Qualified residential mortgages and default risk☆

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ABSTRACT

The Dodd–Frank Act tasks regulators with defining a Qualified Residential Mortgage (QRM) as an exemption from risk retention for residential mortgage-backed securities. Congress instructs regulators to consider factors that result in lower levels of historic default in defining a QRM. We analyze non-agency loans and find credit scores and loan-to-value ratios are among the most significant predictors of default, even when controlling for risky loan products and loose underwriting standards. Importantly, credit scores and loan-to-value ratios better tradeoff the benefit of reduced default risk with the cost of limiting access to capital than most factors, yet are absent from the final QRM definition. Our results have important implications for current and future policy on residential mortgage securitization, risk retention, and disclosure.

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1. Introduction

"When every mortgage is labeled as 'qualified,' investors should assume none really will be." —SEC Commissioner Daniel M. Gallagher[1]

During the 2000s, non-agency securitizations changed the mortgage landscape through non-traditional loan products and underwriting practices (Keys et al., 2013). Securitization diverges from the traditional lending model where the same agent originates and services the loan (Demiroglu and James, 2012). The resulting moral hazard from conflicts of interest among these agents decreased the quality of securitized mortgages and played a paramount role in the financial crisis (Keys et al., 2013). For example, non-agency residential mortgage-backed security issuances totaled more than $3 trillion between 2002–2007 alone.[2] Yet, we find more than 40% of a representative sample of these loans default within five years.[3]

In the wake of the financial crisis, Congress passed the Dodd–Frank Wall Street Reform and Consumer Protection Act of 2010 (hereafter, Dodd–Frank), requiring regulators to promulgate rules

[2] See Securities Industry and Financial Markets Association (SIFMA), "US Mortgage-Related Issuance and Outstanding," available at http://www.sifma.org/research/statistics.aspx.

[3] We use serious delinquency as a proxy for default. We define a mortgage loan as seriously delinquent if it has ever been 90 days past due, foreclosed, or real estate owned. Properties owned by a lender are considered to be real estate owned. Properties are termed real estate owned after an unsuccessful foreclosure auction, but lenders can become owners of a property at any time after a loan is delinquent or the property is foreclosed (Pennington-Cross, 2006). We define variables in Appendix A.

requiring the originator or sponsor of residential mortgage-backed securities to retain 5% of the credit risk.[4] The risk retention requirements are intended to attenuate moral hazard by aligning the incentives between the securitization agents and investors who bear the default risk. By requiring "skin in the game," securitizers may have greater incentives to improve borrower screening and monitoring (Demiroglu and James, 2012).

Importantly, Dodd–Frank exempts a new class of securitized loans, known as a Qualified Residential Mortgage or QRM, from all risk retention. This loophole is based on the notion that soundly underwritten mortgages with high quality borrower characteristics and prudent loan types results in sufficiently low default risk that risk retention is unnecessary. Congress instructs regulators to define a QRM by considering the underwriting and product features that have historically predicted loan default. The purpose of this paper is to examine characteristics associated with default for loans impacted by the QRM definition.

Dodd–Frank provides a list of borrower (e.g., credit score) and loan characteristics (e.g., interest-only payments) for regulators to consider in defining a QRM, but does not prescribe a target default rate. Although regulators have freedom in defining its characteristics, Dodd–Frank requires that the QRM definition is no broader than the definition of a Qualified Mortgage (QM), which focuses on a borrower's ability to repay by placing restrictions on debt-to-income ratios and riskier loan products.[5]

In 2011, regulators proposed a QRM definition based on analysis of historical loan performance using data on *agency* securitized loans (i.e., loans securitized by Government-Sponsored Enterprises such as Fannie Mae or Freddie Mac).[6] We note that Dodd–Frank exempts agency securitized loans from risk retention because the agencies retain 100% risk retention through payment guarantees. We argue that any analysis of the characteristics associated with default for the purposes of defining a QRM should examine historical data from *non-agency* securitizations since agency loans are exempt from risk retention. Moreover, academic literature identifies non-agency securitized loans as being subject to higher levels of moral hazard and performing differently than agency securitizations (e.g., Keys et al., 2012). Thus, our analysis focuses on non-agency securitizations.[7]

After considerable lobbying by housing industry participants, regulators re-proposed the QRM definition in August 2013 with two alternatives: QRM could (a) be identically defined as a QM; or (b) have additional restrictions beyond that of a QM, such as stipulations on credit history, down payments, and loan-to-value ratios.

In October 2014, regulators chose to equate the definition of a QRM with QM, but included a provision that requires a periodic review. In the final rule, regulators admit that aligning QRM with QM ignores useful factors that mitigate default risk (e.g., credit history and loan-to-value ratios) due to concerns of a potentially disparate impact on access to capital for low income, minority, or first-time homebuyers.[8] This justification is based on the premise that weaker QRM standards facilitates greater access to mortgage capital by making it easier to arrange and securitize residential mortgages. However, some regulatory principals expressed con-

cerns that the final QRM definition ignores important factors, such as loan-to-value ratios.[9]

Since regulators must periodically review the QRM definition, we contribute to the policy debate and academic literature by examining the loan and borrower characteristics for each of the proposed QRM definitions. Our primary research questions are as follows:

1. What loan and borrower characteristics are the principal drivers of default in non-agency residential mortgage-backed securities loans?
2. Do the characteristics of a QM efficiently tradeoff default risk and access to capital?
3. For securitized loans requiring risk retention, how long should the risk be retained?

To answer these questions, we analyze a dataset of ex-ante observable loan-level characteristics of non-agency securitized mortgages originated over 1997–2009. Our selection of loan characteristics associated with default is motivated both by factors identified in Dodd–Frank and extant academic literature. We find a number of characteristics are significantly associated with default in non-agency securitized loans. In agreement with the definition of a QM, we find certain product types (e.g., negative amortization, balloon or interest-only payments) and relaxed underwriting standards (e.g., less than full documentation) are associated with greater serious delinquency. However, our results indicate that borrower credit scores and combined loan-to-value ratios are better determinants of default than most factors included in the definition of a QM. These findings are in line with extant literature identifying credit scores (Demyanyk and Van Hemert, 2011) and loan-to-value ratios (Mian and Sufi, 2009) as important determinants of non-agency mortgage default.[10]

Consistent with recent studies (e.g., Demiroglu and James, 2012), we also find evidence that loans with a higher probability of moral hazard significantly underperform those where moral hazard is attenuated. Loans with an affiliation between the originator and servicer are much less likely to default than those where no affiliation is present, and this relationship has among the greatest marginal effect on default in a logistic regression. Similarly, loans with less than full documentation of income and assets, where the role of loan screening of soft information is enhanced (Keys et al., 2012), are associated with greater instances of default. Yet, the explanatory power of credit scores and combined loan-to-value ratios remain statistically and economically large even when controlling for the heightened role of moral hazard and screening of soft information. We show that this relationship is robust to a number of treatments and controls, including a propensity score matching analysis.

To answer our second research question regarding the effectiveness of QM in trading off default risk and access to capital, we first present historical default rates under each of the proposed definitions of QM and QRM. We find more than 44% of our sample of non-agency securitized loans became seriously delinquent. Filtering on loans meeting the definition of QM reduces the historical

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[4] Risk retention refers to originators or sponsors maintaining a financial interest in the securitization.

[5] A summary of the proposed and final definitions of QM and QRM is provided in Appendix B.

[6] See Credit Risk Retention, 76 Fed. Reg. 24089 (proposed Apr. 29, 2011), available at https://www.gpo.gov/fdsys/pkg/FR-2011-04-29/pdf/2011-8364.pdf.

[7] Appendix C summarizes differences in the performance of agency and non-agency securitized loans.

[8] See Credit Risk Retention, 79 Fed. Reg. 77688 (adopted Dec. 24, 2014) available at https://www.gpo.gov/fdsys/pkg/FR-2014-12-24/pdf/2014-29256.pdf.

[9] SEC Commissioner Daniel Gallagher notes that, *"residential mortgages with zero percent down and weak loan-to-value ratios that in the past would have been called subprime will now carry the same 'quality' endorsement from the government as solid mortgages with significant down payments and strong loan-to-value ratios."* See "Dissenting Statement of Commissioner Daniel M. Gallagher Concerning Adoption of Rules Implementing the Credit Risk Retention Provisions of the Dodd–Frank Act" available at http://www.sec.gov/News/PublicStmt/Detail/PublicStmt/1370543240793#.VInqD2TF-1I.

[10] The mortgage default predictive power of credit scores and loan-to-value ratios has long been identified in academic literature. von Furstenberg (1969) found loan-to-value ratios are the most important determinant of default over the life of a mortgage. Avery et al. (1996) find credit scores are a strong predictor of loan performance even among non-traditional loan products.

serious delinquency rate only modestly to 34%. Additional factors consistent with a narrower definition of a QRM significantly reduces the default rate. For example, historical QM-eligible loans with a credit score of at least 690 and a combined loan-to-value ratio no more than 90% reduces overall default risk by more than 75%, as these loans have a serious delinquency rate of 10.3%. However, these restrictions also reduce historical loan volume meeting these key thresholds.

Thus, we present a benefit-cost ratio that estimates the trade-off between reduced serious delinquency (i.e., a benefit) and the reduction in the number of historic loans qualifying for the 2011 proposed definition of QRM (i.e., a cost). We find the benefit of reductions in default rates through additional restrictions on credit scores and combined loan-to-value ratios accumulate faster than costs of reduced loan volume, or access to capital. These factors also more efficiently tradeoff reductions in default risk with access to capital than variables included in the definition of a QM, such as debt-to-income ratios. The implication of these findings is that including even modest restrictions on credit scores and loan-to-value ratios in the definition of a QRM would more efficiently tradeoff default risk and access to capital than those included in the definition of a QM.

