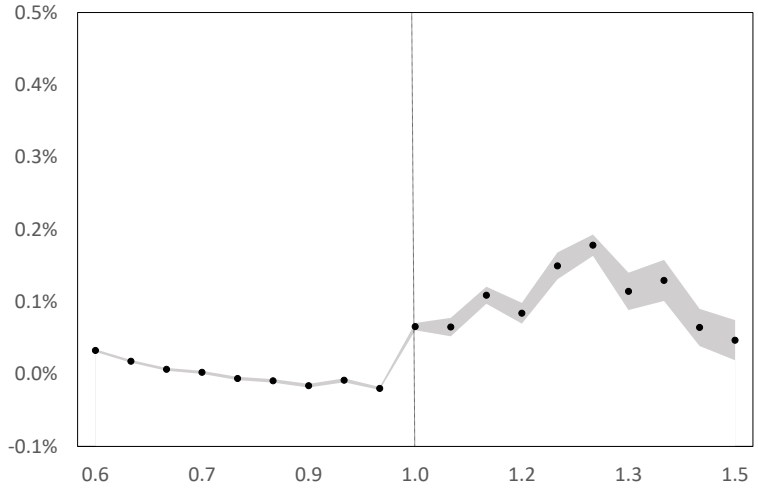
Panel (a), (b), and (c) show the interest rates of FRMs for the full sample (2007-2016), 2008, and 2014 respectively by the loan principal amount divided by the conforming loan limit in the county-year of origination. The cutoff is at 1, shown by a dotted vertical line. Interest rates are residualized against loan characteristics including purpose, credit score, LTV, and term. Shaded regions represent 95% confidence intervals. Data are from BlackKnight.



(a) Full sample



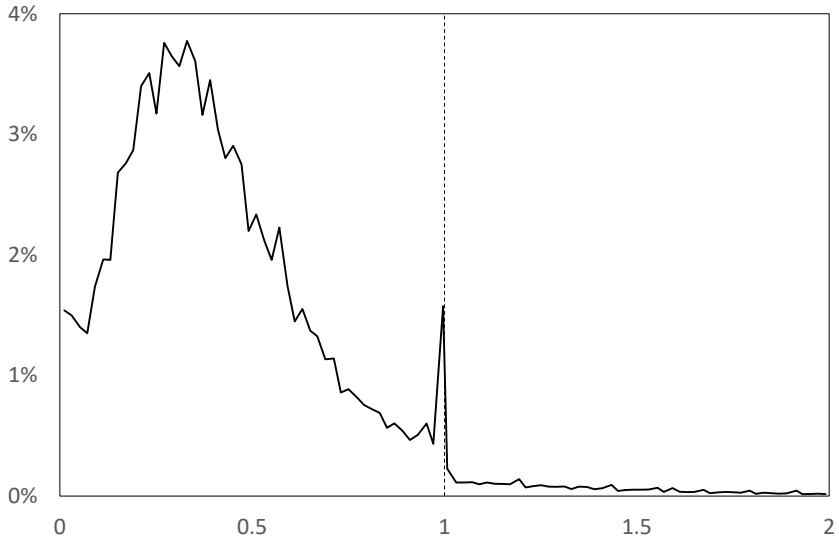
(b) 2008



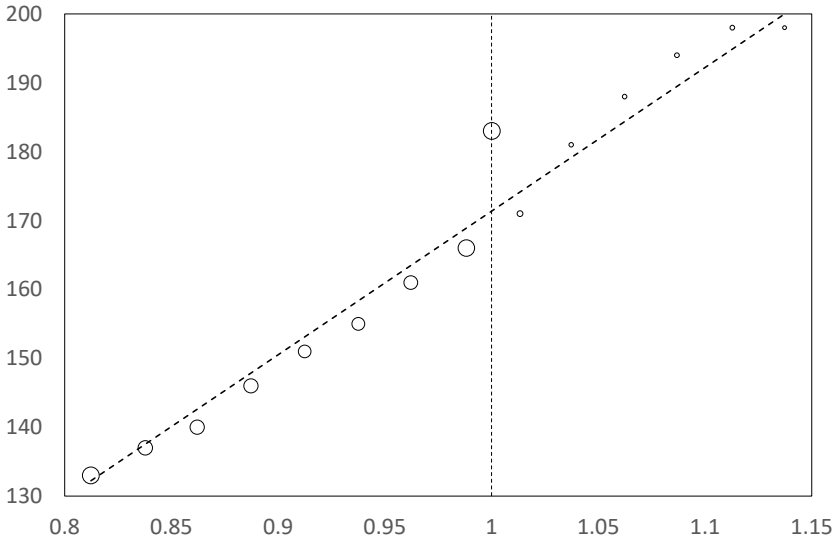
(c) 2014

Figure 7: Loan Distribution and Borrower Income around the Conforming Loan Limit

Panel (a) shows the distribution of loan principal amounts by 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 line. Panel (b) shows borrower binned average income around the conforming loan cutoff. Data are from HMDA.



