Non-Banks and Mortgage Securitization

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Annual Review of Financial Economics
2022. 14:1–34

https://doi.org/10.1146/((please add article doi))

Keywords

securitization, non-bank financial institutions, mortgage prepayment, systemic risk, financial regulation
JEL G21, G23, G28

Abstract

This paper reviews the dramatic growth of non-bank mortgage lending after the Global Financial Crisis, especially to borrowers with lower credit scores, and the related importance of mortgage-backed securitization. Our literature review suggests that the existing theoretical and empirical work on securitization is more relevant to bank than to non-bank lenders, thus leaving outstanding questions on why non-bank market shares have increased to their current levels and how best to structure non-bank oversight. To highlight key differences in the mortgage-lending incentives of banks and non-banks, we build a simple theoretical model of bank versus non-bank mortgage lending and use it to generate and test empirical hypotheses. We find, in particular, that loans issued by non-banks are more likely to prepay early than loans issued by banks, the difference not explainable by non-bank borrowers prepaying more rationally. Using regulatory filings from non-banks that are typically unavailable to academic researchers, we examine the balance sheets and liquidity and capital positions of large Ginnie Mae non-bank servicers, which face and pose more risk in the current mortgage system. We find that on average these servicers have reasonable liquidity and capital positions relative to standard regulatory thresholds, particularly in 2022:Q1 after a few quarters of elevated profits. However, some large Ginnie Mae servicers appear to have inadequate capital as gauged by risk-based capital measures. If defaults rise on a large scale, the liquidity and capital positions of these servicers may amplify the disruption in the mortgage and housing markets.

Contents

1. INTRODUCTION

Securitization, where issuers pool mortgages and then issue mortgage-backed securities (MBS) collateralized by those pools, is the dominant source of funding for mortgages in the United States. More than two-thirds of the $12.5 trillion in one- to four-family mortgages outstanding at year-end 2021 were funded through securitization.[1] Historically, securitization served as a means to channel capital from locations where it was abundant to locations where it was scarce (Snowden 1995), thereby better matching borrowers and savers. However, due to inherent frictions in securitization markets that we describe in this paper, mortgage-backed securitization has also served as a source of financial instability, most dramatically during the Global Financial Crisis (GFC) but in several other historical episodes as well.

In the last 50 years or so, there have been three main types of MBS in the US: those guaranteed by the government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac; those guaranteed by Ginnie Mae; and "private-label" securities (PLS) not guaranteed by either the GSEs or Ginnie Mae. MBS are issued by both banks and non-banks.[2] We describe these institutions and their role in the securitization market in more detail in Section 2.

Most of the existing literature on mortgage securitization focuses on the bank securitization market and on the experience of the PLS market in the GFC. However, securitization

[1] Authors' calculation based on the Financial Accounts of the United States, table L.218.

[2] "Banks" are defined here to include credit unions. Non-banks are generally finance companies. Some are subsidiaries of bank holding companies, and some have elected to be taxed as real estate investment trusts. We will refer to them simply as "non-banks" for convenience in this paper.

looks very different today than it did prior to the GFC. First, PLS all but disappeared after the crisis and that portion of the market has still not recovered. Instead, lower-credit quality mortgages are now funded primarily by Ginnie Mae securitizations. Second, while both non-banks and securitization have existed in the United States since the 1870s (Snowden 1995), non-banks have become increasingly dominant players in the mortgage market since the GFC, originating around 60% of mortgages in 2020 (versus 35% in 2013) and about 90% of the mortgages funded by Ginnie Mae pools (versus 35% in 2013).[3] The vulnerabilities of a mortgage system in which riskier mortgages are originated by non-banks and securitized in Ginnie Mae pools have received very little attention in the academic literature, with the exception of Kim et al. (2018).

Section 3 reviews the academic literature on mortgage securitization and non-bank lenders, highlighting the reasons why securitization exists, the frictions inherent in securitization, some explanations for why the non-bank market share has increased, and the new and unique risks posed by the growth of non-banks and Ginnie Mae securitization. The new risks center on servicing: a lender who originates a mortgage also creates the obligation to service it, which involves handling and distributing payments from borrowers and trying to limit losses associated with borrowers who default. Servicing delinquent mortgages imposes liquidity and capital obligations that are substantially higher for non-bank Ginnie Mae issuers than those faced in the past by bank PLS issuers.

In Section 4 we build a simple theoretical model of mortgage lending that incorporates both banks and non-banks, and highlights the interaction between lenders' capital requirements and screening incentives. The model shows that under different circumstances it may be optimal for a financial institution either to increase or to decrease its exposure to risk. The model predicts that mortgages originated by non-bank lenders are more likely to prepay and default, and that non-bank lenders themselves are more likely to go out of business than bank lenders.

We confirm these predictions in Section 5 using merged loan, property, borrower, and performance data, and in Section 6 using regulatory data on non-bank balance sheets. We find that loans issued by non-banks are more likely to prepay early than loans issued by banks. The difference is not explainable by non-bank borrowers prepaying more rationally. We find that loans in Ginnie Mae pools that were originated by non-banks are also more likely to default early than loans originated by banks. Finally, we show that some non-banks have less capital than banks; in certain time periods a sizeable fraction would not meet the bank regulatory definition of being well capitalized on a risk-weighted basis.

We then use the regulatory data to identify the aspects of non-bank balance sheets, liquidity, and capital that have implications for the stability of the mortgage system. Comprehensive data on non-bank balance sheets have long been unavailable to researchers, and thus so has basic information on the capital and liquidity of these firms. We focus on the 100 largest non-bank Ginnie Mae issuers since these firms face and pose the greatest risks. These issuers held the servicing rights on 47% of loans in GSE or Ginnie Mae pools as of 2022:Q1. Jiang et al. (2020) also use these regulatory data to compare the capital of bank and non-bank mortgage originators, but we are the first to focus on the risks specific to

[3]The overall statistics are from Kim et al. (2018) for 2013 and Consumer Financial Protection Bureau (2021) for 2020. The Ginnie Mae statistics for both years are from Urban Institute (2022). This rise is part of the broader increase in non-bank intermediation (Pozsar et al. 2013, Adrian & Ashcraft 2016, Gorton & Metrick 2011, 2012, Gennaioli et al. 2012, 2013).

Ginnie Mae issuers.

We show that non-bank business models vary substantially, with some non-banks concentrating on originating loans and others focusing more on servicing. We find that non-bank assets are focused in mortgage-related assets that are likely to all perform poorly if mortgage defaults rise, and that the main unencumbered non-bank asset is mortgage servicing rights (MSRs). MSRs are the present discounted value of the anticipated revenue from servicing the pool of mortgages and, as we discuss, can be volatile, illiquid, and hard to value.[4] Most non-bank liabilities are short-term and in some circumstances susceptible to runs.

We find that most Ginnie Mae issuers emerged from the pandemic with stronger capital and liquidity positions than they had before, due to the large profits that they accumulated from refinancing mortgages in 2020 and 2021. However, whether these issuers in general are well capitalized depends on whether MSRs are considered high-quality assets. The Ginnie Mae leverage ratio in effect as of June 2022 treats MSRs and cash as equivalent sources of strength, while risk-based capital ratios required for banks, and proposed for Ginnie Mae issuers, do not. Under these risk-based ratios, 25% to 40% of the mortgages in Ginnie Mae pools, depending on the measure, were held by a non-bank that was not well capitalized at year-end 2018 and 20% to 30% were held by such a non-bank in 2022:Q1.

Our analysis highlights the tradeoffs that policymakers face in deciding on non-bank capital regulation. In times of stress, Ginnie Mae issuers need capital and liquidity to carry out their obligations with respect to default servicing. MSRs are unlikely to hold their value in those situations. However, the firms that would be most affected by tighter capital regulation play a systemically important role in the liquidity of the MSR market (through their purchases from other firms) and in the operational aspects of mortgage servicing. Policymakers must balance the need to ensure that their counterparties have enough capital and liquidity to carry out their responsibilities while still maintaining the liquidity of the MSR market and servicing capacity of the mortgage system.

2. BACKGROUND ON NON-BANKS AND SECURITIZATION

The US mortgage market and securitization. The mortgage market in the United States is enormous and composed mostly of long-term fixed-rate loans. Only around $3.2 trillion of the $12.5 trillion in mortgages outstanding at year-end 2021 were funded by banks.[5] The sheer size of the market, and the fact that most bank liabilities are short-term and floating rate, make the capital markets a natural funding source for the bulk of mortgages.

In the MBS process, issuers pool mortgages and then issue debt securities that are collateralized by the mortgages and sold to investors around the world. The MBS market is the second-largest U.S. fixed-income market, larger than corporate bonds. In addition to creating a funding source that is a better match for long-maturity fixed-rate assets, securitization channels capital from locations where it is abundant to locations where it is scarce, thereby better matching borrowers and savers. Securitization also transforms whole

[4] Eisfeldt & Papanikolaou (2014) and Crouzet et al. (2022) highlight that intangible assets such as mortgage servicing rights present significant measurement challenges to both economists and accountants.

[5] Table L.218., Financial Accounts of the United States.

mortgages into multiple assets with different risk-return profiles, thereby better matching investors and assets. Finally, securitization provides long-term cost-effective funding to non-banks. Since non-banks would otherwise have a much higher cost of funds than banks, securitization allows non-banks to compete with banks in the mortgage market and offer more choices to borrowers. We discuss other motivations for securitization in Section 3.1.

Types of MBS. In the United States, there are three main types of MBS: those guaranteed by the GSEs Fannie Mae and Freddie Mac; those guaranteed by Ginnie Mae; and "private-label" securitizations without a GSE or Ginnie Mae guarantee. Fannie Mae and Freddie Mac are publicly held financial institutions that were chartered by Congress and have been in government conservatorship since a dramatic deterioration in their financial situation in 2008 (Frame et al. 2015). Fannie Mae and Freddie Mac purchase mortgages from banks and non-banks and issue MBS collateralized by these mortgages. Ginnie Mae is a wholly owned government corporation. Under its program, banks or non-banks issue the MBS and Ginnie Mae provides a guarantee of timely payment of principal and interest to investor. Private-label securitizaitons are sponsored by private financial institutions. Fuster et al. (2022) provide a comprehensive overview of the MBS market.