Our third research question focuses on the length of risk retention by examining the association between ex-ante risk characteristics and the time to default. Conditioned upon non-agency securitized loans having at least one spell of serious delinquency, we show that more than half of the serious delinquencies occur within three years of origination. This finding provides suggestive evidence that risk retention beyond three years might be unnecessary.[11] We also find higher combined loan-to-value ratios strongly expedite serious delinquency using a Cox proportional hazard model, which reinforces the notion that many of the most important default factors are absent from the final QRM definition.

Overall, our study provides many important contributions. To our knowledge, we are the first to comprehensively examine the performance of non-agency securitization in the context of the QM and QRM definitions. We demonstrate that credit scores and loan-to-value ratios are among the most important predictors of default in non-agency securitized mortgages, yet they are absent from the definition of both a QM and a QRM. Our findings have important policy implications for both US and European regulators as they periodically review the risk retention requirements for securitized mortgages.[12] Our results also help inform regulators about which loan and borrower characteristics should be disclosed to residential mortgage-backed securities investors so they may appropriately price risk (Schwarcz, 2008). We also identify the observable ex-ante loan characteristics that are associated with expediting or delaying the timing of default. Our results, therefore, inform academics, practitioners, and regulators on the factors that are associated with default in non-agency securitizations during periods of higher and lower securitizations when there are varying levels of moral hazard.

Our study is related to theoretical work by Guo and Wu (2014), who show that mandatory 5% risk retention reduces the ability of securitizers to signal the quality of a non-agency securitization. Our paper complements work by Elul (2016), who examines risk characteristics associated with default in the context of securitized versus non-securitized loans.[13] Our findings also support the notion that analysis of securitization and underwriting standards should separately evaluate agency and non-agency loans (Keys et al., 2010; 2012).

The remainder of this paper is organized as follows. Section 2 provides background information on Dodd–Frank and discusses the evolution of non-agency securitizations. Section 3 describes the data and Section 4 presents the findings. Section 5 concludes.

2. Background

In this section, we discuss the evolution of non-agency securitizations to understand the factors that contributed to the subprime mortgage crisis and ultimately the passage of Dodd–Frank. We then provide a summary of the proposed and final QRM definition.

2.1. Prior to the Dodd–Frank Act

Keys et al. (2013) describe the dramatic change in non-agency securitizations during the 1990s–2000s. The emergence of loans to borrowers with credit constraints and non-traditional mortgage products spurred growth in the non-agency securitization market. These securitizations included loans characterized by market participants as Alt-A and subprime, as well as jumbo loans with non-conforming loan balances.[14] Although delinquency rates increased in the early 2000s following the bursting of the dot-com bubble, low interest rates and rapid housing price appreciation allowed distressed borrowers to sell or refinance troubled loans, potentially masking earlier problems in the non-agency securitization space.

The non-agency securitization market experienced large growth through the mid-2000s and peaked in 2006 prior to steep declines in housing prices starting in 2007. At the beginning of 1997, there were $215 billion in non-agency securitizations outstanding, or 6% of the residential mortgage market. By the end of 2007, non-agency securitizations represented 20% of the residential mortgage market with $2.2 trillion outstanding.[15] Similarly, non-agency residential mortgage backed securities issuances averaged $95 billion per year over 1997–2000 and $443 billion per year over 2001–2007 (see Fig. 1). Once housing prices began to fall, many borrowers were

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[11] In the Credit Risk Retention final rule, regulators provide a sunset on risk retention. The term "sunset" refers to the expiration date where sponsors of mortgage-backed securitizations may hedge or transfer the residual interest maintained as risk retention. For non-QRM securitized loans, regulators require a minimum seven years duration of risk retention unless the total unpaid principal balance is reduced to 25% and five years have passed since the closing of the securitization.

[12] In December 2013, the European Banking Authority (EBA) finalized 5% risk retention rules for securitizations in the European Union under Articles 405–410 of the Capital Requirements Regulation. See https://www.eba.europa.eu/regulation-and-policy/single-rulebook/interactive-single-rulebook/-/interactive-single-rulebook/toc/504. The EBA must report annually to the European Commission on the effectiveness of its risk retention rules. Jaffee (2015) and Schwarcz (2016) review reform differences in US and European mortgage markets.

[13] Elul finds evidence that prime, non-agency securitized loans originated during 2005–2006 are more likely to be seriously delinquent than agency securitized loans. Our paper differs from Elul's study in the following ways. First, Elul does not analyze the impact of QM or QRM on securitizations. Second, we examine a much longer sample period (1997–2009 versus 2005–2006) to include periods of higher and lower securitizations and allow for evolving product types to understand how ex-ante risk characteristics perform across these periods. This is noteworthy as Keys et al. (2012) and Rajan et al. (2015) find lenders' incentives to originate loans that rely more on hard information is heightened during periods of greater securitization. Since non-agency securitizations peak during Elul's smaller sample period of 2005–2006, it is not clear that the risk factors in that analysis would behave similarly during other time periods where levels of moral hazard differ. Third, we include a number of risk characteristics specific to the definition of QM (e.g., debt-to-income and negative amortization) and the proposed definition of QRM (e.g., lien status) that are not included in Elul's analysis. Finally, our study does not include non-securitized loans.

[14] Gorton (2009) notes that regulators do not define the terms Alternative-A (Alt-A) or subprime. These loans are considered to have higher default risk than prime mortgages due to non-conforming features such as a lack of full documentation, high loan-to-value ratios, or low credit scores.

[15] Data are for one-to-four family mortgage debt. See http://www.federalreserve.gov/econresdata/releases/mortoutstand/mortoutstand20091231.htm.
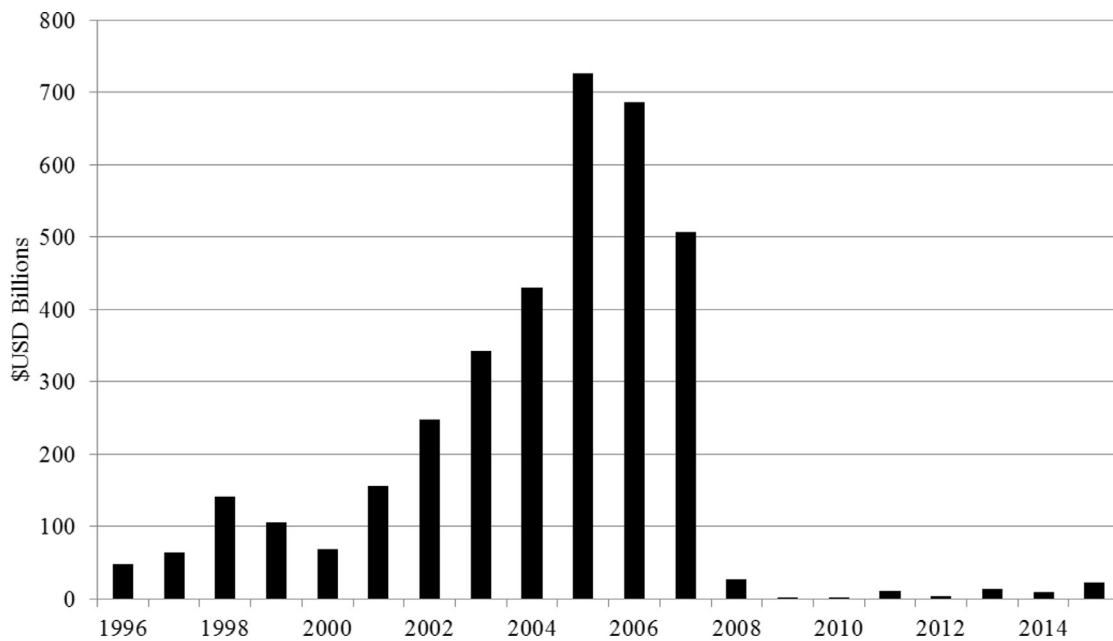
Fig. 1. Non-agency residential mortgage-backed securities issuance. This figure presents a column chart of non-agency residential mortgage-backed securities (RMBS) issuance over 1996–2015. These data are obtained from the Securities Industry and Financial Markets Association. See "US Mortgage-Related Issuance and Outstanding," available at http://www.sifma.org/research/statistics.aspx.
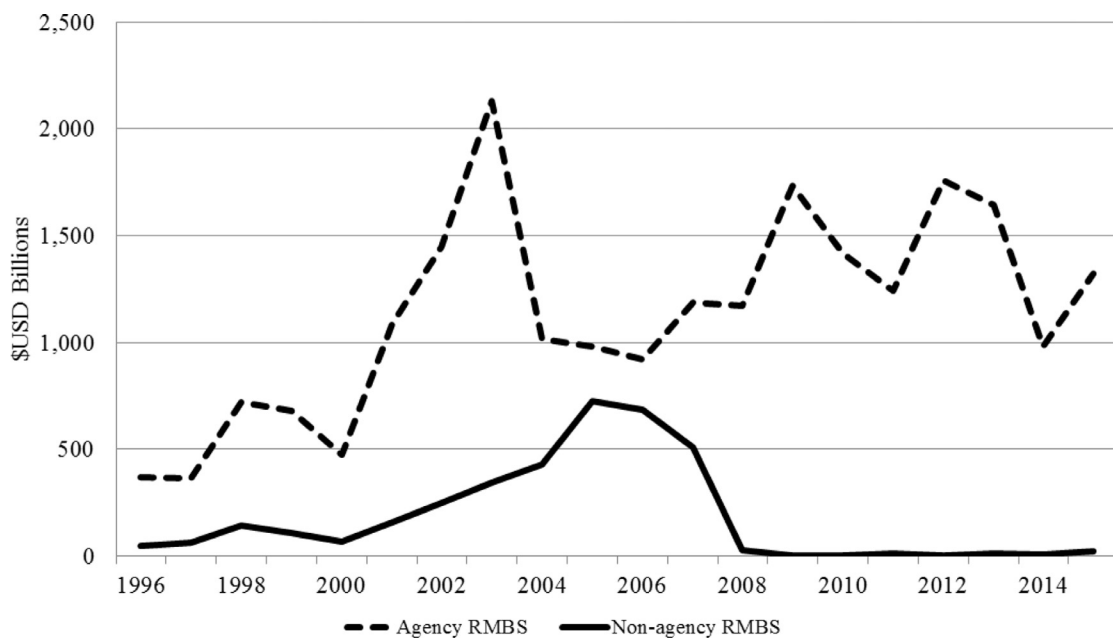
Fig. 2. Agency versus non-agency residential mortgage-backed securities issuance. This figure presents a line graph of agency and non-agency residential mortgage-backed securities (RMBS) issuance over 1996–2015. These data are obtained from the Securities Industry and Financial Markets Association. See "US Mortgage-Related Issuance and Outstanding," available at http://www.sifma.org/research/statistics.aspx.