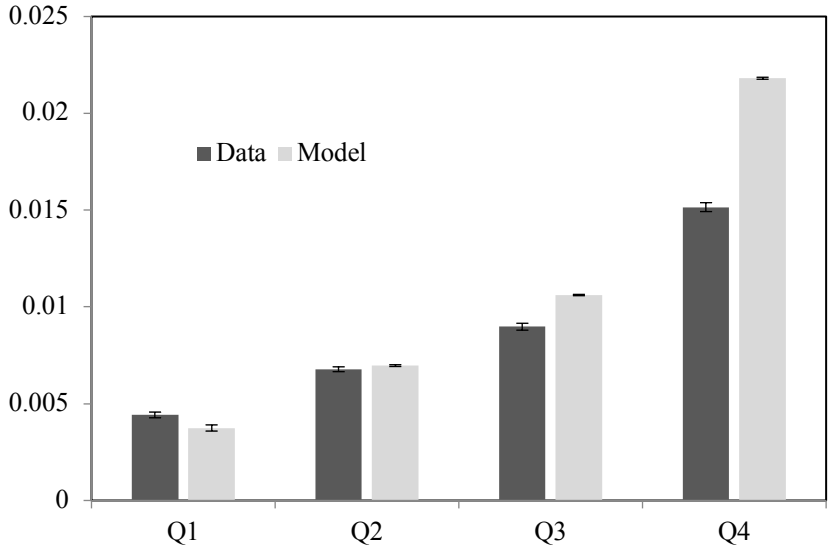
(a) Distribution of loan sizes



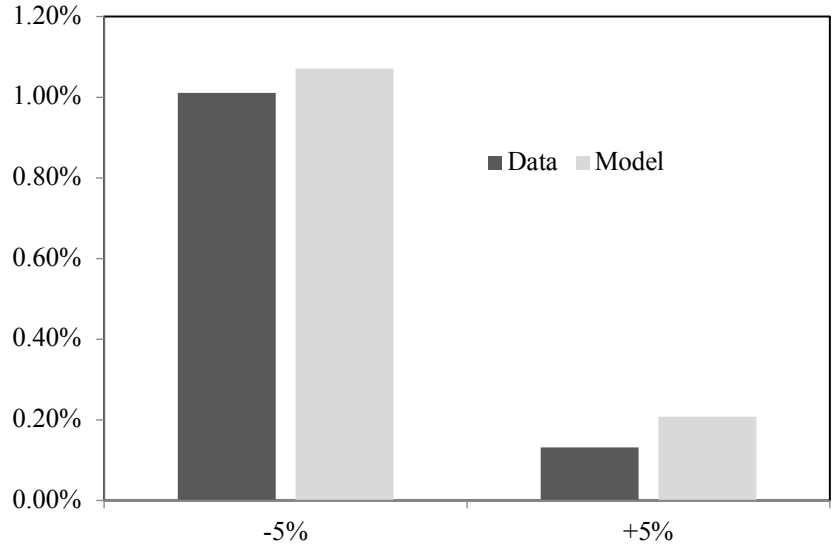
(b) Borrower average income

Figure 8: Empirical versus Model Conforming Loan Bunching

This figure shows actual and predicted market shares around the conforming loan limit. Panel (a) bins markets by predicted bunching quantile and plots the average market share of originations within +/-1pp of the conforming loan limit, with standard errors shown. The dark gray bars are actual bunching market share; the gray bars are the bunching share predicted by the model. Panel (b) shows the average market share across all markets for +/-5pp of the conforming loan limit. Data are from HMDA and the estimated model.



(a) Actual and predicted bunching share by predicted quartile



(b) Actual and predicted market share around conforming loan limit

Figure 9: Marginal Loan Origination Costs for Traditional and Shadow Banks

Figure 9 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 solid line shows the marginal cost for banks originating jumbo loans. The dashed black line shows marginal cost for banks originating conforming loans. The solid grey line shows the marginal cost for shadow banks originating conforming loans.