Securitization has funded 65%–70% of mortgages since the early 1990s, but the securitization type has changed dramatically over this period. In particular, the market share of private-label MBS rose significantly in the 2000s, peaking at funding just over 20% of mortgages at the end of 2006, before subsequently plummeting in the GFC. At year-end 2021, about half of mortgages were funded by GSE securitizations, a bit less than 20% were funded by Ginnie Mae MBS, and 3% were funded by private-label MBS.[6]

Comparison of MBS. The three types of MBS pose different risks to investors. Eligible collateral for GSE MBS are loans that meet the underwriting standards of Fannie Mae and Freddie Mac. These mortgages are typically originated to higher credit quality borrowers that meet certain income documentation requirements and need mortgages smaller than a certain size. The GSEs insure investors against credit loss on the mortgages and guarantee that investors will receive timely principal and interest payments. Investors in these securities are not exposed to credit risk but are exposed to prepayment risk — that is, the risk that they will receive principal payments at a pace different than they anticipated, likely because an unexpected change in mortgage rates shifts the rate at which borrowers refinance their mortgages. Before 2008, the GSEs benefited from the market's assumption that the federal government would step in to rescue them if the GSEs were unable to honor their guarantees. Since they entered conservatorship, the GSEs have had more explicit government backing.

Eligible collateral for Ginnie Mae MBS is mortgages that are guaranteed or insured against credit loss by the Federal Housing Administration (FHA), the Department of Veterans Affairs (VA), or a couple of smaller government programs. The borrowers served by these programs tend to have lower credit scores than those who obtain loans guaranteed by the GSEs. Issuers can securitize these loans through the Ginnie Mae platform, and Ginnie Mae guarantees that investors will receive timely payment. Unlike the GSEs, the Ginnie

[6] Authors' estimates from Table L.218, Financial Accounts of the United States, and Recursion, "Agency Mortgage Market Monthly Update," April 2022.

Mae guarantee is an explicit guarantee of the full faith and credit of the U.S. government. As with GSE MBS, investors in these securitizations are exposed only to prepayment risk.

Eligible collateral for private-label MBS tends to be loans that are ineligible for these programs, usually because the size of the loan exceeds the program limit ("jumbo" mortgages) or the loan does not meet the documentation requirements (non-qualified, or "non-QM", mortgages, sometimes also called "expanded credit"). Before the GFC, this category also included "subprime" loans, extended to borrowers with low credit scores, and "alt-A" loans, extended to borrowers that did not want to document income or preferred non-standard mortgage products. Since the GFC, these borrowers are served by the non-QM market or the FHA market, or are unable to obtain mortgage credit. Investors in these securitizations are exposed to both prepayment and credit risk.

Securitizations issued by the GSEs and Ginnie Mae are almost all pass-through securities, in which investors receive proportionate shares of the cash flows of the underlying mortgages. Private-label MBS are generally collateralized mortgage obligations that have multiple classes of securities, known as tranches, that differ in their payment priority. These tranches can be designed to appeal to investors with different investment objectives and risk tolerances. In all cases, securitization also creates a separate asset, the mortgage servicing right, which is the present discounted value of the anticipated revenue from servicing the pool of mortgages. This asset is sometimes retained by the loan originator and sometimes sold to a third-party investor.

3. RECENT LITERATURE

3.1. Theoretical foundations and empirical tests

The theoretical literature on mortgage-backed securitization points to a variety of complementary reasons why simply repackaging a portfolio of individual loans into pools creates value. Some reasons apply to all types of MBS. For example, DeMarzo & Duffie (1999) motivate securitization as a way for issuers to free up capital for higher return investments, while Loutskina & Strahan (2009) note that securitization can improve a bank's liquidity position.

Most of the theoretical literature applies primarily to private-label MBS where investors bear credit risk and securitizations have multiple credit tranches in contrast to the pass-through securitization that dominates the current mortgage market and is the subject of our review. DeMarzo (2005) shows that if the residual risk of the underlying assets is not highly correlated, pooling large numbers of assets can create value through risk diversification. Diamond (1984) suggests that pooling loans may save on monitoring costs. Hartman-Glaser et al. (2012) find that selling pooled mortgages is more efficient than selling mortgages individually because pooling allows investors to learn about the underwriter's effort more quickly. Oldfield (2000) notes that issuers can create value by tailoring securities for investors' risk and return preferences; Riddiough (1997) also shows that tranching securities can create value relative to whole loan sales.

Downing et al. (2009), Fusari et al. (2022), and Huh & Kim (2020) document that originators appear to use private information about loan quality in mortgage securitization in the GSE to-be-announced (TBA) market. In the TBA market, investors only know the broad parameters of the MBS that they purchase, and not the individual loans. The findings are more mixed on this question for the subprime private-label market before the GFC, with Calem et al. (2011) finding such adverse selection, Agarwal et al. (2012) finding

more mixed results, and Jiang et al. (2014) finding that investors were able to overcome the informational asymmetry.

Investors know that issuers face these incentives, and so discount the price that they are willing to pay accordingly. Issuers who originate high-quality loans, and who do not want to receive such "lemons" pricing, can take actions to reveal the quality of their loans, as in the classic signaling model of Spence (1974). One such mechanism is credit risk retention. Because it is more costly for originators to retain bad loans than good ones, retention may serve to signal quality to investors as in Leland & Pyle (1977). Originators' ability to signal through retention is consistent with the findings in Begley & Purnanandam (2021, 2017) and Ivashina (2009). Likewise, Vanasco (2017) concludes that the optimal mechanism to implement asset screening is costly retention of cash flows. Adelino & Hartman-Glaser (2019) find that MBS issuers can signal the quality of their securitizations by extending the time between mortgage origination and securitization. Hartman-Glaser (2017) models the interaction between retention and an issuer's reputation for honesty in signaling asset quality. Winton & Yerramilli (2021) also focus on the interaction among reputation concerns, loan retention, and monitoring effort on the part of issuers. Daley et al. (2020) find that under certain conditions, external credit ratings can reduce the need for an issuer to retain loans to signal their credit quality.

Information asymmetries also give originators an incentive to underwrite with less care: under the "originate to distribute" (OTD) model, in which they sell their originations to third-party investors, the credit risk is borne by the investor or the government securitization guarantor. Multiple studies have found that the informational problems in the OTD model, and specifically in private-label MBS, led to a deterioration in underwriting before the GFC (see Purnanandam 2011, Keys et al. 2010, 2012, Mian & Sufi 2009, Nadauld & Sherlund 2013, Elul 2016). Bubb & Kaufman (2014) and Foote & Willen (2018), however, cast some doubt on the idea that these frictions were as central to the GFC.

Securitization also splits the mortgage from the obligation to service it, and may cause a principal-agent conflict between the MBS investor and servicer. Several studies have shown that the servicer may have different incentives from the investor, particularly when it comes to preserving value for investors when mortgages default (see Piskorski et al. 2010, Aiello 2022). Adelino et al. (2013, 2014), though, suggest that other factors may also explain these findings.

Looking at these studies as a whole, many of them focus on securitization from the perspective of a bank issuer, or focus on the private-label MBS market and the GFC period. This work is only partially informative about the current securitization market, in which most issuers are non-banks that fund themselves through GSE- and Ginnie Mae-guaranteed securitizations. For example, issuers in the GSE and Ginnie Mae markets are not required to retain any risk in these securitizations under current risk retention rules. Instead, mortgage servicing rights, which are not covered in any of these studies, serve as the primary form of skin in the game for these issuers because servicing costs are higher for mortgages that default. Our paper thus attempts to fill the gap noted by Metrick & Tarullo (2021): "the precrisis developments in mortgage finance have been well studied, but the postcrisis shift in nonprime mortgage finance has received far less scholarly attention."

3.2. Why has non-bank market share increased since the global financial crisis?

The post-GFC decline in the bank share of mortgage originations is generally attributed to regulatory changes and non-banks' quicker adoption of new technologies (Buchak et al. 2018). Some of these regulatory changes only affect banks, such as stress testing (e.g., Calem et al. 2019, Gete & Reher 2018), higher capital requirements (e.g., Gertler et al. 2016, Dempsey 2020, Reher 2021, Irani et al. 2021, Chernenko et al. 2022, Begenau & Landvoigt 2022), and the liquidity coverage ratio (Roberts et al. 2021). Other post-GFC developments, such as the qualified-mortgage requirements (e.g., DeFusco et al. 2020), litigation risk (e.g., D'Acunto & Rossi 2022, Gissler et al. 2016), and putback requests, attempts to recover credit losses, and foreclosure-related litigation (Kim et al. 2018) affect both banks and non-banks. However, these developments may weigh more heavily on bank decision making because banks are scrutinized more closely by their regulators and because banks' multiple lines of business and higher franchise value, relative to the monoline non-bank mortgage model, makes it more costly to go out of business in response to large losses.

Some non-bank originators, which we refer to as "fintech" non-banks, have also been quicker to harness technological innovation in general (see Gertler et al. 2016, Ordoñez 2018) and automated underwriting for consumer credit (see Buchak et al. 2018, Fuster et al. 2019, Bartlett et al. 2022). Originators such as Rocket Mortgage (the former Quicken Loans) originate some mortgages almost entirely online with no human loan officer. Additionally, fintech lenders may be better able to screen potential borrowers, leveraging alternative sources of information and the big data approaches inherent in technology-based lending (see Blattner & Nelson 2021).

Although banks have stepped back from originating mortgages directly, they have increased their role in two other parts of the mortgage market. First, banks provide the warehouse lines of credit that non-banks use to finance their mortgage originations (Jiang 2021). The Bankruptcy Abuse and Consumer Protection Act (BACPA) in 2005 made it easier for warehouse creditors to seize their collateral and thereby increased banks' interest in extending these lines. The BACPA changes also reduced non-bank costs and contributed to rapid non-bank growth both pre-2008 (e.g., Ganduri 2021, Lewis 2021) and post-GFC (see Kim et al. 2018, Metrick & Tarullo 2021).