no longer able to refinance or sell homes, exposing weaknesses in non-agency underwriting standards and product types (Gorton, 2009; Keys et al., 2013; Mayer et al., 2009). Non-agency residential securitizations only averaged $1 billion per year in 2009–2010, while agency securitizations remained robust (see Fig. 2).

As demand for non-agency securitized loans increased in the 2000s, other changes altered the residential mortgage environment. Rapidly increasing house prices made securitized loans less information sensitive as investor returns from residential mortgage-backed securities benefited from housing price appreciation even with low quality loans (Gorton, 2010). Increasingly, non-agency securitized loans included layers of risk through non-

traditional mortgages and increasingly sophisticated product types. For example, the number of loans with low documentation and high loan-to-value ratios increased, while the average time to securitize these loans sharply decreased (Keys et al., 2013). Moreover, lenders increasingly securitized mortgages with short-term hybrid adjustable rate mortgages, negative amortization, and interest-only payments.

A growing number of financial institutions adopted an originate-to-distribute model that creates additional incentives to offer lower quality loans. In this model, originators make loans expressly to be sold into securitization pools, which allows lenders to simply pass the default risk along to investors. Since investors

in residential mortgage-backed securities must rely upon hard information disclosed in prospectuses, lenders in the originate-to-distribute model could essentially ignore useful soft information regarding default risk (Keys et al., 2010; 2013), especially during the periods of higher securitization (Rajan et al., 2015). Empirical evidence also suggests that lenders not operating in the originate-to-distribute model strategically exploited soft information in choosing which loans to securitize versus keep on their balance sheet (Keys et al., 2012).

2.2. The Dodd–Frank Act

After the financial crisis, Congress turned to risk retention under Dodd–Frank as a mechanism for addressing conflicts of interest in non-agency securitizations. Dodd–Frank requires that regulators promulgate rules requiring securitizers to retain at least 5% of the credit risk of each asset-backed securities issuance. The retained risk may not be hedged or transferred.[16] Barney Frank, Chairman of the House Financial Services Committee, argues that, *"the single most important part of the (Dodd–Frank) bill was risk retention."*[17]

For securitized residential mortgages, Dodd–Frank provides a complete exemption from risk retention for loans meeting the QRM definition. Congress instructs regulators to define a QRM by considering the underwriting and product features that were historically associated with lower default risk. Dodd–Frank identifies potential loan and borrower characteristics for regulators to consider in determining the QRM definition but does not provide a target rate of default.[18] Importantly, Dodd–Frank limits the QRM definition to be no broader than the QM definition, and exempts agency loans from risk retention because their payment guarantee is essentially 100% risk retention. Thus, risk retention rules only apply to non-agency securitized loans.

Regulators first proposed the QRM definition in March 2011. In response to objections by politicians and housing market participants, regulators re-proposed the QRM definition in August 2013.[19] In the re-proposal, regulators offered two alternatives. First, the QRM definition could be aligned with the definition of a QM so that the rules are identical (i.e., QRM equals QM). Alternatively, a QRM would be required to meet the definition of a QM with additional restrictions. In October 2014, regulators finalized the QRM definition by aligning it with QM. The final rule requires regulators to review the definition of QRM no later than four years after the effective date and every five years thereafter, and provides each regulatory agency with the ability to request a review of the QRM

definition at any time. We provide a summary of the QM definition and both the 2011 and 2013 proposed definitions of a QRM in Appendix B.

2.3. Relation between QRM and QM

The QM definition is determined by the Consumer Financial Protection Bureau and focuses on borrower ability to repay and risky loan products. To be considered a QM, the loan must have full documentation of a back-end debt-to-income ratio that does not exceed 43%.[20] Additionally, certain payment and amortization features do not meet the QM definition (e.g., negative amortization). We label a historical loan as QM-eligible if the loan: term is 30 years or less; has full documentation; does not have negative amortization, interest-only, or balloon payments; and back-end debt-to-income is less than or equal to 43%.[21]

Notably, the QM definition does not include thresholds for many of the originally proposed features of a QRM. For example, a QM requires no minimum down payment, no maximum loan-to-value ratio, and no credit history requirements. Thus, a loan to a borrower with little or no down payment and a low credit score could be a QM.

3. Data

Our analysis uses historical non-agency securitized loan origination and performance data from MBSData, LLC. The MBSData database covers approximately 95% of non-agency securitizations over 1997–2009.[22] This dataset includes loans that may be characterized as Alt-A, subprime, and jumbo loans with balances exceeding the agency limits for a conventional mortgage published by the Federal Housing Finance Agency.[23] The data include loan-level information disclosed to investors at the time of securitization. All variables are reported as of the loan origination date. Borrower characteristics include credit score (FICO), back-end debt-to-income ratio, combined loan-to-value ratio, and occupancy status. Loan characteristics include the origination date, loan amount, interest rate, interest rate type, lien status, loan purpose, documentation level, private mortgage insurance information, originator and servicer name, and product types such as negative amortization, interest-only or balloon payments, prepayment penalties, and teaser rates.[24]

Dodd–Frank requires that the QRM definition is no broader than a QM, which caps back-end debt-to-income ratios at 43%. Thus, our analysis is restricted to a subset of the full MBSData database due to a large number of loans with missing back-end debt-to-income information.[25] Additionally, we require full information on credit score and combined loan-to-value ratios. These restrictions result

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[16] Dodd–Frank tasks these agencies with jointly defining a QRM: The Board of Governors of the Federal Reserve System, the Department of Housing and Urban Development, the Federal Deposit Insurance Corporation, the Federal Housing Finance Agency, the Office of the Comptroller of the Currency, and the Securities and Exchange Commission. The Department of Treasury coordinates the joint rulemaking.

[17] See Floyd Norris, "Mortgages Without Risk, at Least for the Banks," *New York Times*, 28 Nov. 2013.

[18] Dodd–Frank lists the following factors for regulators to consider in defining a QRM: loan documentation and verification, the ratio of residual income to monthly debt obligations, payment shocks associated with adjustable rate mortgages and other product features, mortgage guaranty insurance, and the use of balloon payments, negative amortization, prepayment penalties, interest-only payments, and other features as being associated with a higher risk of default. See Dodd–Frank, Pub. L. No. 111–203 124 Stat. 1895, available at https://www.gpo.gov/fdsys/pkg/PLAW-111publ203/pdf/PLAW-111publ203.pdf.

[19] In the 2013 re-proposed QRM rule, regulators note that they received comments from more than 10,500 persons, institutions, or groups regarding the risk retention rules. Regulators indicate that an overwhelming majority of the comments by industry participants and many members of Congress criticized the 2011 proposed QRM definition (see Credit Risk Retention, 78 Fed. Reg. at 57933, 57988, and 57994 (proposed Aug. 28, 2013), available at https://www.gpo.gov/fdsys/pkg/FR-2013-09-20/pdf/2013-21677.pdf). These comments are available at http://www.sec.gov/comments/s7-14-11/s71411.shtml.

[20] Front-end debt-to-income is calculated as the monthly mortgage debt payment divided by monthly income. The back-end debt-to-income ratio divides a borrower's total monthly debt by monthly income.

[21] Due to data limitations, some loans with points and fees greater than 3%, loans with prepayment penalties after three years, and certain hybrid adjustable rate mortgages may be erroneously classified as a QM.

[22] We end our sample in 2009 in for several reasons. First, our analysis requires five years of performance data after origination. Second, the non-agency securitization market largely dries up after this period. For example, non-agency residential mortgage backed securities issuances average only $6.8 billion per year during 2010–2014 as compared to $270 billion over 1997–2009 (see Fig. 1). Third, ending the sample period in 2009 prevents contamination of originators or sponsors potentially voluntarily holding risk retention in anticipation of the final Dodd–Frank rule.

[23] Historical loan limit data are available at https://www.fanniemae.com/content/fact_sheet/historical-loan-limits.pdf.

[24] We combine low and no documentation loans in this analysis.