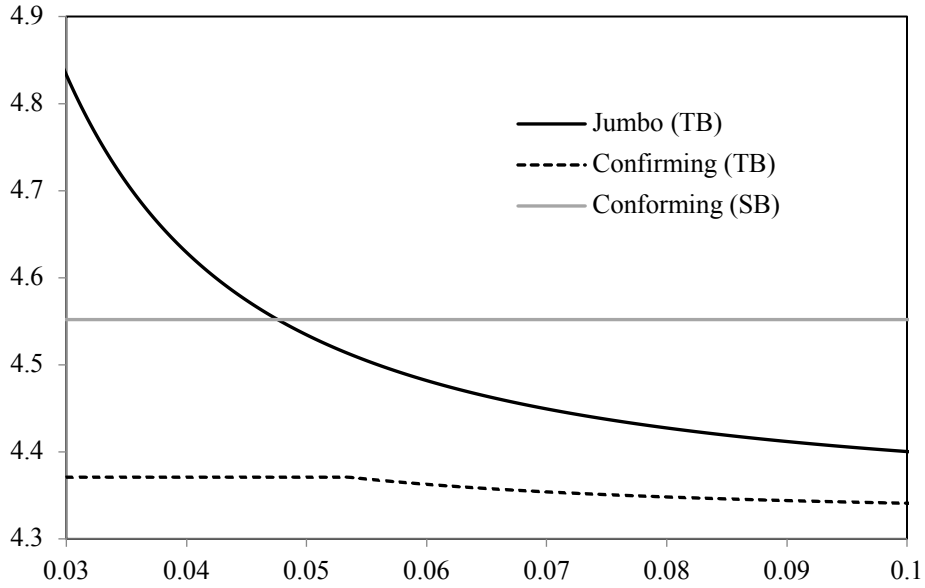
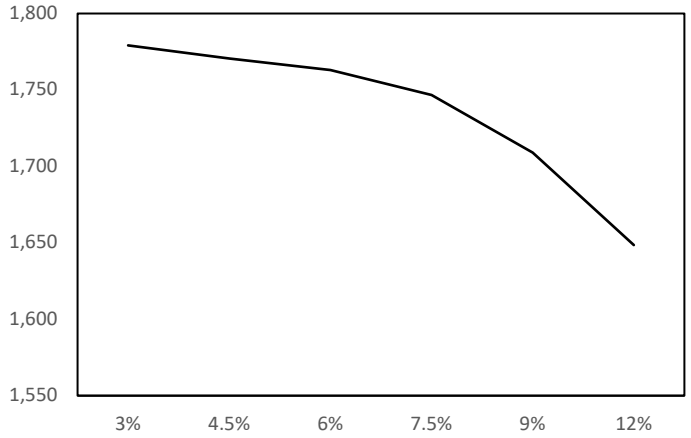
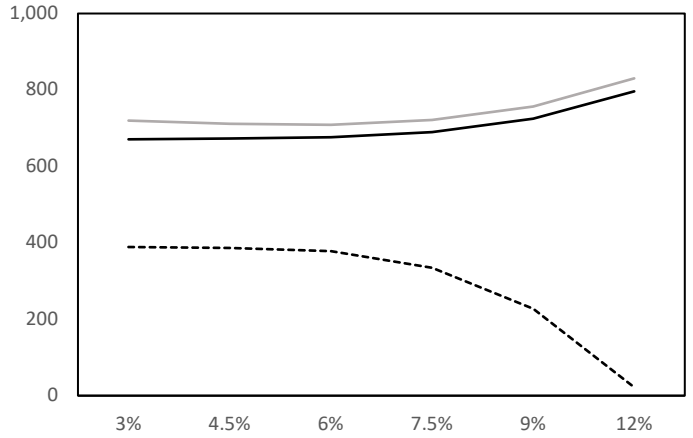


Figure 10: Counterfactual Analysis – Capital Requirements

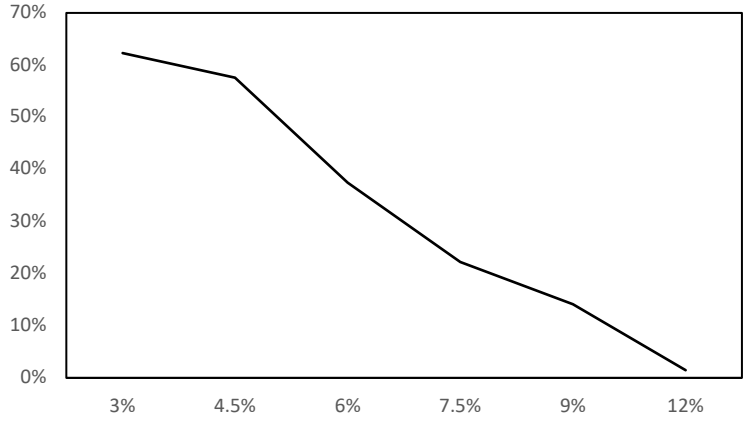
Panel (a) shows aggregate mortgage origination volume (in $ billions) across various bank capital ratio requirements (in %). Panel (b) shows the composition of aggregate lending (in $ billions) split by the shadow bank conforming lending volume (black line), bank conforming lending volume (grey line), and bank jumbo lending volume (dashed line) across various bank capital ratio requirements. Panel (c) shows the percentage of loans that are retained on banks' balance sheets across various capital requirements.



(a) Overall lending volume ($ billions)



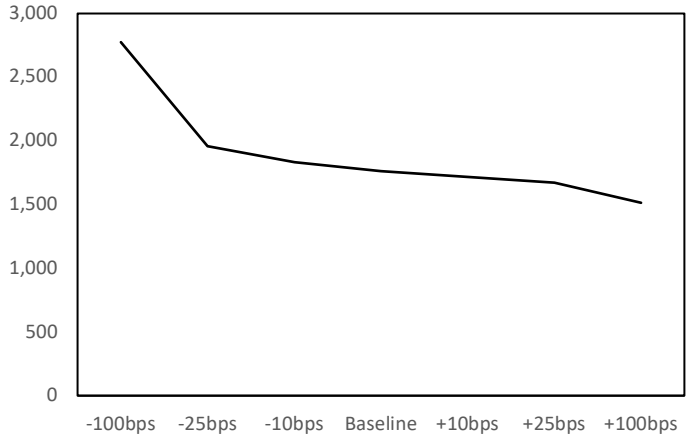
(b) Shadow bank conforming (black), bank conforming (grey) & jumbo (dashed)