Second, banks are major holders of mortgage-backed securities. Banks have an incentive to hold GSE or Ginnie Mae guaranteed MBS, rather than the equivalent whole loans, because the MBS have lower capital charges as a result of the government guarantees. As of year-end 2021, commercial banks held nearly $2.5 trillion of the roughly $9.4 trillion in agency MBS outstanding.[7]

The increase in non-bank market share has brought benefits to consumers. Non-banks can be more nimble than banks in entering new markets, adapting to changing market conditions, and adopting new technologies. Gete & Reher (2021) find that the increased non-bank market share may be welfare-improving due to increased access to homeownership. Non-banks may also have played a role in maintaining access to credit after the GFC. The sharp rise in the non-bank market share of mortgages funded by Ginnie Mae pools post-GFC, for example, suggests that borrowers with lower credit scores would have faced tighter credit conditions without non-bank lenders.

Non-banks also bring financial stability risks to the mortgage market because they are

[7] Authors' calculations from the Financial Accounts of the United States.

reliant on short-term, runnable funding; are not required, in some cases, to hold the liquidity and capital necessary to carry out their responsibilities under their servicing contracts; and may amplify house price cycles by originating and servicing loans with less care than they would if they held the full credit risk of the mortgage. We briefly summarize these risks here and refer the reader to other studies (see Kaul & Goodman 2016, Kim et al. 2018, Hubbard et al. 2021, Gete & Reher 2021, Conference of State Banking Supervisors (CSBS) 2017, 2021, Financial Stability Oversight Council 2020) for more details.

Turning first to short-term funding, as described in Section 3.2, non-banks fund their mortgage originations on short-term warehouse lines of credit until the mortgages are securitized. In times of stress, and especially when the non-banks are in violation of the line performance covenants, warehouse lenders can tighten terms on the lines, require more margin, or cancel the lines altogether, leading to a contraction in credit availability, asset fire sales, and funding freezes. Some nonbanks also have financing facilities for other purposes that are collateralized by their MSRs; some of these facilities are longer-term. Unlike banks, non-banks cannot turn to the Federal Home Loan Bank System or the Federal Reserve System for liquidity when their other sources of funding dry up. Kim et al. (2018) and Pence (2022) describe how these dynamics played out in the GFC and in spring 2020, respectively. In addition, some MBS investors are also dependent on short-term runnable funding (see Metrick & Tarullo 2021, Pence 2022) and runs on this funding can affect the ability of non-bank originators to obtain long-term securitization funding. These risks relate to the larger literature on the run risk associated with the shadow banking system (see Gorton & Metrick 2011, 2012, Hanson et al. 2015).

Turning next to the servicing contracts, as discussed in detail in Kim et al. (2018), servicers for all types of securitizations—GSE, Ginnie Mae, and PLS—are required to advance principal and interest to investors on behalf of mortgage borrowers who do not make their payments. Servicers are eventually repaid these advances, but must finance them in the interim. Servicers are only obliged to advance payments for a few months for loans in GSE-guaranteed pools; in PLS pools, servicers are not required to advance any funds that they do not anticipate being able to recover. However, for Ginnie Mae pools the obligations can stretch out for much longer. Servicers are also exposed to credit losses on Ginnie Mae pools because servicers are required to absorb any losses not covered by FHA or VA insurance.

Servicing advances became a major policy concern in spring 2020. As part of the pandemic response, Congress implemented broad-based forbearance for mortgage borrowers, but did not provide a funding mechanism for the servicers that advanced these payments on behalf of borrowers. The servicers weathered the strain because of policy interventions and the cash windfall they received from mortgage refinancing (Pence 2022).

As we show in more detail in Section 6, some servicers do not appear to be holding the liquidity or capital necessary to carry out their obligations under the Ginnie Mae contract. In addition, because their business model centers almost exclusively on mortgage-related activities, their income and their assets are heavily exposed to shocks to house prices and interest rates. Thus a rise in mortgage delinquencies will likely lead to a simultaneous rise in non-bank obligations under their servicing contracts and a drop in their income and assets. As non-banks come under strain in this scenario, they are likely to cut back on their loan originations and on the quality of their servicing, which could weigh on mortgage credit supply and contribute to unnecessary foreclosures.

Finally, nonbanks do not hold onto their loan originations, and as described in Section 3.1, the OTD model gives them less incentive to underwrite mortgages with care.

They also do not bear the full credit risk of the loans that they service, and so may not always service loans in a way that preserves value for the investor. These incentive issues can amplify house-price cycles. Originating low-quality mortgages may increase the supply of credit to marginal borrowers and boost house prices. Defaults on these mortgages, coupled with poor-quality servicing, may increase foreclosures and these property fire sales may weigh on house prices. Buchak et al. (2018) find that non-bank mortgages are more likely to be delinquent than mortgages originated by banks.

Non-banks with insufficient liquidity and capital may be particularly prone to these behaviors because the cost of bankruptcy and lost franchise value is lower. Cherry et al. (2021) and Kim et al. (2022) show, for example, that borrowers with mortgages serviced by non-banks, and especially non-banks with less liquidity or capital, were less likely in 2020 to receive COVID-related forbearance relief under the CARES Act despite appearing to be eligible.

3.3. Non-bank oversight

Non-banks are regulated more lightly for prudential purposes than banks. State banking supervisors are given this prudential responsibility and have taken steps such as establishing model prudential standards (Conference of State Bank Supervisors 2021), but some observers have cast doubt on the state regulators' ability to provide comprehensive prudential supervision (Hubbard et al. 2021). Instead, the Federal Housing Finance Agency (in its role as conservator of Fannie Mae and Freddie Mac), Ginnie Mae, and warehouse lenders serve as de-facto non-bank regulators through the capital and liquidity requirements they set for their counterparties. However, these entities set their requirements with the goal of protecting their own interests, rather than preserving the stability of the mortgage system as a whole, and overall there is no comprehensive capital regulation or regulatory stress-testing of non-banks. Several studies (Kim et al. 2018, Hubbard et al. 2021, Jiang et al. 2020), as well as our analysis in Section 6.3, consider the liquidity and capital positions of non-banks, but no existing studies provide a framework for how much liquidity and capital these entities should have.

In recent years, government agencies and outside observers have developed some preliminary reform proposals (see Hubbard et al. 2021, Metrick & Tarullo 2021, U.S. Department of the Treasury 2019, Kaul & Goodman 2020, Kaul & Tozer 2020). The proposals consider, for example, whether a single federal prudential regulator for non-bank mortgage companies would be more effective than the existing state-based system. The proposals also ask whether the federal government should provide a liquidity backstop for non-bank mortgage companies, either by permitting membership in the Federal Home Loan Bank system or creating a backstop facility in times of crisis. Expanding the scope of the FHLBs, however, also carries risks (Flannery & Frame 2006, Ashcraft et al. 2010, Sundaresan & Xiao 2021, Gissler & Narajabad 2017).

4. ANALYSIS FRAMEWORK

As highlighted in the literature review, the existing theoretical literature focuses on securitization from the bank perspective, even though the majority of mortgage originators and MBS issuers in the post-GFC period are non-banks. In this section, we therefore introduce a parsimonious framework of a market with banks and non-banks, focusing on the

previously discussed differences between these lending entities. Specifically, non-banks have access to novel technologies making their loan handling more efficient (faster) and allowing for more rapid removal of newly originated loans from their balance sheets.[8] Additionally, as described earlier, non-banks are monolines with less franchise value and less vigilant regulators than banks, and so have a more viable option to go out of business. As a consequence, banks and non-banks may have different incentives to screen borrowers in a market with loan applications of heterogeneous quality.

We use our framework, which is necessarily very stylized, to analyze and discuss the implications of these major differences between banks and non-banks. We further discuss the implications later in the paper, when analyzing the data.

4.1. Societal value of mortgages

A large number of agents (potential borrowers) are in the market for mortgage loans. Each agent is of type $v \in \{\ell, h\}$. Agents of type ℓ are vulnerable to shocks, whereas those of type h are resilient against such shocks.

A social planner associates societal value $A > 0$ with a resilient type obtaining a mortgage loan (the *resilience benefit*), and $-B < 0$ of a vulnerable type obtaining such a loans (the *vulnerability cost*). Associated with each agent is "hard" information $p \in (0, 1)$ such that, conditioned on p, the probability that the agent is of the resilient type is p. The hard information can be thought of as that found in a credit report, which is easily measured and straightforward to quantify. We call p the agent's *score*.

There also exists soft information about an agent's resilience, which can be obtained by screening, at a cost $C > 0$. We may think of such screening as the gathering and evaluation of soft information, a fairly human-capital-intensive effort. For example, a loan officer may need to spend time interviewing a potential borrower or going over a number of documents to see if there are any patterns in historical behavior that raise a red flag.

For simplicity, we assume that C is the same for all agents, and that the soft information allows unambiguous identification of the agent's type. Moreover, we focus on the economically interesting case in which the cost of soft information is not too high, $C < \frac{AB}{A+B}$.

Without soft information, the social planner prefers a mortgage to be extended to a potential borrower if the expected resilience benefit outweighs the expected vulnerability cost, i.e., if $Ap+(1-p)(-B) > 0$. So mortgages should be extended to agents with associated scores

$$p > p^* \stackrel{\text{def}}{=} \frac{B}{A+B}.$$

When soft information is available, the planner views the following outcome as optimal:

Proposition 1 *In the first-best outcome: (i) no agent with score $p < \frac{C}{A}$ obtains a loan; (ii) soft information is obtained for agents with scores $\frac{C}{A} \le p \le 1 - \frac{C}{B}$ and only the resilient agents within this pool obtain loans; (iii) all agents with scores $p > 1 - \frac{C}{B}$ obtain loans.*

The differences between the two outcomes are that resilient agents with scores $p \in \left[\frac{C}{A}, \frac{B}{A+B}\right)$

[8] As discussed in Kim et al. (2018), newly originated mortgages generally sit on non-bank balance sheets for two weeks or less. In contrast, in the GSE market, larger banks primarily swap their newly originated mortgages for mortgage-backed securities composed of their own loans. Thus, their balance-sheet holdings of their own securities is long and banks are the dominant long-term investors in these securities.

obtain loans when soft information is available, and vulnerable agents with scores $p \in \left[\frac{B}{A+B}, 1-\frac{C}{B}\right)$ do not, which increases the precision of loan allocations.