[25] Back-end debt-to-income information is available for 13% of the full MBSData database. Although originators often have debt-to-income information, variation exists in the standards used to verify this information. Thus, some debt-to-income

Table 1
Sample distribution.

Origination year	Number of loans (N)	Dollar volume ($ billions)	Serious delinquency (%)
1997	874	0.1	20.3
1998	3,353	0.3	13.7
1999	4,158	0.3	15.3
2000	15,134	1.5	44.3
2001	45,278	6.9	33.7
2002	70,945	13.3	19.2
2003	118,749	27.0	13.9
2004	304,832	57.4	20.8
2005	778,688	151.2	39.6
2006	1,083,997	221.1	57.6
2007	263,132	66.0	55.1
2008	2	0.1	50.0
2009	1	0.1	100.0
Full sample	2,689,143	545.0	44.4

The table presents the sample distribution of non-agency securitized loans originated between 1997 and 2009 with full information on borrower and loan characteristics. Variables are defined in Appendix A.

Table 2
Descriptive statistics.

	Mean	Median	Standard deviation
Borrower characteristics			
Debt-to-income ratio	39.2	40.8	9.4
Loan-to-value ratio	65.5	80.0	27.9
Combined loan-to-value ratio	86.0	90.0	15.6
Credit score	660.2	659.0	69.6
Loan characteristics (percent)			
Full documentation	55.3		49.7
Negative amortization	6.4		24.6
Interest only	17.9		38.3
Balloon payment	15.0		35.7
Adjustable rate	59.5		49.1
Initial interest rate	7.9	7.8	2.4
Initial interest rate spread	1.5	1.3	2.5
Teaser rate	43.0		49.5
Long-term loan	2.4		15.4
First lien	77.5		41.7
Prepayment penalty	53.5		49.9
Jumbo loan	15.0		35.7
Owner occupied	86.9		33.8
Private mortgage insurance	3.3		17.9
Affiliated	45.8		49.8

The table presents the sample distribution of non-agency securitized loans originated between 1997 and 2009 with full information on borrower and loan characteristics. Variables are defined in Appendix A.

in a final sample of 2,689,885 loans from 1997−2009, with the majority of excluded observations stemming from missing data on debt-to-income. Since missing debt-to-income information could bias our results, we compare the properties of our sample to a similarly sized random sample of loans with non-missing debt-to-income information. We find that default rates are higher for loans with reported information on debt-to-income. However, the regression coefficients on serious delinquency are qualitatively similar for loans with and without debt-to-income information. In untabulated results, we also verify that the serious delinquency rates and distributional properties of risk characteristics are similar between the MBSData and CoreLogic databases.

We use serious delinquency rather than foreclosure alone to proxy for default since foreclosure reporting varies across lenders (Avery et al., 1996). Additionally, focusing on foreclosure alone might incorrectly measure the default timing as work shows servicers of securitized loans are less likely to renegotiate than servicers of non-securitized loans (Piskorski et al., 2010). We define a loan as seriously delinquent if it is ever 90 days delinquent, foreclosed, or real estate owned. Performance is measured through 2012 based on the Mortgage Bankers Association classification of delinquencies.[26] Our results are robust to the Office of Thrift Supervision classification of delinquencies.

4. Empirical results

In this section, we first describe our sample and the differences in serious delinquency based on borrower and loan characteristics. Next, we explore the implications of applying the QM and proposed QRM definitions on historical loan performance. We then examine the tradeoff between reduced serious delinquency and loan volume. Finally, we delve into factors associated with the timing of serious delinquency.

4.1. Sample distribution

Table 1 presents the distribution of loan volume and performance for our sample by origination year. Most loans were originated during 2004–2007, with the peak occurring in 2006. Almost

none of the non-agency securitized loans in our sample were originated during 2008 and 2009 as the market for non-agency securitizations dried up. The yearly distribution of total dollar volume is similar to the number of loan originations and totals $545 billion. The mean serious delinquency rate for the full sample of non-agency loans is 44.4%. As a point of reference, we note the default rate for agency securitized loans is 5.3% using the same sample period and definition of serious delinquency (See Appendix C). Consistent with Keys et al. (2012), non-agency loans originated during the peak securitization years of 2006 and 2007 exhibit the highest serious delinquency rates, which in our sample amount to 57.6% and 55.1%, respectively. Serious delinquency rates fluctuate during the remainder of the sample period and range from 13.7% in 1998 to 44.3% in 2000.

Table 2 presents descriptive statistics for the sample. For ease of presentation, we categorize the characteristics by borrower and loan characteristics. We define variables in Appendix A. There are no distinct differences between mean and median values across most continuous variables, thus we are less concerned about a potentially skewed distribution or outliers impacting our multivariate analysis. The average credit score in our sample is approximately 660. The mean combined loan-to-value ratio is 86% and the average reported back-end debt-to-income ratio is 39.2%.

The majority of the non-agency loans in our sample are owner occupied (86.9%) and first-lien loans (77.5%). Just over half of our sample has full documentation (55.3%), prepayment penalties (53.5%), and adjustable interest rates (59.5%). A sizable portion of the loans have non-conventional product features such as negative amortization (6.4%), interest-only (17.9%) and balloon payments (15.0%). While a noticeable percentage of our loans include teaser rates (43%), only a small percentage has amortization periods longer than 30 years (2.4%) or reported private mortgage insurance (3.3%). We find just under half of our sample has a loan originator affiliated with the servicer agent.[27] Since unaffiliated loans are subject to greater moral hazard (Demiroglu and James, 2012),

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observations should be considered self-reported, especially for loans without full documentation.

[26] There are periods of missing remittance data for 4,961 loans, or 0.2% of the final sample. We do not classify these loans as seriously delinquent, but the results are similar regardless of treatment.

[27] Although disclosure of originator names was not mandatory prior to January 1, 2006 (see Asset-Backed Securities (Reg AB), 70 Fed. Reg. at 1538 (adopted Dec. 22, 2004), available at https://www.gpo.gov/fdsys/pkg/FR-2005-01-07/pdf/05-53.pdf),

Table 3
Serious delinquency statistics.

	Number of loans	Serious delinquency (%)
Full sample	2,689,143	44.4
Borrower characteristics		
Credit score (FICO)		
FICO ≥ 720	572,054	26.6
FICO ≥ 690	907,190	31.9
FICO ≥ 660	1,343,524	36.9
FICO < 660	1,345,619	51.9
Combined loan-to-value (CLTV) ratio		
CLTV ≤ 70%	383,338	24.7
CLTV ≤ 80%	676,885	29.6
CLTV ≤ 90%	1,534,478	38.5
CLTV > 90%	1,154,665	52.3
Debt-to-income (DTI) ratio		
DTI ≤ 36%	898,810	37.2
DTI ≤ 38%	1,103,238	38.3
DTI ≤ 43%	1,673,572	41.0
DTI > 43%	1,015,571	50.1
Owner occupied	2,336,283	44.3
Non-owner occupied	352,860	45.2
Loan characteristics		
Full documentation	1,486,947	40.4
Low or no documentation	243,230	48.5
Negative amortization	173,299	44.5
Interest only	481,581	47.9
Balloon payment	402,707	61.6
Fixed rate	1,088,471	41.2
Adjustable rate	1,600,672	46.6
Teaser rate	1,157,540	51.1
Initial interest rate spread ≤ 3.5%	2,179,457	42.5
Initial interest rate spread > 3.5%	509,686	52.6
Loan term ≤ 30 years	2,623,841	44.1
Loan term > 30 years (long-term loan)	65,302	59.3
First lien	2,084,510	44.7
Secondary lien	604,633	43.4
Prepayment penalty	1,437,463	52.3
Jumbo loan	402,455	39.6
Loan has private mortgage insurance	88,894	37.8
Affiliated	1,231,402	35.3
Not-affiliated	1,457,741	52.1

This table presents serious delinquency rates for our sample of non-agency securitized loans originated from 1997 to 2009 with full information on borrower and loan characteristics. Variables are defined in Appendix A.

we use this relationship to proxy for the processing of soft information at the screening stage of the non-agency securitized loans.

4.2. Loan characteristics and serious delinquency

In Table 3, we report the number of loans and the related percentage of loans with serious delinquency by each borrower and loan characteristic. For certain borrower characteristics (credit score, combined loan-to-value and debt-to-income ratios), we examine specific thresholds to examine the sensitivity of serious delinquency rates to the proposed definitions of a QRM. Recall that the average serious delinquency rate for the full sample is 44.4%.

The number of loans is equally split for borrowers with credit scores above and below 660, and about one-third (33.7%) have a credit score of at least 690. As anticipated, higher credit scores are generally associated with lower serious delinquency rates. However, more than one-fourth (26.6%) of loans on average with credit scores of at least 720 still experience one spell of serious delinquency. Thus, credit score alone cannot explain high serious delinquency rates for non-agency securitized loans.

Only 25.2% of the sample has a combined loan-to-value level less than or equal to the originally proposed QRM level of 80%. The serious delinquency rate appears to decline proportionally greater moving from a 90% to 80% combined loan-to-value threshold (−8.9%) than from an 80% to 70% threshold (−4.9%). Combined loan-to-value levels exceeding 90% represent 42.9% of the sample and have an average serious delinquency rate of 52.3%.

Debt-to-income levels above the QM threshold of 43% have an average serious delinquency rate of 50.1%. This rate drops to 41.0% for loans at or below the QM-established debt-to-income ratio limit. As compared to the QM limit, there is a small reported difference (−3.8%) in the serious delinquency rate when restricting debt-to-income ratios to the originally proposed QRM limit of 36%, which suggests restrictions on debt-to-income may have a lower marginal impact than credit score or combined loan-to-value limitations. We further explore this relationship in our multivariate setting in Section 4.5.