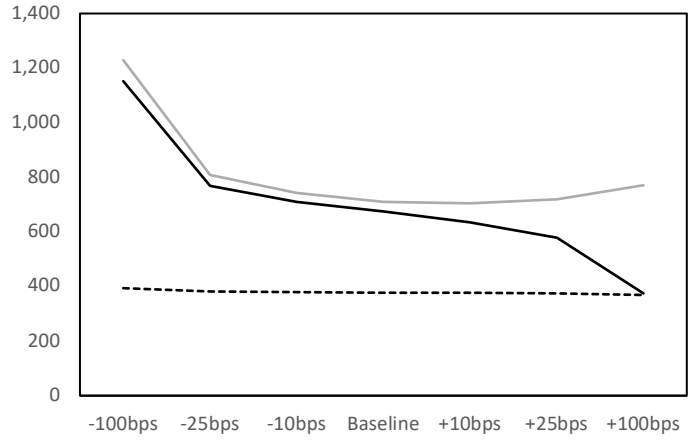
(c) Balance sheet financing share (in %)

Figure 11: Counterfactual Analysis – GSE Financing Costs

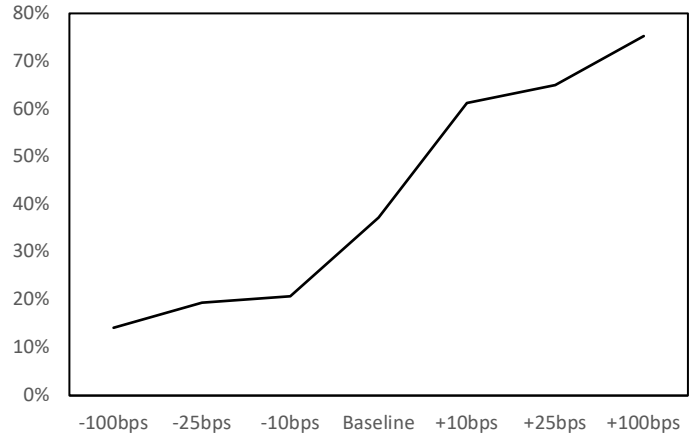
Panel (a) shows aggregate mortgage origination volume (in $ billions) across various changes to the GSE financing costs relative to the baseline (in basis points). Panel (b) shows the composition of aggregate lending (in $ billions) split by the shadow bank conforming lending volume (black line), bank conforming lending volume (grey line), and bank jumbo lending volume (dashed line) across various changes to the GSE financing costs. Panel (c) shows the percentage of loans that are retained on banks' balance sheets across various changes to the GSE financing costs.



(a) Overall lending volume ($ billions)



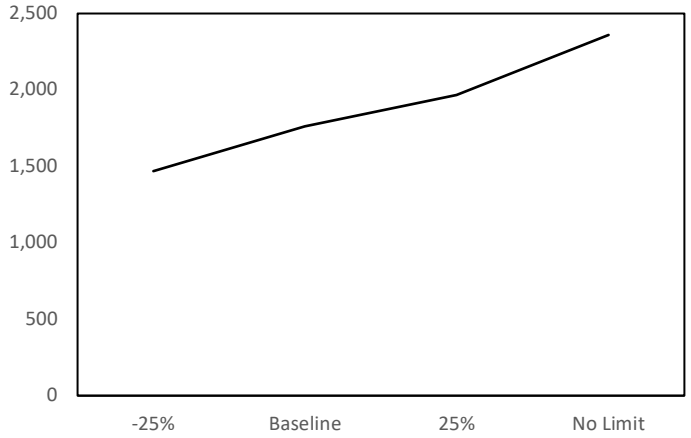
(b) Shadow bank conforming (black), bank conforming (grey) & jumbo (dashed)



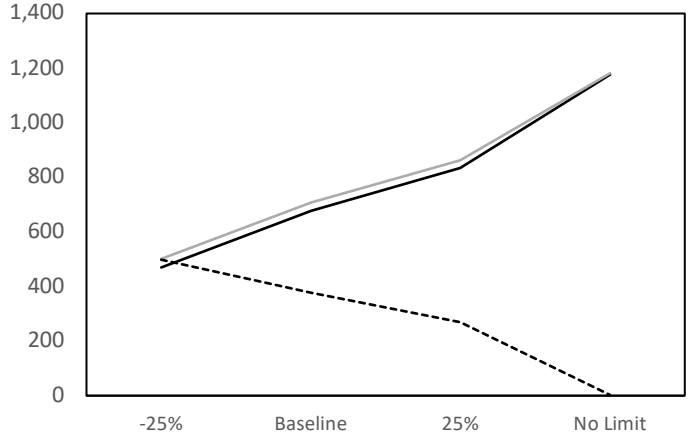
(c) Balance sheet financing share (in %)