4.2. Mortgages, lending, and securitization

A mortgage loan is characterized as follows: The borrower receives 1 dollar and commits to pay the lender an annuity stream with long maturity. For simplicity, we assume that payments are structured as a perpetuity, i.e., the borrower commits to pay the *mortgage rate* of s dollars per unit time to the lender in perpetuity. Here, $s > r$, where r is the discount rate. Time is continuous and the horizon is infinite, $t \geq 0$.[9]

Borrowers may be hit by publicly observable shocks, the arrival of which is governed by a Poisson process with arrival intensity λ. When a shock arrives, a vulnerable borrower defaults and immediately stops making payments on the mortgage. Resilient borrowers are not affected by shocks; one can therefore infer that a borrower who continues to pay after the arrival of a shock is resilient. For simplicity, we assume that no value is recovered by the lender when a borrower defaults. The most straightforward interpretation of the shock is a macroeconomic event that triggers default among all vulnerable borrowers.[10]

Mortgage lenders fund loans with a combination of equity and debt. The interest a lender pays on such funding debt, the *funding rate*, is q. Here,

$$0 < r < q < s < r + \lambda.$$

These inequalities ensure that there is a funding rate premium over the discount rate, and a mortgage rate premium over the funding rate. Also, the condition $s < r + \lambda$ ensures that our focus is on the economically interesting case for which it is not profitable for a lender to lend to a borrower that is surely of the vulnerable type. Debt is also structured as a perpetuity, possibly because of maturity matching. To keep things simple, we assume that each lender handles exactly one potential borrower.

We interpret the shock as a default event. In the supplementary material, we extend the model to also include prepayment risk. In the extension, higher prepayment risk leads to a lower expected future surplus generated by the spread between the lending rate and the funding rate, although the cost associated with prepayment is less severe than under default since the capital is recovered when there is prepayment whereas it is not under default.

A lender that uses equity capital e to fund a mortgage needs debt funding of $d = 1 - e$. The lender's *capital ratio* is then e. The choice of e may be restricted because of regulation, i.e., subject to the constraint $e \geq \underline{e} \geq 0$. A lender's surplus, $s - qd$, is instantaneously paid

[9] Note that for a resilient agent, the total surplus value generated by extending a loan is $\frac{s}{r} - 1$. This is therefore an upper bound on the total surplus value of extending a loan to an agent who may be vulnerable. For parsimony, we treat s as an exogenous parameter, and we assume that it is independent of agent score. The difference between s and r could for example arise because of operational fixed costs that a lender needs to cover via marginal profits on individual loans. It could also arise through barriers to entry that make the industry less than perfectly competitive. This approach is thus inherently partial equilibrium with respect to discount rates. We view the endogenization of s as an interesting future extension.

[10] We can think of this as the limit of a discrete-time model with time interval Δt that tends to zero, where in each period a shock hits with probability $\lambda \Delta t$, and payments occur at the end of the period if default has not yet occurred.

out as a dividend to equity holders, and thus the equity ratio remains constant over time, as long as there is no shock. If a shock hits a vulnerable borrower and the corresponding bank has chosen $e < 1$, it defaults.

A mortgage may be securitized T periods after issuance, as long as it has not defaulted at that point. For simplicity, we assume that securitized mortgages are fully insured by a GSE. They are therefore worth $P = \frac{s}{r}$ in the competitive market.

After a mortgage has been securitized, the lender repays its debt, and distributes the surplus to equity holders. Since P is the value of the mortgage if the borrower is known to be resilient, it is always optimal for the lender to securitize the loan at T.[11]

Absent soft information, the value for a lender of issuing a mortgage to an agent with score p, using equity capital e, is then

$$V = \left(pe^{-rT} + (1-p)e^{-(r+\lambda)t}\right)\left(\frac{s}{r} - d\right) + \left(p\frac{1-e^{-rT}}{r} + (1-p)\frac{1-e^{-(r+\lambda)T}}{r+\lambda}\right)(s - dq) - e. \quad 1.$$

This is the *loan value function*. The first term in this expression represents the present value of future securitization, the second term represents the present value of cash flows before securitization, and the third term represents the initially invested capital.

4.3. Banks

A traditional bank faces a relatively long period T before securitization may occur. For simplicity we use the approximation $T = \infty$.[12,13] The loan value function for a bank therefore reduces to

$$V = \frac{r + p\lambda}{r(r+\lambda)}(s - q(1-e)) - e. \quad 2.$$

A lending bank chooses the capital ratio e that maximizes V. Two factors influence this choice. First, a higher capital ratio increases the surplus dividends, since $s > q$, providing

[11] This can be seen via the following argument: The time T cash flow associated with immediately securitizing is $V_T = \frac{s}{r} - d$, where the debt level satisfies $0 \le d \le 1$. If, instead, the lender waits until $T' > T$, the discounted value of future cash flows is $V_{T'} = \int_T^{T'} e^{-r(t-T)}\left(p + (1-p)e^{-\lambda(t-T)}\right)(s - qd)dt + e^{-r(T'-T)}\left(p + (1-p)e^{-\lambda(T'-T)}\right)\left(\frac{s}{r} - d\right)$, which represents the discounted expected cash flows associated with waiting. One verifies from this expression that the two conditions $\frac{s}{r} > d\frac{\lambda+r-q}{\lambda}$, and $\frac{s}{r} - d \ge \frac{s}{r} - \frac{q}{r}d$, are jointly sufficient for $V_T > V_{T'}$. Now, $\frac{s}{r} > 1 \ge d = d\frac{\lambda}{\lambda} \ge d\frac{\lambda+r-q}{\lambda}$, where the rightmost inequality follows from $q \ge r$, so the first condition holds. Moreover, $q \ge r$ also implies that the second condition holds. Thus, $V_T > V_{T'}$, and it is always optimal for the lender to securitize as quickly as possible.

[12] The approximation captures the general idea that a traditional bank is exposed to mortgage risk for an extensive time period after origination, potentially via so-called putback options after the loan has been sold, as discussed in Kim et al. (2018). Loans in default can be put back to non-bank lenders as well, but in the aftermath of the global financial crisis this remedy was not effective because many non-banks went out of business.

[13] Even after the loans have been securitized, banks — but not non-banks — often buy (or swap) them back in securitized form, which is economically very close to holding on to them, again supporting the idea that T is larger for banks than for non-banks. Of course, in the model, banks would not want to continue holding on to the loans in this way, since $q > r$, but in reality regulatory-capital rules provide an incentive for this behavior.

an incentive for the bank to choose a high e. Second, a lower capital ratio decreases the loss to equity holders in case of borrower default, providing an incentive to choose a low e. The latter incentive is more important when p is low. The former incentive is more important when p is high (since the expected length of dividend payments is increasing in p).

The following result characterizes a bank's joint optimal choice of whether to lend and the capital ratio conditional on lending:

Proposition 2 *Define* $p_1^* \stackrel{\text{def}}{=} \frac{r(r+\lambda-s)}{s\lambda}$ *and* $p_2^* \stackrel{\text{def}}{=} \frac{r(r+\lambda-q)}{q\lambda}$, *and note that* $0 < p_1^* < p_2^* < 1$. *The bank optimally chooses lending and capital ratios as follows:*

(i) When $p > p_1^*$, *the bank lends regardless of* e, *whereas if* $p \leq p_1^*$ *it only lends if it can choose*

$$e \leq e^* \stackrel{\text{def}}{=} \frac{(s-q)(r+p\lambda)}{r(r+\lambda-q)-pq\lambda}.$$

(ii) If $p > p_2^*$, *the bank chooses* e *as high as possible, i.e.,* $e = 1$, *leading to value*

$$V = \frac{r+p\lambda}{r(r+\lambda)}s - 1.$$

(iii) If $p < p_2^*$ *a lending bank will choose* e *as low as possible,* $e = \underline{e}$.

Note that the function $e^*(p)$ defined in (i) of Proposition 2 is increasing in p, and that $e^*(0) = \frac{s-q}{r+\lambda-q}$.

A regulator who does not want mortgages extended to agents who are known to be vulnerable (i.e., those with score $p = 0$), in line with the social planner's views discussed earlier, will set the regulated minimum capital ratio above $\frac{s-q}{r+\lambda-q}$. We therefore henceforth assume

$$\underline{e} > \frac{s-q}{r+\lambda-q}.$$

We incorporate the bank's option to obtain soft information about an agent into the decision problem. Recall that the bank has the option to pay C to resolve uncertainty about the resilience of an agent, and will then lend only if the agent is resilient. The expected net payoff when soft information is obtained is then:

$$V^C = p\left(\frac{s}{r} - 1\right) - C. \tag{3.}$$

The bank compares the loan value function V with V^C, leading to the following optimal behavior:

Proposition 3 *Define the threshold cost*

$$C^* \stackrel{\text{def}}{=} \frac{(q-r)(r+\lambda-s)}{q\lambda},$$

and the threshold minimal capital ratio

$$\underline{e}^* = \frac{(s-q)(s-r+\lambda C)}{(s-r)(r+\lambda)-q(s-r+\lambda C)}.$$

The bank proceeds as follows:

(i) If $C > C^*$, *the bank does not obtains soft information regardless of* p, *and lends to an agent with* $p \geq p_1^*$, *in accordance with Proposition 2.*

(ii) If $C < C^*$, and $\underline{e} > \underline{e}^*$, the bank:

- *neither obtains information about nor lends to an agent with score $p < C\frac{r}{s-r}$,*
- *obtains information about an agent with score*

$$p \in \left(C\frac{r}{s-r}, 1 - C\frac{r+\lambda}{r+\lambda-s} \right),$$

  and lends only if the agent is resilient.

- *lends to, but does not obtain information about an agent with score $p > 1 - C\frac{r+\lambda}{r+\lambda-s}$.*

(iii) If $C < C^*$, and $\underline{e} < \underline{e}^*$, the bank:

- *does not obtain information about and does not lend to an agent with*

$$p < \frac{\underline{e}r(r+\lambda-q) - r(s-q)}{(s-q(1-e))\lambda},$$

- *does not obtain information about an agent with score*

$$p \in \left(\frac{\underline{e}r(r+\lambda-q) - r(s-q)}{(s-q(1-e))\lambda}, \frac{r(\underline{e}(\lambda+r-q) - (s-q) - C(r+\lambda))}{r(r+\lambda-s) - q(1-e)\lambda} \right),$$

  lends to the agent, and minimizes capital $e = \underline{e}$.