We find many differences in serious delinquency rates based on loan characteristics. Non-agency securitized loans with balloon payments (serious delinquency rate = 61.6%), terms exceeding 30 years (serious delinquency rate = 59.3%), initial interest rate spreads exceeding 3.5% (serious delinquency rate = 52.6%), and those with prepayment penalties (serious delinquency rate = 52.3%) all exhibit higher serious delinquency rates than the full sample. Conversely, jumbo loans (serious delinquency rate = 39.6%), fully documented loans (serious delinquency rate = 40.4%), and fixed rate loans (serious delinquency rate = 41.2%) have a lower serious delinquency rate than the full sample.

Lower potential moral hazard issues among securitization agents are associated with improvements in serious delinquency rates. For example, the serious delinquency rate is 52.1% when originators and servicers are not affiliated, but declines to 35.3% when an affiliation is observed. This result suggests that moral hazard problems in non-agency loans might be attenuated when the interests of originators and services are aligned.

4.3. Impact of QM and QRM on historical loan performance

In this section, we stratify our sample of historical non-agency securitized loans according to whether they would meet the QM or proposed additional QRM requirements. In Table 4, we present the serious delinquency rate, dollar volume, and loan origination percentages based on this stratification for the full sample and for subsamples based on loan purpose.

Applying the QM eligibility criteria reduces overall serious delinquency rates from 44.4% to 33.6%. As expected, we find two variables, credit score and combined loan-to-value ratio, significantly impact serious delinquency levels as they drop from 33.6% to 10.3% (QM-eligible, combined loan-to-value ratio ≤ 90%, and credit score ≥ 690). Further narrowing the requirements to the 2011 proposed QRM threshold of combined loan-to-value ratio ≤ 80% reduces the serious delinquency rate to 6.5%. Thus, historical loans meeting only two key provisions of the 2011 proposed definition of a QRM are approximately five times less likely to become seriously delinquent than the QM-eligible sample. Looking across loan purposes, we find that purchase loans have higher serious delinquency rates than rate and term refinance loans. Cash-out refinance loans have higher serious delinquency rates than rate and term refinance loans for all thresholds of QM-eligible loans. Although combined loan-to-value thresholds differ by loan purpose in the originally proposed 2011 QRM definition, the re-proposed 2013 definition of a QRM does not distinguish between these three loan purposes. Thus, we do not partition our sample by loan purpose for the remainder of our analysis.

Restricting borrower and loan factors associated with higher default rates will also result in fewer securitized loans meeting the

Table 4
Loan purpose.

	Full sample	QM-eligible sample			
	Any CLTV Any FICO	Any CLTV Any FICO	CLTV ≤ 90% FICO ≥ 690%	CLTV ≤ 80% FICO ≥ 690%	CLTV ≤ 70% FICO ≥ 690%
Serious delinquency rate (%)					
All	44.4	33.6	10.3	6.5	5.0
Purchase	48.4	37.1	12.5	7.8	7.2
Rate and term refinance	42.5	30.4	7.0	4.3	3.0
Cash-out refinance	43.2	35.0	12.9	8.7	6.5
Loan dollar volume (%)					
All	100.0	16.3	4.5	2.9	1.9
Purchase	43.6	6.2	1.5	0.6	0.3
Rate and term refinance	12.8	2.1	1.0	0.8	0.6
Cash-out refinance	40.9	7.1	1.3	0.9	0.6
Loan originations (%)					
All	100.0	22.3	3.8	2.1	1.4
Purchase	47.7	9.0	1.1	0.3	0.2
Rate and term refinance	9.0	1.9	0.5	0.4	0.3
Cash-out refinance	37.6	9.1	1.0	0.6	0.4

This table presents serious delinquency rates and loan volume as a percentage of the total sample dollar volume and number of loan originations by loan purpose. We designate a loan as QM-eligible if the loan term is no greater than 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is no greater than 43%. Column 1 presents the results for the full sample. Columns 2–5 present the results for loans designated as QM-eligible with increasing restrictions on combined loan-to-value (CLTV) ratios and credit scores (FICO). Variables are defined in Appendix A.
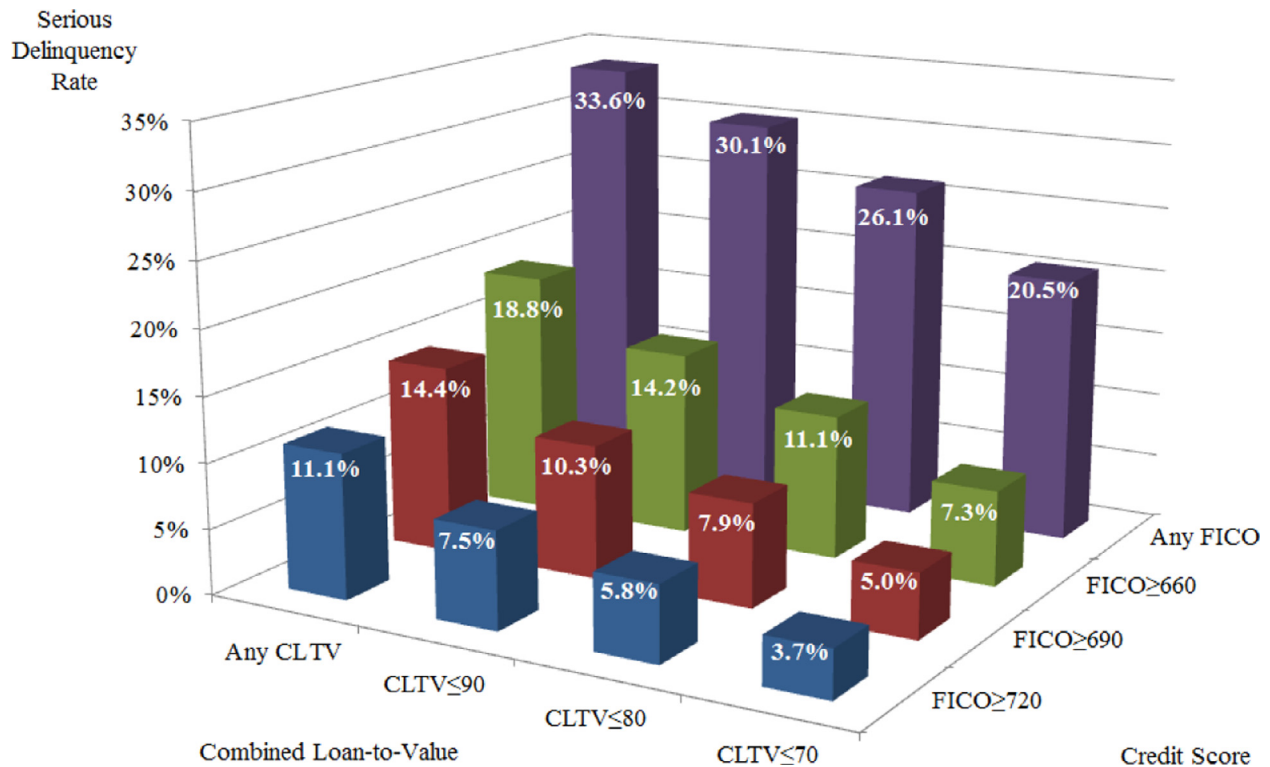
Fig. 3. Serious delinquency rate for QM-eligible loans. This figure presents a three-dimensional chart of serious delinquency rates for QM-eligible loans with combinations of credit score (FICO) and combined loan-to-value (CLTV) restrictions. We designate a loan as QM-eligible if the loan term is less than or equal to 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is less than or equal to 43%.

definition of a QM or a QRM. We examine both the loan dollar volume and number of originations to measure this impact. Only 16.3% of the dollar volume of loans in our sample meets the QM definition, and less than 2% meets the 2013 proposed additional QRM restrictions on combined loan-to-value ratio (≤70%) and credit score (≥690). When examining the number of loans, these percentages are slightly higher for QM-eligible loans but lower for loans with a combined loan-to-value ratio ≤70% and a credit score ≥690. Figs. 3 and 4 provide three-dimensional illustrations of the changes in the serious delinquency rate and total

dollar volume when applying various credit score and combined loan-to-value ratio restrictions to historical loans that meet the QM definition.