Figure 12: Counterfactual Analysis – Conforming Loan Limit

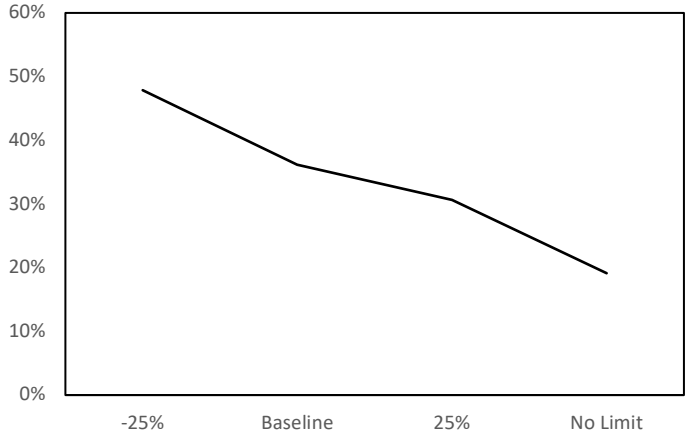
Panel (a) shows aggregate mortgage origination volume (in $ billions) across various changes in the conforming loan limit relative to the baseline (in %). Panel (b) shows the composition of aggregate lending (in $ billions) split by the shadow bank conforming lending volume (black line), bank conforming lending volume (grey line), and bank jumbo lending volume (dashed line) across various changes in the conforming loan limit relative to the baseline. Panel (c) shows the percentage of loans that are retained on banks' balance sheets across various changes in the conforming loan limit.



(a) Overall lending volume ($ billions)



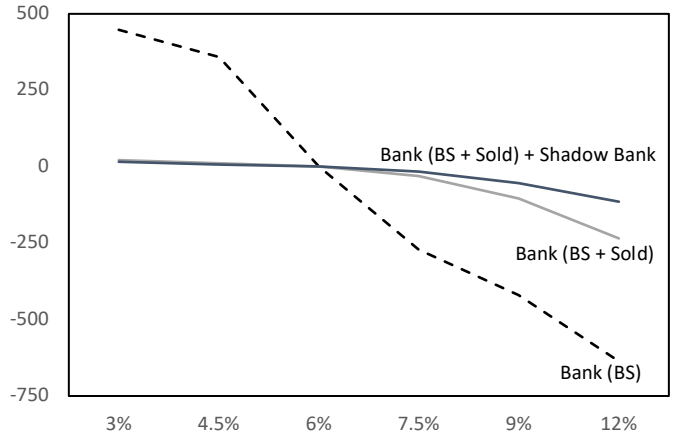
(b) Shadow bank conforming (black), bank conforming (grey) & jumbo (dashed)



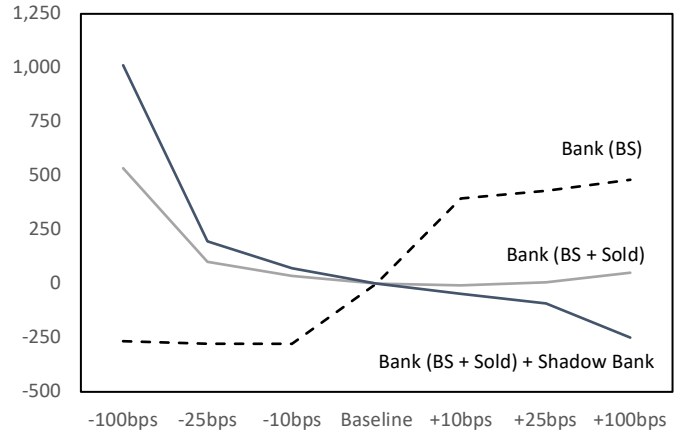
(c) Balance sheet financing share (in %)

Figure 13: Counterfactual Analysis – Importance of Balance Sheet Retention and Shadow Bank Migration Margins

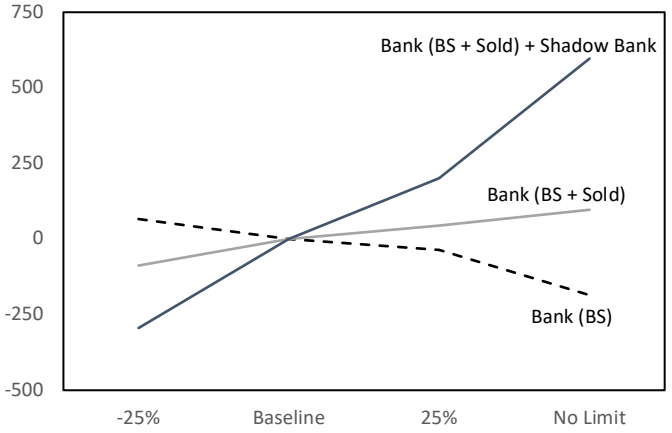
Panel (a) shows a change in the aggregate mortgage origination volume (in $ billions) across various bank capital ratio requirements (in %) relative to the baseline scenario (6% requirement). The dotted line shows the changes in the aggregate amount of bank balance sheet lending [Bank (BS)]. The grey line shows the overall change in the aggregate mortgage origination volume among bank lenders that includes both balance sheet lending and securitized loans [Bank (BS+Sold)]. The solid black line shows the overall change in the aggregate amount of lending accounting for both bank and shadow bank response [Bank (BS+Sold)+Shadow Bank]. Panel (b) shows the corresponding changes in loan origination volume across various changes to the GSE financing costs relative to the baseline (in basis points), while Panel (c) shows the changes in loan origination volume across various changes in the conforming loan limit relative to the baseline (in %).