- *obtains information about an agent with score*

$$p \in \left(\frac{r(\underline{e}(\lambda+r-q) - (s-q) - C(r+\lambda))}{r(r+\lambda-s) - q(1-e)\lambda}, 1 - C\frac{r+\lambda}{r+\lambda-s} \right),$$

  and lends only if the agent is resilient,

- *lends to, but does not obtain information about an agent with score $p > 1 - C\frac{r+\lambda}{r+\lambda-s}$.*

The proposition shows that when costs of obtaining information are not too high, $C < C^*$, the regulator can make traditional banks lend to agents with lower scores, by lowering the required capital ratio. However, this will not induce banks to obtain soft information about the additional agents with low scores who receive loans. Instead, the bank lends to all such agents, without obtaining soft information, and choose minimal capital ratios, anticipating default if a vulnerable agent is hit by a shock. Note that the score threshold above which a bank does not obtain soft information and lends to all agents is unaffected by any change in $\underline{e}$. The only way for a regulator to impact the upper threshold is by affecting the cost of obtaining information, C, the mortgage rate, s, the discount rate, r, or the shock rate, λ. More details of the bank's behavior appear as Section A in the Supplemental Material.

4.4. Non-banks

Non-banks differ from banks in two dimensions. First, they are less regulated and as a consequence face lower minimal capital ratios, $\underline{e}^{NB} < \underline{e}$. Second, they have access to a technology that allows them to sell a mortgage faster than a bank. Specifically, it takes a

non-bank the time $S < T$ to sell a mortgage.[14] To simplify the analysis we focus on the case where S is small. In this case, we can use the approximations $e^{-\lambda S} \approx 1-\lambda S$, $e^{-rS} \approx 1-rS$, which leads to the following approximate loan value function for a non-bank:

$$V^{NB} = \left(\frac{s}{r} - 1\right) - \lambda(1-p)\frac{s}{r}S + (e-1)(q-r-\lambda(1-p))S.$$

It follows that when S is small, it is never worthwhile for a non-bank to obtain soft information, since the non-bank faces a much lower risk of being affected by mortgage default for any given loan.

The sign of the coefficient $q - r - \lambda(1-p)$ multiplying eS in the non-bank's loan value function determines its optimal capital ratio. A non-bank therefore chooses the minimum possible capital ratio, $e = 1$, if and only if $p > p_3^* = \frac{r+\lambda-q}{\lambda}$. Otherwise, it chooses $e = \underline{e}^{NB}$. We summarize these results in the following

Proposition 4 *A non-bank lends to all agents, never obtains soft information, and chooses the following capital ratio $e = \underline{e}^{NB}$ if $p \leq p_3^*$, and $e = 1$ otherwise.*

Note that $p_3^* = \frac{r}{q}p_2^* < p_2^*$, so the non-bank always chooses a higher score threshold than the bank, above which it is fully capitalized. It is also less discriminatory below the threshold in its lending. Altogether, the risk that it defaults when a shock arrives is therefore higher than for a bank. Banks and non-banks will choose the similar (high) capital ratios when lending to prime borrowers. If $\underline{e} \approx \underline{e}^{NB}$, then they also choose similar (low) capitals ratios for when lending to agents with low scores. For agents with intermediate scores, non-banks may choose to be less capitalized than banks, and lend more aggressively since they do not screen these agents.

In Section B of the Supplemental Material, we introduce heterogeneous prepayment risk across agents, and show that non-banks still lend to all agents since they can securitize the mortgage before prepayment occurs. Banks, on the other hand, become more conservative in lending, when facing agents with high prepayment risk, since prepayment decreases the expected surplus from future cash flows and securitization. As a consequence, loans originated by non-banks have higher average prepayment rates than loans originated by banks.[15]

As noted in our previous discussion about the banks, when the planner provides incentives for a traditional bank to lend to low-score segments of the population, it has the unwanted side-effect of making the bank less prone to obtain soft information about such agents, some of whom were previously screened. An alternative may be for the planner to keep the minimal capital ratio high for traditional banks, and set a lower rate for non-banks. With this approach, banks continue to optimally screen the low-score segments they lend to, and the non-banks serve the lowest segment, without screening.

[14] In line with our previous discussion about putback options, the difference between S and T also captures differences in exposure to such options between non-banks and banks. Indeed, qualitatively similar results to those we derive will arise when these differences in exposure are the main reason why $S < T$.

[15] Note that this result is not about whether and how banks and non-banks participate in the market for refinancing. Rather, the result covers the differentiated response to *future* prepayment risk of a potential borrower (whether that borrower is refinancing or not).

4.5. Implications of framework

We summarize the different implications for bank and non-banks:

1. Bank-originated mortgages default less often than non-bank mortgages, especially in times of financial distress.
2. The prepayment rate of bank-originated mortgages is lower than that of non-bank mortgages.
3. Banks are less likely to go out of business than non-banks.
4. Banks' loan origination processes are more costly, and especially more labor intense, than non-banks'.
5. Banks and non-banks may choose similar levels of capitalization when serving low- and high-score borrowers, but non-banks choose lower capital ratios when serving intermediate-score borrowers, and also lend more aggressively to these than banks.
6. The amount a bank invests in screening may be nonmonotone in borrower score, p.

5. MORTGAGE PERFORMANCE: BANKS VS. NON-BANKS

In this section, we test the model's prediction that loans originated by non-banks will prepay more quickly than those originated by banks.

5.1. Data

To analyze loan performance, we use linked loan-level data from several providers. Our description here borrows heavily from Bartlett et al. (2022), which uses the same data to study lending discrimination and which should be consulted for additional details. The specific data providers used are

- HMDA data include information on applicant income, race, ethnicity, loan amount, and lender name, as well as the census tract of the property.
- ATTOM data provide transaction and assessor information, including lien-holder name, loan-performance data (i.e., prepayment and default), borrower and lender names and exact property location, but very little information on mortgage contract terms other than the loan amount, the origination date, the purpose of the loan, and whether it is a fixed or floating contract.
- McDash data provide loan-level data compiled by Black Knight Financial Services and include detailed mortgage terms (including interest rates, loan amount, loan-to-value ratio, and zip code of the mortgaged property) and month-by-month mortgage performance information.

We exploit overlapping variables within HMDA, ATTOM, and the McDash data sets to construct a merged data set of candidate loans with performance information, contract terms, the mortgage lender type (banks versus non-banks), and borrower information. To standardize our loan-pricing analysis, we focus on candidate loans in each data set that are first-lien, fixed-rate, owner-occupied 30-year single-family residential loans, securitized by the GSEs or insured or guaranteed by the FHA and VA over the period 2005–2015. We exclude manufactured housing, investment properties, condos, duplexes, triplexes, quadraplexes, and loans with outstanding second liens at origination. We also impose minimum and maximum loan-to-value ratios and minimal credit scores, among other filters discussed in

more detail in the Internet Appendix to Bartlett et al. (2022). Our overall merge rate for candidate loans is 73.99% and the final filtered data set includes loans from all states.

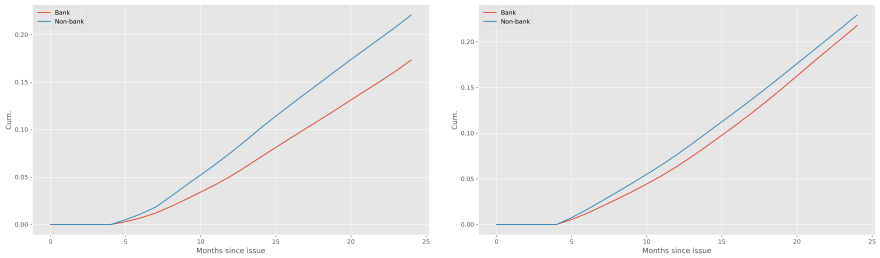
5.2. Performance comparison

One of the main implications of Section 4 is that bank-originated mortgages should default less and prepay more slowly than non-bank mortgages (see Implications 1 and 2). This implication is supported by existing studies. Using HMDA data merged with performance data from Fannie Mae and Freddie Mac for loans issued between 2010 and 2013, Buchak et al. (2018) find that loans originated by non-banks are more likely to be at least 60 days delinquent within two years of issue than loans originated by banks. The result is mostly driven by non-banks that don't employ fintech, as loans from fintech non-banks behave similarly to those from banks. However, the differences are small in magnitude, and Buchak et al. (2018) note that because default risk is insured by the GSEs while prepayment risk is not, prepayment risk is more important to originators than default in this market. They find much larger differences in prepayment behavior, with loans from non-banks in general between 16% and 22% more likely to prepay within 2 years than comparable loans from traditional banks. Fintech non-banks exhibit even higher differences.

Using Equifax's CRISM data, which merges McDash mortgage servicing records with Equifax credit-bureau data, between 2010 and 2016, Fuster et al. (2019) try to determine "whether this fact reflects faster-prepaying borrowers selecting into mortgages from FinTech lenders, or whether FinTech lending directly affects the likelihood of refinancing, thereby potentially affecting aggregate refinancing behavior. If FinTech mortgage lending does affect the market-wide propensity to refinance, an important follow-up question is whether this is due to a reduction in errors of omission (meaning that more borrowers who should refinance do so), or instead reflects an increase in errors of commission (more borrowers refinance even when they should not)." They find that prepayment rates are higher in counties with a higher FinTech market share, suggesting that the higher prepayment rates are county-wide rather than being limited to just the individual borrower who selected FinTech lenders. Next, they use the "square root" optimal-refinancing rule from Agarwal et al. (2013) to split the sample into buckets by how much the prepayment option is "in the money," and find that the faster-refinancing effect is strongest when the refinancing option is at- or just in the money, and is actually *negative* when the refinancing incentive is negative. They conclude that "In sum, the results suggest that a higher share of FinTech lending is associated not just with faster refinancing, but also more optimal refinancing decisions, at least on average. This effect, however, appears somewhat weaker for the borrowers that would benefit most from refinancing."