Fig. 3 depicts the historical average serious delinquency rate for all QM-eligible loans in our sample and with iterative restrictions to credit score and combined loan-to-value ratio both separately and combined. Recall that Table 4 indicates the QM definition results in a decline in serious delinquency rates from the 44.4% for the overall sample to 33.6% for the QM-eligible sample. This is a relative decline in serious delinquency of 24%. Narrowing
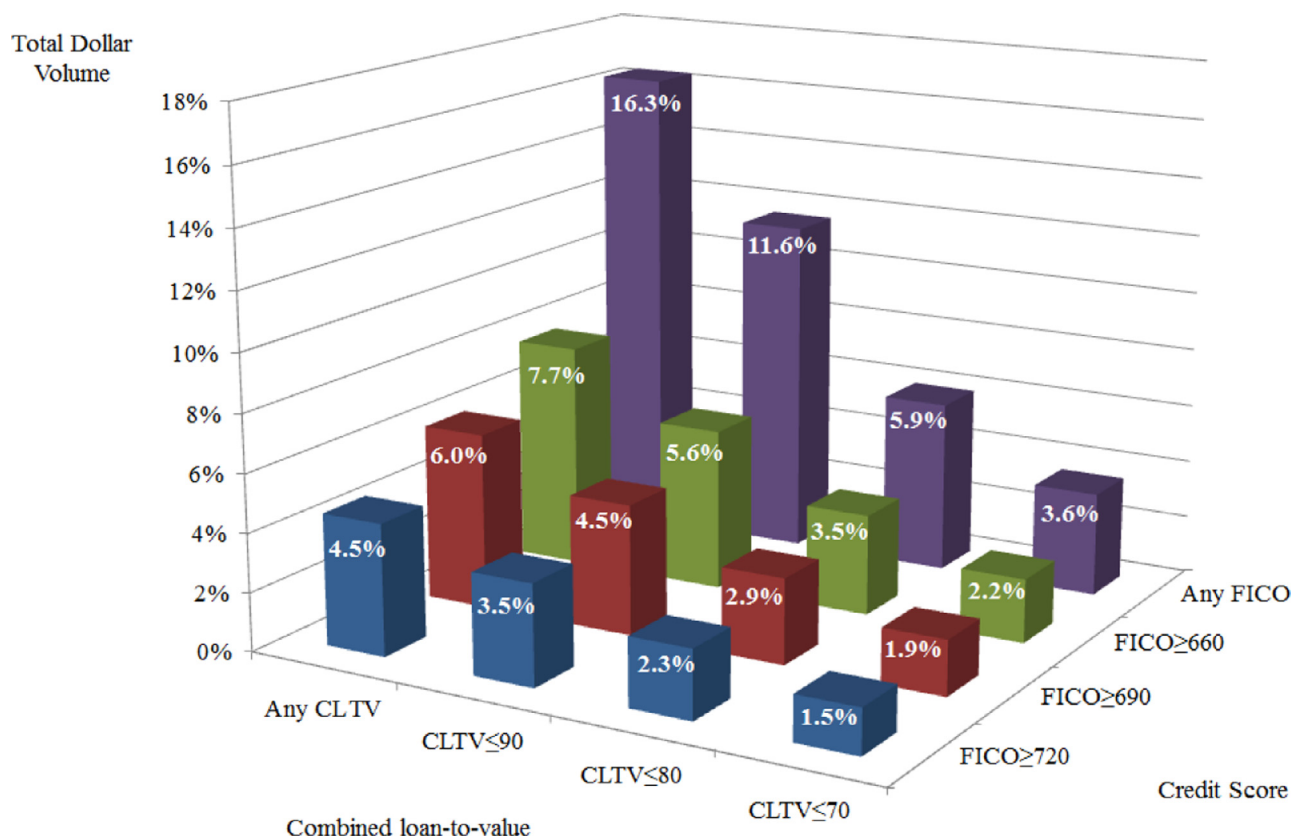
Fig. 4. Percent of dollar volume for QM-eligible loans. This figure presents a three-dimensional chart of the percentage of total sample loan volume for QM-eligible loans with combinations of credit score (FICO) and combined loan-to-value (CLTV) restrictions. We designate a loan as QM-eligible if the loan term is less than or equal to 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is less than or equal to 43%.

QM-eligible loans to credit scores of at least 660 but placing no restrictions on the combined loan-to-value ratio reduces the serious delinquency rate for the full sample by more than half to 18.8%. Restricting credit scores to at least 690 and 720 with any level of combined loan-to-value ratio lowers the serious delinquency rate for QM-eligible loans to 14.4% and 11.1%, respectively. For QM-eligible loans with any credit score, imposing a 90% maximum combined loan-to-value ratio reduces the average serious delinquency rate to 30.1%, which is a 10.4% relative decline from the QM-eligible serious delinquency rate. QM-eligible loans with an 80% maximum combined loan-to-value ratio and any credit score further reduces the mean serious delinquency rate to 26.1%, which is a 22.3% reduction from the full QM-eligible sample serious delinquency rate. Looking at the interaction of credit scores and combined loan-to-value ratios associated with the re-proposed QRM definition, a minimum 690 credit score and a combined loan-to-value ratio no greater than 70% results in an serious delinquency rate of 5.0%, which is an 89% decrease from the overall serious delinquency rate. Overall, Fig. 3 illustrates that credit score and combined loan-to-value ratio restrictions considerably reduce serious delinquency rates, both individually and in combination.

Fig. 4 illustrates the impact of additional credit score and combined loan-to-value ratio restrictions beyond the definition of a QM to the total dollar volume of historical loans in our sample. For ease of comparison with Fig. 3, we present the effect as a percentage of the total dollar volume for all loans in our sample. Historical total dollar volume meeting the definition of a QM constitutes 16.3% of the dollar volume for the full sample. Approximately 6% of the full sample meets the QM requirements and has a credit score of at least 690 or a combined loan-to-value ratio

no greater than 80%. When combined, less than 2% of the sample meets the QM definition and has a combined loan-to-value ratio ≤ 70% and credit score ≥ 690. Therefore, most (98%) historical non-agency securitized loans would not meet these two key thresholds in the 2013 proposed definition of a QRM. We further examine the tradeoff of serious delinquency and dollar volume in Section 4.7.

Overall, the comparative statistics indicate that many factors impact the performance of non-agency securitized mortgages. We find an application of the definition of QM results in a modest decline in serious delinquency rates. However, additional restrictions on credit score and combined loan-to-value appear to significantly reduce serious delinquency rates. We also find a strong indication of moral hazard when the loan originator is not affiliated with the loan servicer. One possible interpretation is that less screening on soft information takes place for loans that are eventually securitized and serviced by unaffiliated agents. Next, we examine risk characteristics and application of the QM definition and factors associated with the proposed QRM definitions in a multivariate setting.

4.4. Model of serious delinquency

We estimate binomial logistic models and the effects of borrower and loan characteristics on the probability of serious delinquency (SDQ). Specifically, we estimate the following equation for our full sample. All variables are defined in Appendix A.[28]

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[28] We provide a discussion of the expected relationship of each variable with default risk based on extant literature in an Internet Appendix.

$$Ln\frac{SDQ_i}{1-SDQ_i} = \alpha + \beta_1 Debt\text{-}to\text{-}income_i + \beta_2 Combined\ loan\text{-}to\text{-}value_i + \beta_3 Credit\ score_i$$
$$+ \beta_4 Interest\ rate_i + \beta_5 Private\ mortgage\ insurance_i + \beta_6 Teaser\ rate_i$$
$$+ \beta_7 First\ lien_i + \beta_8 Prepayment\ penalty_i + \beta_9 Owner\ occupied_i + \beta_{10} Affiliated_i$$
$$+ \beta_{11} Jumbo\ loan_i + \beta_{12} Full\ documentation_i + \beta_{13} Long\text{-}term\ loan_i$$
$$+ \beta_{14} Negative\ amortization_i + \beta_{15} Interest\ only_i + \beta_{16} Balloon_i \qquad (1)$$

We also estimate a similar equation for historic loans meeting the current definition of a QM. To determine the potential impact of defining a QRM more narrowly than a QM, we estimate Eq. (2) for three ranges of combined loan-to-value ratios and credit scores: 70%, 80% and 90% maximum combined loan-to-value ratios; and 660, 690, and 720 minimum credit scores.

insurance does not attenuate serious delinquency in non-agency securitized loans when holding other default risk factors constant. Overall, the explanatory power of the model as captured by the pseudo R-squared values does not vary considerably across the five models indicating that these risk factors help explain serious

$$Ln\frac{SDQ_i}{1-SDQ_i} = \alpha + \beta_1 Debt\text{-}to\text{-}income_i + \beta_2 Combined\ loan\text{-}to\text{-}value_i + \beta_3 Credit\ score_i$$
$$+ \beta_4 Interest\ rate_i + \beta_5 Private\ mortgage\ insurance_i + \beta_6 Teaser\ rate_i$$
$$+ \beta_7 First\ lien_i + \beta_8 Prepayment\ penalty_i + \beta_9 Owner\ occupied_i + \beta_{10} Affiliated_i + \beta_{11} Jumbo\ loan_i \qquad (2)$$

For Eqs. (1) and (2), we analyze the marginal effects, with larger absolute values corresponding to a greater impact on serious delinquency rates. For continuous variables (credit score, combined loan-to-value and debt-to-income ratios, and interest rate), we follow prior literature (e.g., Demyanyk and Van Hemert, 2011) in providing an economic interpretation by examining the predicted marginal effects for a one standard deviation increase in the corresponding loan characteristic. Thus, the reported values in Table 5 can be interpreted as the increase or decrease in the odds of serious delinquency for a one standard deviation increase in the continuous borrower or loan characteristic. For all binary characteristics, the marginal effects represent the percent change in the probability of serious delinquency associated with the presence of the loan or product feature. In each model estimate, we include loan origination year and property state fixed effects.[29]

4.5. Logistic regression results

In Table 5 we present our logistic regression estimates to analyze the explanatory power of risk characteristics on serious delinquency levels. In both Panel A and Panel B, we present regression estimates when using the full sample, QM-eligible loans, and QM-eligible loans stratified on differing levels of combined loan-to-value ratios and credit scores. These tests are intended to measure differences in the explanatory power of the independent variables on the serious delinquency levels as we apply the QM and proposed QRM criteria.