(a) Lending volume changes across bank capital requirements



(b) Lending volume changes across changes in the GSE financing costs



(c) Lending volume changes across changes in the conforming loan limit

Appendix

Table A1: Counterfactual Analysis – Capital Requirements with Equity Raising and Asset Sales

This table shows the impact of various capital requirements when banks can issue equity (or sell assets) at a 25bp cost over the conforming. Column (1) shows the case a 3% capital requirement, Column (2) for a 4.5% capital requirement, Column (3) for a 6% capital requirement (baseline), Column (4) for a 7.5% capital requirement, Column (5) for a 9% capital requirement, and Column (6) for a 12% capital requirement. Rows show the predicted impact of the counterfactual change on various outcomes.

	Capital Requirement					
	(1)	(2)	(3)	(4)	(5)	(6)
	3%	4.5%	6% (Baseline)	7.5%	9%	12%
Lending Volumes						
Overall Lending Volume ($b)	1,777	1,770	1,764	1,761	1,763	1,760
Conforming Volume ($b)	1,388	1,385	1,383	1,383	1,386	1,384
Jumbo Volume ($b)	389	385	381	378	376	376
Bank Volume ($b)	1,106	1,097	1,089	1,084	1,085	1,082
Loan Financing						
Balance Sheet Lending ($b)	1,106	1,042	646	423	397	388
Share of Loans Financed on Balance Sheet (%)	62%	59%	37%	24%	23%	22%
Share of Conforming Loans Financed on Balance Sheet (%)	52%	47%	19%	3%	1%	1%
Shadow Bank Market Share (%)	38%	38%	38%	38%	38%	38%
Shadow Bank Share of Conforming Loans (%)	48%	49%	49%	49%	49%	49%
Share of Loans Financed with new Equity Issuance (%)	0%	1%	8%	11%	21%	21%
Interest Rates (deviation from baseline)						
Conforming Interest Rate (%)	-0.01	-0.01	-	0.00	0.00	0.00
Jumbo Interest Rate (%)	-0.12	-0.07	-	0.05	0.07	0.07
Jumbo - Conforming Spread (%)	-0.10	-0.07	-	0.05	0.07	0.07
Profits and Consumer Welfare (deviation from baseline)						
Overall Lender Profits ($b)	2	1	-	-1	-1	-1
Bank Profits ($b)	2	1	-	-1	-1	-1
Shadow Bank Profits ($b)	0	0	-	0	0	0
Overall Consumer Surplus ($b)	3	1	-	-1	-1	-1
Overall Consumer Surplus for Top Income Market ($b)	1	1	-	0	-1	-1

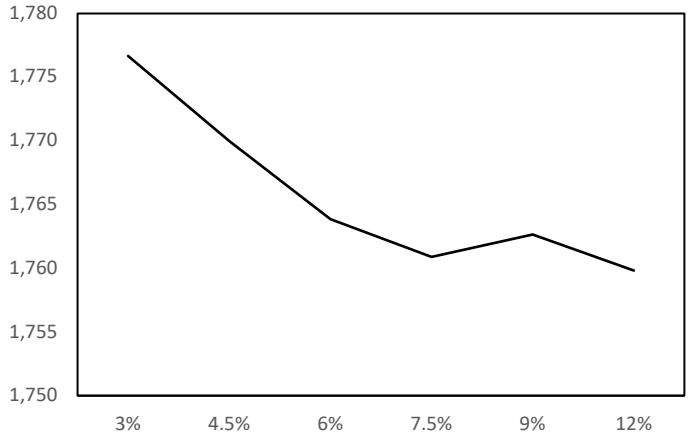
Table A2: Counterfactual Analysis – Capital Requirements with Jumbo Securitization

This table shows the impact of various capital requirements when jumbo loans can be securitized at a 25bp spread over conforming. Column (1) shows the case a 3% capital requirement, Column (2) for a 4.5% capital requirement, Column (3) for a 6% capital requirement (baseline), Column (4) for a 7.5% capital requirement, Column (5) for a 9% capital requirement, and Column (6) for a 12% capital requirement. Rows show the predicted impact of the counterfactual change on various outcomes.