We revisit these results using the mortgage-performance data described in Section 5.1 above. **Figure 1** shows cumulative mortgage prepayment within the first two years of loan issue, split by whether the issuer was a bank or a non-bank institution. Panels (a) and (b) split these results by loans funded in Ginnie Mae vs. GSE pools. It can clearly be seen that loans issued by non-banks are on average substantially more likely to prepay quickly than are loans issued by banks, especially for Ginnie Mae loans. It seems likely that this is related to the issue of VA "loan-churning" (see Goodman et al. 2019, Bright 2018), but it is important to note that we see prepayment differences for GSE as well as Ginnie Mae loans.

It is possible that the prepayment differences seen in **Figure 1** arise, for example, due



(a) **Ginnie Mae loans** (b) **GSE loans**

Figure 1: Cumulative prepayment in first 24 months after issue for loans issued by banks vs. non-banks.

to bank and non-bank loans being issued in different amounts, at different dates, or with different interest rates. To investigate this in more detail, **Table 1** regresses the prepayment indicator against a non-bank dummy and the loan interest rate, with fixed effects for year/month × GSE credit-score/LTV bucket[16] and for loan-amount decile. **Table S1** in the Supplemental Material runs the same regression for default. The regressions confirm what we saw in the figures. Non-bank-issued loans, both Ginnie Mae and GSE, are substantially more likely to prepay early than are bank-issued loans, with the difference being higher for Ginnie Mae loans. Ginnie Mae loans issued by non-banks are also more likely to default early, though there is no significant difference in behavior for GSE loans.

In addition, **Figure S3** in the Supplemental Material shows the difference between prepayment behavior split by year of issue, showing that the pattern seen in **Figure 1** is repeated for loans issued in every year from 2005 to 2015, with the possible exception of 2012. The fact that we see these differences for every individual issue year seems to argue against the conclusions of Fuster et al. (2019), at least early in a loan's life. In particular, for loans issued in 2005, mortgage rates rose significantly over the next two years, so the non-bank borrowers who prepaid at faster rates were not doing so for interest-rate reasons.[17]

6. NON-BANK LIQUIDITY AND CAPITAL

6.1. Mortgage call reports

It has historically been difficult to draw many firm conclusions about the financial position of non-bank lenders because most of them are privately held and so little data are available to researchers. However, under the Secure and Fair Enforcement for Mortgage Licensing (SAFE) Act of 2008, companies that hold a state license or state registration through the National MultiState Licensing System are required to file a Mortgage Call Report (MCR)

[16]The GSEs determine credit-risk pricing via a fee that depends only on where the borrower sits in an 8 × 8 matrix of LTVs and credit scores called Loan Level Price Adjustments (see Bartlett et al. 2022).

[17]Note that we would expect some prepayment even when rates rise. For example, FHA borrowers may be able to refinance at the generally lower rates available in the GSE market once they have accumulated some equity.

VARIABLES	Ginnie Mae loans (1) prepay24	GSE loans (2) prepay24
Non-bank	0.0161***	0.0104***
	(0.000442)	(0.000331)
Loan interest rate	15.49***	12.06***
	(0.0686)	(0.0502)
Observations	2,262,186	4,606,484
R-squared	0.125	0.105
FICO/LTV bucket × year/month FE	Y	Y
Amount decile FE	Y	Y

Table 1: **Prepayment.** The dependent variable equals 1 if the loan prepaid within 24 months of issue, and 0 otherwise. The independent variable `Non-bank` equals 1 if the lender is a non-bank institution, and 0 otherwise. Fixed effects are included for year/month × GSE-grid bucket and loan-amount decile. ***, **, and * indicate significance at the 1%, 5%, and 10% conventional levels.

with state regulators. The data include information on firms' balance sheets and on the mortgage applications that they receive. Fannie Mae or Freddie Mac seller/servicers and Ginnie Mae issuers are required to file quarterly. Other firms file balance-sheet information annually and mortgage-application information quarterly. We have obtained these data and use them here to study the business models and financial positions of non-bank mortgage lenders.

We are the first to use the full universe of these data, obtained under Section 1512 of the SAFE Act, which permits data collected under the Act to be shared with State and Federal regulatory officials with mortgage or financial services industry-oversight authority.[18] We extract the MCR records corresponding to the 100 largest for-profit issuers of Ginnie Mae securities collateralized by forward mortgages, excluding banks, non-banks that specialize in reverse mortgages, and entities chosen by their states to issue mortgage revenue bonds under the state's municipal bond allotment. These state-affiliated entities typically have a significant non-profit component to their work as well as access to the municipal bond market. We also exclude the captive finance arms of manufactured-home builders since those lenders have access to cash from their parents. We select the 100 largest remaining firms.

We focus on Ginnie Mae issuers because, as described earlier, these non-banks face and pose the most risk to the mortgage market. Specifically, these firms serve borrowers that are more likely to default and the Ginnie Mae servicing contract implicitly requires the issuers to share in this risk. However, these firms also have significant involvement in the Fannie

[18] A subset of the MCR data has been used previously in Jiang (2021) and Jiang et al. (2020); these authors obtained the data by filing Freedom of Information Act requests with state regulators. Our data are more recent and more complete, covering all states, the District of Columbia, and U.S. territories.

Mae and Freddie Mac markets. In total, firms in our sample held the mortgage-servicing rights on 75% of loans in Ginnie Mae pools and 39% of mortgages in Fannie Mae or Freddie Mac pools as of 2022:Q1. By way of comparison, non-banks as a whole held the MSRs on 82% of loans in Ginnie pools and 62% of loans in GSE pools in March 2022.[19]

We merge the MCR data for these firms with information on their servicing portfolios from eMBS. The eMBS data provide detailed information on the characteristics of the mortgages, including delinquency status. Our data run from 2015 to 2022:Q1.

6.2. Business models

Non-banks are more heterogeneous in their business models than has typically been recognized in the literature. This heterogeneity matters because different activities carry different risks. On the origination side, non-banks can originate mortgages directly through retail channels or indirectly through brokers; they can also purchase mortgages originated and underwritten by other firms through correspondent channels. The retail channel is considered the least risky channel because the non-bank has the most direct information on the quality of the loan.

On the servicing side, non-banks can choose to retain the servicing rights or sell them. If they retain the servicing rights, they book an MSR on their balance sheets. Holding the MSR means assuming the risks associated with its volatility, since its value can fluctuate dramatically with interest rates and mortgage delinquencies, and the responsibility of advancing payments on behalf of delinquent borrowers. The MSR holder also decides whether to hire a subservicer or to carry out itself the operational aspects of servicing, which involve operational and compliance risk.[20]

As examples of this wide range of business models, consider three of the largest publicly traded non-banks. At Rocket (formerly Quicken), about two-thirds of its originations come from retail channels, and Rocket services the loans that it originates. United Wholesale Mortgage originates mortgages exclusively through brokers and contracts out its servicing to subservicers. New Residential acquires more than half of its originations from correspondent channels. It purchases MSRs from other firms as an investment opportunity, and performs sub-servicing for more than 60 other entities through a subsidiary. Firms that purchase MSRs from other firms, like New Residential, are sometimes referred to as "MSR aggregators."[21]

On average, large Ginnie Mae issuers perform a wider variety of activities and handle more types of mortgages.[22] They are more likely to acquire loans through retail, correspondent, and broker channels; to service their own loans and to subservice for others; and to sell loans to the GSEs as well as issue securitizations guaranteed by Ginnie Mae. Small issuers are more likely to hold only retail loans and less likely to service their own loans or subservice loans for others. However, small issuers tend to have riskier portfolios on two

[19]Authors' calculation from data in Recursion, "Agency Mortgage Market Monthly Update," April 2022.

[20]Hiring a subservicer does not absolve the MSR holder of these risks because it is responsible for the actions of its counterparties.

[21]All information in this paragraph is drawn from the publicly available 2020 10-K filings of these firms.

[22]We assess issuer size by the unpaid principal balance of the loans for which the non-bank holds the servicing rights.

other dimensions: they are more likely to concentrate in loans funded by Ginnie Mae pools or in loans originated to borrowers with low credit scores. **Table S2** in the Supplemental Material breaks out these results.

As suggested by these results, the operational aspects of servicing are concentrated in a fairly small number of Ginnie Mae issuers. In total, only 38% of the issuers that hold the servicing rights on loans carry out the operational aspects of the servicing. On a mortgage-weighted basis, 62% of the mortgages in our sample are serviced by the firm that holds the servicing rights.

6.3. Balance sheets

The balance sheet of a typical Ginnie Mae non-bank issuer consists almost entirely of cash and mortgage-related assets: mortgages held for sale, mortgages eligible for repurchase, and MSRs (**Figure 2**). Of the mortgage-related assets, only MSRs are potentially available for use to meet any unexpected obligations. "Mortgages held for sale" are the loans that are funded on warehouse lines of credit before securitization. These mortgages collateralize the lines and are not available for any other use. "Mortgages eligible for repurchase" is an accounting concept pertaining to loans in Ginnie Mae pools that are 90 or more days delinquent. Since the servicer has the unilateral right to repurchase these loans out of the pool, for accounting purposes the servicer has to recognize these loans on the balance sheet. These assets also cannot be monetized for other purposes.[23]

MSRs are a low-quality asset. Their valuations can move dramatically with interest rates and mortgage delinquencies, and they can become illiquid in times of stress (see Kim et al. 2018, Hubbard et al. 2021, Board of Governors of the Federal Reserve System et al. 2016). When MSR valuations decrease because of a rise in mortgage delinquencies, the rest of the non-bank's balance sheet will likely be stressed as well: mortgages held for sale will fall in value, and the non-bank's cash will come under pressure from a drop in origination revenue and an increase in servicing costs. MSR valuations can also be hard to determine: since they trade infrequently, their valuations are determined using models and subjective assumptions.

As of 2022:Q1, the median ratio of cash to assets for the issuers in our sample was 7%, the median ratio of MSRs to assets was 20%, and the median ratio of mortgages held for sale to assets was 53%.[24] **Table S3** in the Supplemental Material shows these ratios for different sizes of non-banks. However, these asset shares can shift substantially with macroeconomic conditions. When mortgage rates fell at the start of the Covid-19 pandemic, loans held for sale rose along with the surge in mortgage refinancing (**Figure 2**). MSR valuations dropped, both because the expected servicing income associated with existing loans fell when those loans became more likely to prepay and because servicers anticipated that the pandemic would lead to a rise in delinquencies. Meanwhile, as borrowers took advantage of forbearance programs, loans eligible for repurchase rose. When mortgage rates rose sharply in 2022:Q1, these trends reversed. MSRs surged as a share of assets and loans held for sale dropped.