The five explanatory variables with the highest absolute marginal effects are affiliation, negative amortization, credit score, combined loan-to-value ratio, and full documentation. The association of agent affiliation and credit scores with serious delinquency levels remains economically significant even for QM-eligible loans with combined loan-to-value ratios capped at 70%. Interestingly, we find the association between debt-to-income and serious delinquency is small across all models. We also find a positive coefficient for private mortgage insurance indicating that mortgage

delinquency equally for the full sample and for QM-eligible loans with higher and lower combined loan-to-value ratios. For the full and QM-eligible sample, all variables presented in Table 5 are significantly related to serious delinquency. However, as we examine more restrictive levels of combined loan-to-value ratios for QM-eligible loans in Panel A, we see a loss in statistical significance for coefficients on first lien and jumbo loans in some specifications.

In Panel B, we examine credit score stratification with and without combined loan-to-value ratio restrictions. In the first three columns, we place no restrictions on combined loan-to-value ratio while increasing the minimum credit score from 660 to 690 and 720, respectively. In the last three columns, we restrict the minimum credit score to 690 to look at the combination of a credit score ≥ 690 and differing combined loan-to-value ratio thresholds. Overall, we find the marginal effects of most independent variables are attenuated once tighter restrictions on credit score and combined loan-to-value ratio are combined. For example, the marginal effect of agent affiliation on serious delinquency is reduced from −13% for the full sample to −3% for the QM-eligible sample with a combined loan-to-value ratio ≤ 90% and credit score ≥ 690. We conjecture that this indicates that the restriction of loans to higher quality hard information (i.e., credit score and combined loan-to-value ratio) reduces but does not eliminate the presence of moral hazard.[30] Collectively, the logistic regression models reinforce the notion that credit score and combined loan-to-value ratio are important determinants of loan performance, even when filtering out risky product types, high debt-to-income ratios, and less than full documentation prohibited from the QM definition.[31]

4.6. Propensity score analysis

One concern with our logistic regression is that many of our key variables are likely endogenous to mortgage default risk. For

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[29] Our results are robust to clustering at the originator level; controlling for the states within the top quintile of originations and delinquencies during the sample period; replacing the initial interest rate with the initial interest rate spread; controlling for loan purposes (i.e., purchase versus refinance); and examining fixed and adjustable interest rates separately. For the sake of brevity, these results are not tabulated.

[30] As the level of securitizations increase, moral hazard (Rajan et al., 2015) and the incentives of originators to screen borrowers on hard information (Keys et al., 2012) also increase. Because many loans in our sample originate during 2004–2007, we re-estimate our models separately for loans both during and outside of this period. The results are robust.

[31] As an additional untabulated test of factor performance in accurately predicting default, we also compare the area under the receiving operating characteristic (ROC) curve (Bauer and Agarwal, 2014; Medema et al., 2009). In single factor models of serious delinquency, we find the ROC curve area is significantly greater using either credit scores or combined loan-to-value ratios versus a single factor model with debt-to-income as the right-hand side variable.

Table 5
Probability of serious delinquency.

Panel A. Combined loan-to-value (CLTV) stratification

	Full sample	QM-eligible sample			
	Any CLTV Any FICO	Any CLTV Any FICO	CLTV $\leq$ 90% Any FICO	CLTV $\leq$ 80% Any FICO	CLTV $\leq$ 70% Any FICO
Coefficient					
Debt-to-income	0.95***	0.71***	0.88***	1.04***	0.94***
Combined loan-to-value	2.99***	2.01***	1.69***	1.47***	0.04***
Credit score	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***
Interest rate	0.08***	0.12***	0.16***	0.21***	0.24***
Private mortgage insurance	0.04***	0.07***	0.18***	0.30***	0.39***
Teaser rate	0.09***	0.08***	0.06***	−0.05***	−0.05**
First lien	0.22***	0.05***	0.09***	0.00	−0.08**
Prepayment penalty	0.31***	0.31***	0.30***	0.34***	0.44***
Owner occupied	−0.25***	−0.40***	−0.45***	−0.31***	−0.24***
Jumbo loan	0.10***	0.02*	0.01	0.04	0.08**
Affiliated	−0.54***	−0.48***	−0.51***	−0.55***	−0.61***
Full documentation	−0.42***				
Long-term loan	0.04***				
Negative amortization	0.50***				
Interest-only	0.31***				
Balloon payment	0.28***				
Marginal effects					
Debt-to-income	0.02***	0.01***	0.01***	0.01***	0.01***
Combined loan-to-value	0.11***	0.07***	0.05***	0.03***	0.02***
Credit score	−0.11***	−0.11***	−0.08***	−0.07***	−0.06***
Interest rate	0.04***	0.04***	0.05***	0.05***	0.06***
Private mortgage insurance	0.01***	0.02***	0.04***	0.05***	0.06***
Teaser rate	0.03***	0.02***	0.01***	−0.01***	−0.01**
First lien	0.03***	0.01***	0.02***	0.00	−0.01**
Prepayment penalty	0.10***	0.06***	0.06***	0.05***	0.06***
Owner occupied	−0.06***	−0.09***	−0.09***	−0.05***	−0.03***
Jumbo loan	0.04***	0.00*	0.00	0.01	0.01**
Affiliated	−0.13***	−0.10***	−0.10***	−0.08***	−0.08***
Full documentation	−0.11***				
Long-term loan	0.02***				
Negative amortization	0.12***				
Interest-only	0.09***				
Balloon payment	0.07***				
Average serious delinquency rate	44.4%	33.6%	30.1%	23.1%	20.5%
Observations	2,689,142	599,380	366,064	168,533	101,078
Pseudo R^2	0.1747	0.1515	0.1529	0.1637	0.1750

Panel B. Credit score (FICO) and combined loan-to-value (CLTV) stratification

	QM-eligible					
	Any CLTV FICO $\geq$ 660	Any CLTV FICO $\geq$ 690	Any CLTV FICO $\geq$ 720	CLTV $\leq$ 90% FICO $\geq$ 690	CLTV $\leq$ 80% FICO $\geq$ 690	CLTV $\leq$ 70% FICO $\geq$ 690
Coefficient						
Debt-to-income	0.95***	1.11***	1.21***	1.71***	2.26***	2.09***
Combined loan-to-value	1.77***	1.99***	2.12***	2.00***	1.70***	0.58***
Credit score	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***
Interest rate	0.13***	0.15***	0.18***	0.27***	0.45***	0.51***
Private mortgage insurance	0.20***	0.17***	0.15***	0.24***	0.25	−0.11
Teaser rate	0.10***	0.15***	0.18***	0.06*	−0.01	−0.12
First lien	0.16***	0.21***	0.28***	0.44***	0.53***	0.51***
Prepayment penalty	0.43***	0.49***	0.52***	0.59***	0.69***	0.77***
Owner occupied	−0.40***	−0.32***	−0.24***	−0.23***	−0.03	0.03
Jumbo loan	−0.13***	−0.25***	−0.32***	−0.21***	−0.06	0.08
Affiliated	−0.47***	−0.44***	−0.45***	−0.49***	−0.74***	−0.67***
Marginal effects						
Debt-to-income	0.01***	0.01***	0.01***	0.01***	0.01***	0.00***
Combined loan-to-value	0.04***	0.03***	0.03***	0.02***	0.01***	0.00***
Credit score	−0.05***	−0.03***	−0.02***	−0.02***	−0.02***	−0.01***
Interest rate	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
Private mortgage insurance	0.02***	0.02***	0.01***	0.01***	0.01	0.00
Teaser rate	0.01***	0.01***	0.01***	0.00*	0.00	0.00
First lien	0.02***	0.02***	0.02***	0.02***	0.02***	0.01***
Prepayment penalty	0.05***	0.05***	0.04***	0.04***	0.03***	0.02***
Owner occupied	−0.05***	−0.03***	−0.02***	−0.01***	0.00	0.00
Jumbo loan	−0.02***	−0.02***	−0.02***	−0.01***	0.00	0.00
Affiliated	−0.05***	−0.04***	−0.03***	−0.03***	−0.02***	−0.02***
Average serious delinquency rate	18.8%	14.4%	11.1%	10.3%	6.6%	5.0%
Observations	238,615	174,717	122,911	101,026	57,636	36,521
Pseudo R^2	0.1701	0.1665	0.1636	0.1784	0.1756	0.1860

This table presents the results of a logistic regression with a dependent variable equal to one if the loan is ever seriously delinquent (SDQ). Panel A presents the results based on combined loan-to-value (CLTV) stratification. Panel B presents the results based on credit score (FICO) stratification. All models include controls for origination year and property state. For continuous variables, the reported marginal effects are the product of the marginal effect and one standard deviation. Therefore, these values represent the change in the odds of serious delinquency for a one standard deviation increase in the loan characteristic. ***, **, and * indicate significance at the 1%, 5%, and 10% levels. All variables are defined in Appendix A.

Table 6
Propensity score matching analysis.