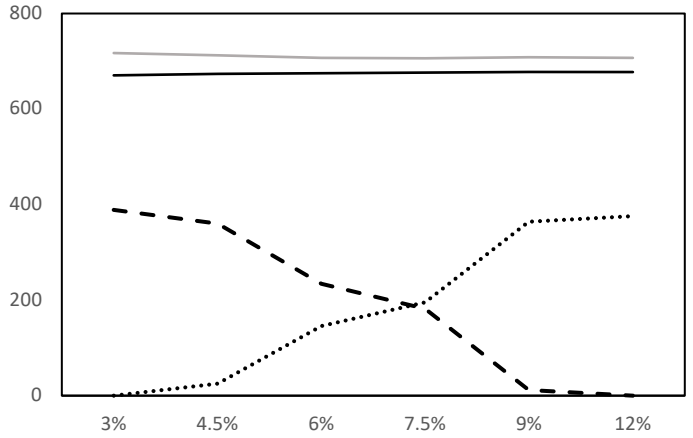
	Capital Requirement					
	(1)	(2)	(3)	(4)	(5)	(6)
	3%	4.5%	6% (Baseline)	7.5%	9%	12%
Lending Volumes						
Overall Lending Volume ($b)	1,792	1,783	1,777	1,775	1,773	1,777
Conforming Volume ($b)	1,360	1,354	1,353	1,355	1,354	1,358
Jumbo Volume ($b)	432	429	424	421	419	419
Bank Volume ($b)	1,079	1,068	1,059	1,055	1,053	1,056
Loan Financing						
Balance Sheet Lending ($b)	1,097	1,030	441	184	21	2
Share of Loans Financed on Balance Sheet (%)	61%	58%	25%	10%	1%	0%
Share of Conforming Loans Financed on Balance Sheet (%)	52%	48%	18%	3%	1%	0%
Share of Jumbo Loans Financed on Balance Sheet	87%	86%	44%	33%	3%	0%
Shadow Bank Market Share (%)	40%	40%	40%	41%	41%	41%
Shadow Bank Share of Conforming Loans (%)	48%	49%	49%	49%	49%	49%
Shadow Bank Share of Jumbo Loans (%)	13%	13%	14%	14%	14%	14%
Interest Rates (deviation from baseline)						
Conforming Interest Rate (%)	-0.03	-0.02	-	0.01	0.02	0.02
Jumbo Interest Rate (%)	-0.10	-0.06	-	0.04	0.06	0.06
Jumbo - Conforming Spread (%)	-0.07	-0.04	-	0.03	0.04	0.05
Profits and Consumer Welfare (deviation from baseline)						
Overall Lender Profits ($b)	2	1	-	0	-1	-1
Bank Profits ($b)	3	1	-	-1	-1	-1
Shadow Bank Profits ($b)	0	0	-	0	0	0
Overall Consumer Surplus ($b)	3	2	-	-1	-1	-1
Individual Consumer Surplus ($)	35	31	-	-26	-20	-17

Figure A3: Counterfactual Analysis – Capital Requirements with Equity Issuance

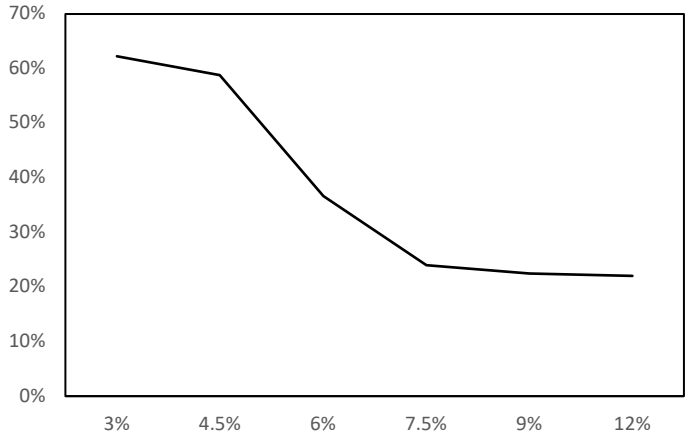
Panel (a) shows aggregate mortgage origination volume (in $ billions) across various bank capital ratio requirements (in %). Panel (b) shows the composition of aggregate lending (in $ billions) split by the shadow bank conforming lending volume (black line), bank conforming lending volume (grey line), jumbos financed with existing equity (dashed), and jumbos financed with new equity (dotted) versus various bank capital ratio requirements. Panel (c) shows the percentage of loans that are retained on banks' balance sheets across various capital requirements. In all cases, equity can be issued at a 25bp spread over conforming securitization costs.



(a) Overall lending volume ($ billions)



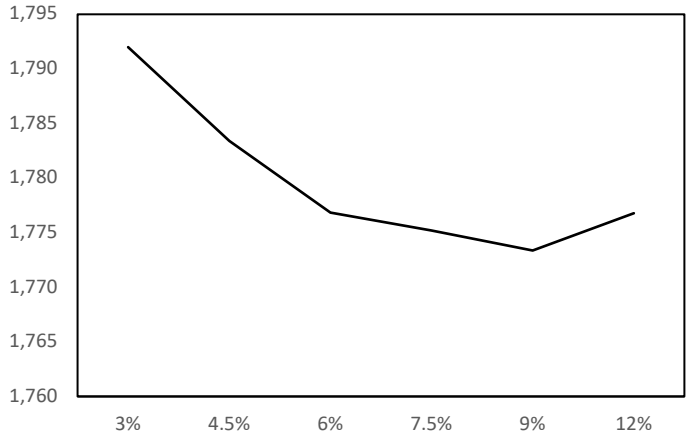
(b) Shadow bank conforming (black), bank conforming (grey), jumbo with existing equity (dashed), and jumbo with new equity (dotted)