The liability side of the non-bank balance sheet is almost entirely short-term debt, with

[23] Loans eligible for repurchase are not explicitly identified in the Mortgage Call Report data. Our comparisons of the "other assets" field in the MCR data with selected companies' 10K filings suggests that "other assets" is a close proxy for loans eligible for repurchase.

[24] "Cash" includes cash equivalents such as commercial paper.

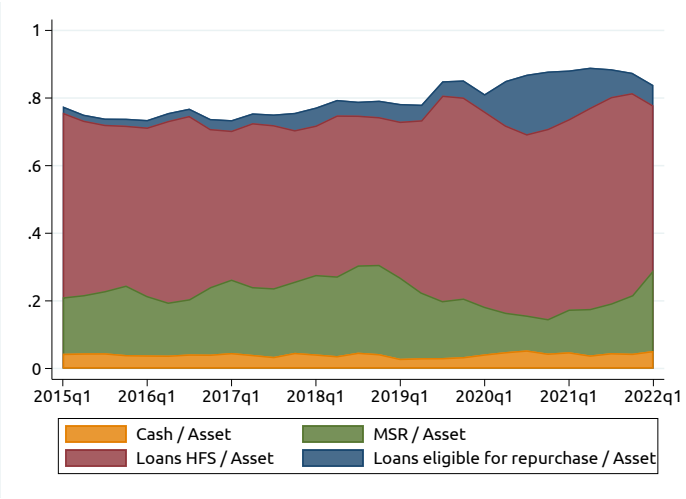


Figure 2: **Non-bank asset composition**. "MSR" = mortgage servicing right; "Loans HFS" = Loans held for sale. Source: Staff calculations based on data from the Conference of State Bank Supervisors, Nationwide MultiState Licensing System & Registry.

the median ratio of short term to total liabilities in our sample being 94%. This finding underscores the susceptibility of these firms to run risk. Some issuers have some long-term funding, presumably from facilities collateralized by MSRs: the 10th percentile of the ratio of short term to total liabilities is 63% (**Table S3** in the Supplemental Material). Firms obtain credit from many lenders: the median number of lenders is 6 across all issuers, and is 5 for smaller issuers and 13 for larger issuers. A larger number of lenders increases the diversification of funding sources, but also heightens run risk, since it only takes one panicky lender to start a run.

6.4. Liquidity and capital

Non-banks need liquidity and capital to originate loans, advance payments on behalf of defaulted borrowers, and absorb credit losses. Ample capital may also signal that a non-bank has an ongoing commitment to the mortgage business, and is able and willing to invest in, and exercise care with, origination and servicing.[25]

Determining whether non-banks have enough capital and liquidity is difficult because there is no agreed-upon framework for answering this question. The metrics used for banks are unlikely to be appropriate for non-banks. Unlike banks, non-banks do not have access to liquidity from the Federal Reserve System or the Federal Home Loan Banks, and as mono-lines, non-banks are more susceptible than banks to certain macroeconomic shocks. On the other hand, unlike banks, non-banks do not have a claim on government-provided deposit insurance. Banks may need stronger regulation because the presence of the insurance may cause private market participants to monitor bank risk taking less carefully.

[25]Securitization issuers provide "representations and warranties" regarding the quality of their originations. These have value only if the issuer is financially viable, so the firm's balance sheet is important for performance.

We gauge liquidity by assessing an issuer's cash relative to its quarterly expenses. The issuer at the median of the distribution in 2022:Q1 had enough cash to cover one quarter's worth of expenses (**Table S4**). However, some issuers, as indicated by the 10th percentile numbers, only had enough cash to cover a month or so of expenses. Larger issuers held more cash: the median cash relative to expenses weighted by servicing UPB was more than 4 months.

Before the pandemic, though, as shown in **Figure 3**, issuers had substantially less cash relative to their expenses, with the median cash at approximately half a quarter's expenses from 2015 to 2019. The increase in cash during the pandemic was widespread across issuers, as indicated by the increases at the 25th and 75th percentiles, and likely stems from the high gain-on-sale profits that originators made from mortgage refinancings during the pandemic (Fuster et al. 2021).

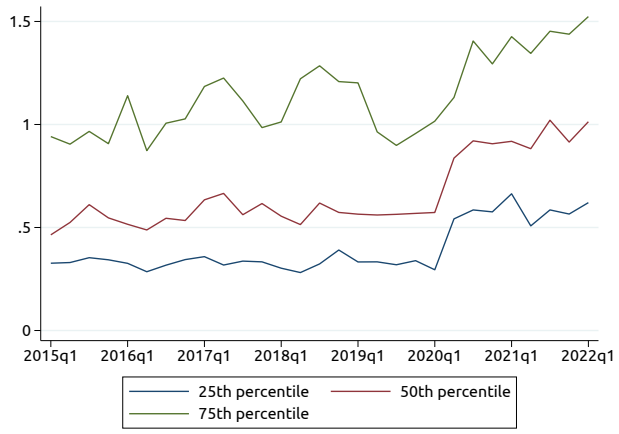


Figure 3: **Percentiles of cash relative to quarterly expenses**. Source: Authors' calculations based on data from the Conference of State Bank Supervisors, Nationwide MultiState Licensing System & Registry.

We assess non-bank capital relative to three benchmarks: the Ginnie Mae leverage ratio in effect as of June 2022; a risk-based capital ratio proposed by Ginnie Mae in July 2021; and the bank Tier 1 capital ratio in effect as of June 2022. Although the bank standards are unlikely to be the right ones for non-banks, they provide a way to compare the capital positions of banks and non-banks.[26]

The three capital measures gauge the non-bank's equity relative to its assets. The substantive difference across the measures is how much credit they give non-banks for their MSR holdings. In Ginnie Mae's existing leverage ratio, equity must be 6 percent or more of total assets. MSRs are treated equivalently to other assets in this calculation. In the bank and the proposed Ginnie Mae risk-based capital measures, MSR holdings are penalized in the calculation of both equity and assets. MSRs above a certain threshold must

[26]The Ginnie Mae leverage ratio requirement can be found in Ginnie Mae (2022) Chapter 3. The proposed standards can be found in Ginnie Mae (2021). The bank standards can be found in the Federal Reserve Board's Regulation Q, 12 C.F.R. pt. 217.

be subtracted from equity; the threshold is lower (and thus more punitive) for the bank measure than the Ginnie Mae measure. Meanwhile, assets are risk-weighted and MSRs have a high weight. Ginnie Mae's proposal would require a non-bank to maintain a risk-weighted capital ratio greater than 10%, whereas a bank must have a Tier 1 risk based capital ratio greater than 8% to be considered well capitalized. The measures are described in detail in **Table S5** in the Supplemental Material. As also described in the Supplemental Material, our measures are approximations of the actual concepts because of data limitations.

We find that the typical Ginnie Mae issuer is reasonably well capitalized. **Figure 4** shows that the median of all three capital ratios remained well above the relevant regulatory thresholds throughout the time period. The medians rose significantly after the onset of the pandemic, presumably because of the cash generated by the heightened mortgage refinancing. In aggregate, we also find, as did Jiang et al. (2020), that the Ginnie Mae issuers in our sample have about the same capital as banks that concentrate in mortgage lending. As of 2022:Q1, the aggregate risk-based Tier 1 capital ratio was 24.7 for banks that concentrate in mortgages and 25.2 for our Ginnie Mae issuers as a whole.[27]

However, this finding in the aggregate masks variation across issuers and time. As we show next, issuers' capital positions look less favorable when evaluated on a risk-weighted basis. They also look less favorable at times when mortgage rates are relatively high and mortgage refinancing activity is muted. At these times, as shown earlier in **Figure 2**, MSRs are a higher share of assets.

Almost all issuers look to be in good condition when gauged by Ginnie Mae's current leverage ratio. **Figure 5a** shows the number of issuers in each quarter with inadequate capital under each of our measures, and **Figure 5b** shows the unpaid principal balance (UPB) of the mortgages on which these issuers hold the servicing rights. Almost no issuers fell below Ginnie Mae's minimum leverage ratio throughout the 2015-2022:Q1 period. In 2022:Q1, the tenth percentile of the leverage ratio was around 16% (**Table S4**), compared with the required minimum of 6%, and only two firms had a value below the threshold.

Ginnie Mae issuers look less consistently well capitalized when risk-weighted measures are applied, and particularly in 2018 and 2019. In 2018:Q4, 14% of issuers had risk-weighted capital ratios below the proposed Ginnie Mae threshold of 10% and 24% had risk-weighted capital ratios below the bank Tier 1 threshold of 8%. These issuers held the servicing rights on fairly large mortgage portfolios. In 2018:Q4, the mortgage servicing rights on 25% of mortgages in Ginnie Mae pools were held by issuers with risk-weighted capital ratios below the Ginnie Mae threshold, and 41% were held by issuers with risk-weighted capital ratios below the bank threshold.

In 2022:Q1, when refinancing ebbed and MSR valuations rose, the risk-weighted capital position of Ginnie Mae issuers eroded relative to 2020 and 2021. The tenth percentile of the Ginnie Mae proposed risk-based capital ratio was 16% weighted equally across firms and 3% weighted by UPB (**Table S4**), and seven firms had values below the threshold. These firms held the servicing rights on 21% of loans in Ginnie Mae pools. The tenth percentile using the bank Tier 1 ratio was 4% in 2022:Q1, weighted equally across firms, and zero when weighted by UPB. Fourteen firms, representing about 30% of UPB of mortgages held in Ginnie Mae pools, would fail this standard in 2022:Q1. In contrast, small firms generally appeared well capitalized, with a tenth percentile for the bank Tier 1 measure of 16%, presumably because they are less involved in mortgage servicing and thus hold fewer

[27]The capital ratio for banks is from Table IV-A of Federal Deposit Insurance Corporation (2022).

MSRs.