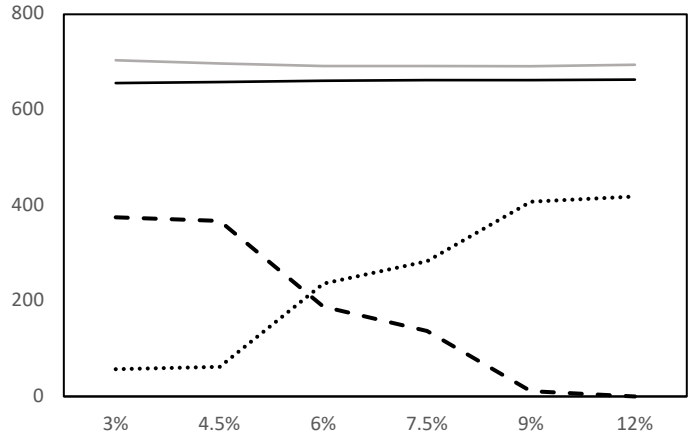
(c) Balance sheet financing share (in %)

Figure A4: Counterfactual Analysis – Capital Requirements with Jumbo Securitization

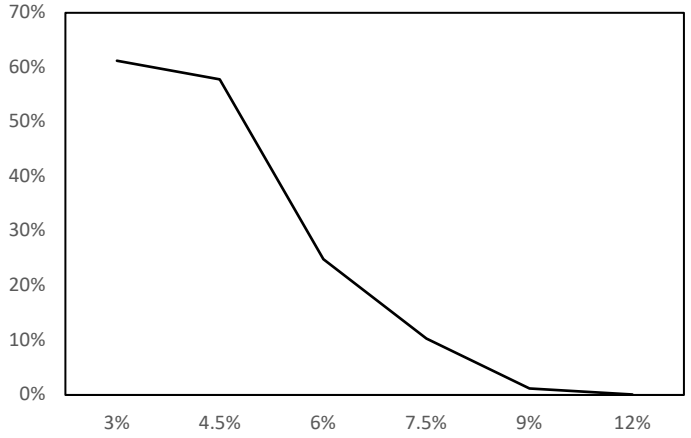
Panel (a) shows aggregate mortgage origination volume (in $ billions) across various bank capital ratio requirements (in %). Panel (b) shows the composition of aggregate lending (in $ billions) split by the shadow bank conforming lending volume (black line), bank conforming lending volume (grey line), balance sheet jumbo (dashed), and securitized jumbo (dotted) versus various bank capital ratio requirements. Panel (c) shows the percentage of loans that are retained on banks' balance sheets across various capital requirements. In all cases, jumbo loans can be securitized at a 25bp spread over conforming loans.



(a) Overall lending volume ($ billions)



(b) Shadow bank conforming (black), bank conforming (grey), balance sheet jumbo (dashed), and securitized jumbo (dotted)



(c) Balance sheet financing share (in %)

Table A5: Robustness Checks for Balance Sheet Financing and Jumbo Origination

This table corresponds to Table 4 with the addition of controls: *NCD / A* is non-core deposits as a fraction of total assets; *CD /A* is core deposits as a fraction of total assets. *NCD + CD = Total Deposits*. All columns include year fixed effects. Even-numbered columns additionally include lender fixed effects. Data from Call Reports and HMDA, 2007—2015.

	Dependent variable:							
	% Held		% Jumbo		% Held (Jumbo)		% Held (Conforming)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Capital Ratio	2.185***	4.212***	0.191***	0.026	0.425**	-0.567*	2.195***	4.444***
	(0.314)	(0.547)	(0.054)	(0.077)	(0.214)	(0.314)	(0.322)	(0.576)
Log(Originations)	-0.159***	-0.242***	-0.014***	-0.020***	-0.042***	-0.087***	-0.155***	-0.230***
	(0.014)	(0.027)	(0.002)	(0.004)	(0.011)	(0.016)	(0.014)	(0.029)
Log(Unique CTs)	0.029**	0.156***	-0.005**	0.018***	-0.081***	0.036	0.034**	0.141***
	(0.014)	(0.039)	(0.002)	(0.006)	(0.012)	(0.023)	(0.014)	(0.042)
Log(Assets)	0.040***	0.011	0.005***	-0.002*	0.048***	0.007	0.036***	0.012
	(0.004)	(0.008)	(0.001)	(0.001)	(0.004)	(0.005)	(0.004)	(0.008)
Log(Average Loan Income)	0.498***	0.637***	0.163***	0.132***	0.350***	0.250***	0.409***	0.601***
	(0.049)	(0.072)	(0.008)	(0.010)	(0.036)	(0.036)	(0.051)	(0.077)
Log(Average Loan Size)	-0.388***	-0.255***	0.032***	0.064***	-0.256***	-0.146***	-0.407***	-0.284***
	(0.027)	(0.041)	(0.005)	(0.006)	(0.025)	(0.027)	(0.027)	(0.043)
NCD / A	-0.742***	-0.380**	0.062***	0.012	-0.185**	-0.103	-0.777***	-0.370*
	(0.112)	(0.186)	(0.019)	(0.026)	(0.078)	(0.124)	(0.115)	(0.195)
CD / A	-1.098***	-0.657***	-0.017	0.094***	-0.521***	-0.385***	-1.103***	-0.678***
	(0.084)	(0.175)	(0.015)	(0.025)	(0.062)	(0.117)	(0.086)	(0.183)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lender FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,241	1,241	1,241	1,241	1,217	1,217	1,241	1,241
R^2	0.494	0.753	0.652	0.888	0.311	0.793	0.498	0.741