Our finding that some Ginnie Mae issuers are less well capitalized than banks, as gauged by the non-trivial share that do not meet the Tier 1 capital ratio in some time periods, is consistent with the prediction of our model that non-banks choose lower capital ratios when their portfolios consist of intermediate-score borrowers, and that the probability of failure is higher for non-banks than banks. Our findings are also consistent with Jiang et al. (2020), who find that non-bank leverage is considerably more dispersed than that of banks.

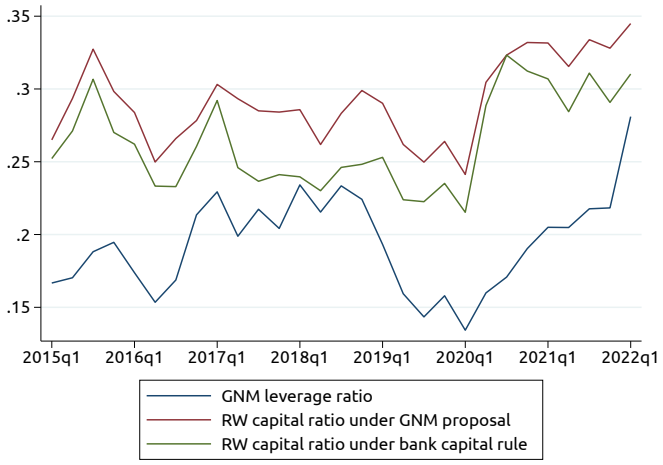
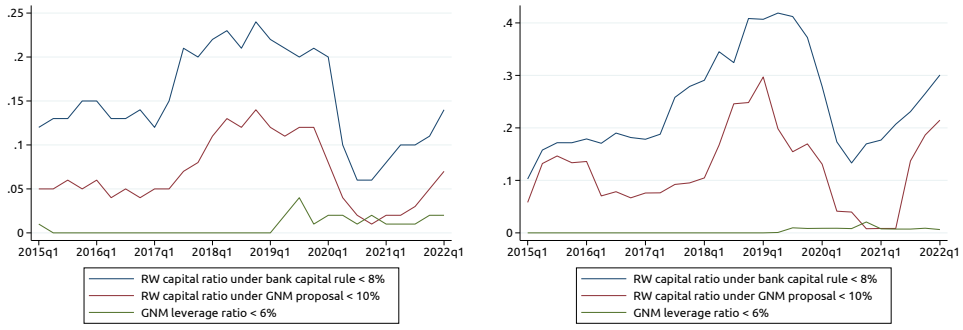


Figure 4: **Median capital ratio under different rules**. Source: Authors' calculations based on data from the Conference of State Bank Supervisors, Nationwide MultiState Licensing System & Registry.



(a) Equal weighted (b) Weighted by Ginnie Mae servicing UPB

Figure 5: **Share of non-banks with binding capital rules**. Source: Authors' calculations based on data from the Conference of State Bank Supervisors, Nationwide MultiState Licensing System & Registry.

In **Table S6** in the Supplemental Material, we look at the characteristics of issuers with risk-weighted capital in 2018:Q4 below the proposed Ginnie Mae threshold. As suggested by the earlier results, they tended to be larger issuers with high MSR holdings and a business model that emphasized purchasing MSRs from other firms. On average, below-threshold issuers held the servicing rights on a portfolio with a UPB of $79 billion, compared with $16 billion for above-threshold issuers. Below-threshold issuers had an average MSR-to-assets ratio of 49%, compared with 15% for above-threshold issuers. On average, below-threshold issuers purchased MSRs in 2017 and 2018 totaling 25% of their 2016:Q4 assets, compared with 4% for above-threshold issuers. Below-threshold issuers also held less cash than above-threshold issuers: the average cash-to-asset ratio for these issuers was 5%, compared with 7% for above-threshold issuers.

The below-threshold issuers also played an important role in the operational aspects of servicing. Around 55% of below-threshold issuers serviced their own loans and 43% subserviced for others, while only 28% percent of above-threshold issuers serviced their own loans and 15% subserviced for others. In total, the 14 below-threshold issuers handled the subservicing operations for more than $500 billion in mortgages, while the other 86 issuers handled the subservicing operations on about $150 billion in mortgages.

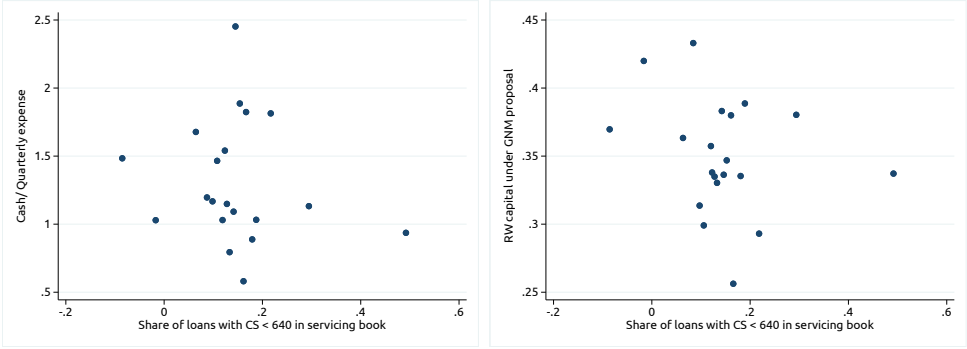
Finally, we explore whether firms that face more potential strains on their capital and liquidity are provisioning accordingly. We measure potential strain with the share of a firm's total servicing portfolio that is mortgages with credit scores at origination below 640. These loans are more likely to default, and so non-banks have the liquidity exposure of funding servicing advances and the capital exposure of absorbing losses not covered by the FHA and VA insurance.

As shown in **Figure 6**, there is no apparent relationship between the concentration of a non-bank's portfolio in low-credit score loans and its liquidity or capital. Perhaps this relationship is not surprising, as Ginnie Mae does not require its servicers to hold more liquidity and capital for lower-score loans even though its servicing contract implies that these loans pose more costs. The industry convention apparently is not to hold more liquidity or capital either.

7. SUMMARY POINTS AND FUTURE ISSUES

SUMMARY POINTS

1. **Non-bank lenders have become dominant in the mortgage market.** They originated about 60% of mortgages in 2020, and about 90% of the mortgages funded by Ginnie Mae securitizations; these mortgages tend to be originated to borrowers with lower credit scores.
2. **Much of the existing securitization literature is more relevant to bank than to non-bank lenders.** We build a simple theoretical model of bank versus non-bank mortgage lending, which predicts that mortgages originated by non-bank lenders are more likely to prepay and default, and that non-bank lenders themselves are more likely to go out of business than bank lenders.
3. **We find significant differences in prepayment behavior between bank and non-bank loans.** Using merged data from HMDA, ATTOM and McDash, we find



(a) Cash/ quarterly expense (b) RW capital ratio under GNM proposal

Figure 6: **Liquidity and capital by share of servicing portfolio with low credit scores**. Source: Authors' calculations based on data from the Conference of State Bank Supervisors, Nationwide MultiState Licensing System & Registry and eMBS, Inc. Data are for 2022:Q1.

that non-bank loans are more likely to prepay early than bank loans, and this is not just non-bank borrowers prepaying more rationally.

4. **Non-bank assets are concentrated in mortgage-related holdings that are likely to all perform poorly if mortgage defaults rise.** The main unencumbered asset of non-banks, mortgage servicing rights, can be particularly illiquid in times of stress.
5. **On average, non-bank Ginnie Mae issuers had stronger liquidity and capital positions in 2022:Q1 than pre-pandemic**, thanks largely to elevated profits from mortgage refinancing.
6. **Some issuers that play an outsized role in mortgage servicing have low capital when measured on a risk-weighted basis.** These capital positions call into question their ability to absorb the servicing losses that they are responsible for under the Ginnie Mae contract when defaults rise.

FUTURE ISSUES

1. **Obtaining data is very difficult.** Most loan and lender-level mortgage data are proprietary and subject to significant limitations on access and completeness. These data limitations apply especially for non-publicly traded non-bank lenders, for whom balance-sheet data can only be accessed under Section 1512 of the SAFE Act or via FOIA requests to a subset of cooperating state regulators (see Jiang 2021). Even these balance-sheet data have very little information on the basic terms of the debt facilities extended to non-banks, let alone information on the assets that collateralize the facilities or the covenants that determine the conditions under which the facilities can be canceled.

2. **The relationship between mortgage servicing rights and household access to mortgage credit is not well understood**. Securitization separates a loan from the right to service it, and in the process creates an asset—mortgage servicing rights—that is an appealing investment opportunity to some market participants such as REITs, in part because its valuation rises with interest rates. Other market participants purchase MSRs in order to gain information about which borrowers can be profitably refinanced. Very little is known in the academic literature about how changes in the valuation and liquidity of these assets affect household access to mortgage credit.
3. **The appropriate capital framework for non-bank servicers is unclear.** Mortgage servicing rights are a lower-quality asset than cash, yet the existing non-bank regulatory infrastructure treats the two assets equivalently for capital purposes. Accounting for the quality of capital, such as with appropriate risk weights, would provide a better gauge of the firms' resources under strain, which is crucial given the systemic importance of these firms in the operational aspects of servicing. Requiring these firms to hold more capital might also affect MSR liquidity, MSR pricing, and access to credit, so regulators would need to calibrate carefully to balance these objectives.
4. **There is a disconnect between the Ginnie Mae servicing contract—which imposes greater risk and cost on issuers with larger portfolios of low-credit quality loans—and the Ginnie Mae capital requirements—which do not require these firms to hold more capital.** The creditors of non-banks may put capital restrictions on non-banks that vary with the portfolio credit quality, but as noted above the covenants on these facilities are not observed by researchers or even many regulators. However, we see no evidence in the data that issuers with more exposure to low-credit quality loans are holding more liquidity or capital.
5. **How to carry out more effective regulatory oversight of mortgage non-banks remains an open question.** The turbulence in the mortgage-funding markets in March 2020 has re-ignited discussion about the need for regulatory oversight of non-bank mortgage lenders and the risks to financial stability arising from macroeconomic shocks to their short-term funding model. Yet there is no agreement about what the appropriate regulatory framework for nonbanks should look like, or how, for example, to carry out meaningful stress tests.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

We are grateful for financial support from the Fisher Center for Real Estate and Urban Economics at the Haas School of Business.

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