	Treated	Untreated	Treated vs. untreated		Treated vs. control	
	N	N	Treatment SDQ %	Standard error	Treatment SDQ %	Standard error
Credit score (FICO)						
FICO $\geq$ 660	1,343,524	1,345,619	−15.01***	0.0006	−14.87***	0.0109
FICO $\geq$ 690	907,190	1,781,953	−18.97***	0.0006	−15.05***	0.0096
FICO $\geq$ 720	572,054	2,117,089	−22.71***	0.0007	−15.88***	0.0085
Combined loan-to-value ratio (CLTV)						
CLTV $\leq$ 70%	383,338	2,305,805	−23.04***	0.0009	−18.39***	0.0018
CLTV $\leq$ 80%	977,839	1,711,304	−6.88***	0.0006	−14.22***	0.0017
CLTV $\leq$ 90%	1,534,478	1,154,665	−13.74***	0.0006	−13.82***	0.0020
Debt-to-income ratio (DTI)						
DTI $\leq$ 36%	88,894	1,790,333	−10.82***	0.0006	−4.41***	0.0036
DTI $\leq$ 38%	1,103,238	1,585,905	−10.39***	0.0006	−4.44***	0.0037
DTI $\leq$ 43%	1,673,572	1,015,571	−9.16***	0.0006	−3.57***	0.0042
Private mortgage insurance	88,894	2,600,249	−6.88***	0.0017	−0.68**	0.0029
Teaser rate	1,157,540	1,531,603	11.64***	0.0006	2.58	0.0211
First lien	2,084,510	604,633	1.27***	0.0007	−1.45***	0.0019
Prepayment penalty	1,437,463	1,251,680	16.86***	0.0006	6.68***	0.0017
Owner occupied	2,336,283	352,860	−0.83***	0.0009	−8.18***	0.0017
Jumbo loan	402,455	2,286,688	−5.67***	0.0008	0.51***	0.0014
Affiliated	1,231,402	1,457,741	−16.80***	0.0006	−9.42***	0.0014
Full documentation	1,486,947	1,202,196	−9.11***	0.0006	−11.67***	0.0015
Long-term loan	65,302	2,623,841	15.20***	0.0020	2.63***	0.0041
Negative amortization	173,299	2,515,844	0.04	0.0012	4.83***	0.0024
Interest-only	481,581	2,207,562	4.24***	0.0008	7.86***	0.0015
Balloon payment	402,707	2,286,436	20.19***	0.0008	13.22***	0.0018

This table presents differences in serious delinquency rates (SDQ) based on a propensity score matching analysis. In the unmatched comparison, we compare sample loans with a loan characteristics or crossing key thresholds for credit scores (FICO), combined loan-to-value (CLTV) and debt-to-income (DTI) ratios (*treated*) versus those that do not (*untreated*). In the matched comparison, we employ a two stage approach. In the first stage, we generate the propensity score from a probit regression that estimates the conditional probability of a loan having a particular characteristic or crossing each threshold based on other loan and borrower covariates. We then generate a control sample by matching each treated loan based on the propensity score to a single nearest untreated neighbor allowing for replacement in the matched loan. The reported values in column (5) are the average differences in serious delinquency rates between the treated and control samples, each containing the same number of observations. ***, **, and * indicate the treatment effect is significantly different from zero at the 1%, 5%, and 10% levels. Variables are defined in Appendix A.

example, higher credit scores might facilitate borrower access to riskier loan products or loans with smaller down payments. To mitigate these concerns, we use a propensity score matching analysis to estimate the treatment effect of loans with certain characteristics and those crossing key thresholds for credit scores, combined loan-to-value ratios, and debt-to-income ratios on serious delinquency.[32]

Similar to Arentsen et al. (2015) and Fuster and Vickery (2015), we first calculate the propensity score from a probit regression estimating the conditional probability of exceeding a key threshold or having a particular loan characteristic based on other loan and borrower covariates.[33] We then match each loan that exceeds the threshold or has the particular loan feature (treated sample) to one that does not (control sample) using the single nearest neighbor. We match with replacement to ensure that the loans in the control sample have the closest possible propensity score to the treated loan. We then compare the difference in average serious delinquency rates between the treated and control samples. We report these values and the associated standard errors in Table 6.

Similar to the logistic regression, we continue to find a greater influence of credit scores and combined loan-to-value ratios on serious delinquency than most other characteristics. Using the credit score $\geq$ 660 threshold, we find a difference in the serious delinquency rate between the treated and control samples of −14.9%. Similarly, we find a difference in serious delinquency rates between the treatment and control samples of −14.2% and −13.8% using the thresholds of $\leq$ 80% and $\leq$ 90% combined loan-to-value ratios, respectively. However, the differences in serious delinquency rates between the treatment and control sample are much smaller using debt-to-income thresholds. Debt-to-income thresholds of $\leq$ 36% and $\leq$ 43% only reduce serious delinquency rates by 4.4% and 3.6%, respectively.

Across other loan factors, none are as influential on serious delinquency as credit scores and combined loan-to-value ratios. Only balloon payment (−13.2%) and full documentation (−11.7%) have a greater than 10% influence on default, but neither match the magnitude of any presented credit score or combined loan-to-value ratio thresholds. Of note, teaser rates appear to have a large association with default (11.6%) when comparing the treated and untreated sample, but this difference diminishes to 2.6% with no statistical significance when comparing the treated and control samples. Similarly, long-term loans appear to have a 15.2% greater rate of serious delinquency versus the untreated sample, but this reduces to 2.6% when compared to the propensity score matched control sample. Overall, the results of the propensity score matching analysis reinforce the notion that credit scores and loan-to-value ratios are better predictors of default than factors included in the QRM definition.

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[32] Our threshold choices for combined loan-to-value ratios (70%, 80% and 90%) and credit scores (660, 690, and 720) are consistent with those presented in Table 5. For debt-to-income ratios, we select three thresholds: 36%, 38%, and 43%. This iterative approach allows us to both address endogeneity concerns and to estimate the magnitude of treatment for each variable. We select 660 as the initial FICO threshold because, as Mian and Sufi (2009) note, Freddie Mac advises in their origination guide during our sample period that applicants with a credit score above this threshold are considered "lower-risk borrowers." We select the 690 threshold to be consistent with credit scores proxy cited in analysis of the QRM proposed rule. Similarly, our combined loan-to-value and debt-to-income thresholds are selected to be consistent with the QRM proposals (see Appendix B).

[33] We implement this analysis in Stata using the program PSMATCH2 from Leuven and Sianesi (2003). To avoid concerns of over-parameterization, we only select the covariates with marginal effects greater than 10% based on our analysis in Table 5. Our analysis is robust to using all covariates from the full regression specification in Eq. (1) as right-hand side variables in generating a propensity score match.
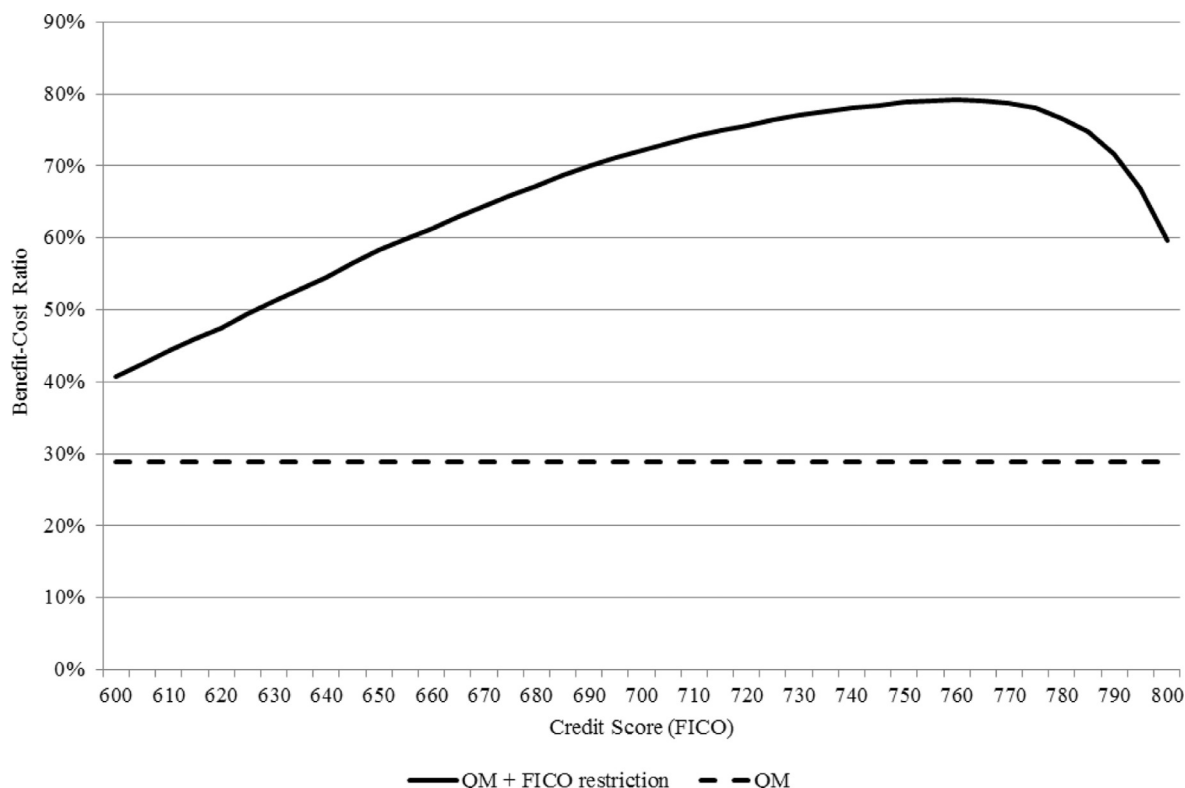
Fig. 5. Credit score benefit-cost ratio. This figure presents the benefit-cost ratio for a range of credit scores (FICO) among QM-eligible loans. The solid line depicts the benefit-cost ratio for each loan with a credit score greater than or equal to the value on the horizontal axis. The dotted line shows the benefit-cost ratio for all QM-eligible loans regardless of credit score. We designate a loan as QM-eligible if the loan term is less than or equal to 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is less than or equal to 43%.

4.7. Tradeoff analysis

In this section, we further examine the tradeoff between reductions in serious delinquency and total dollar volume of historical loans when narrowing the definition of a QRM beyond QM.[34] Our analysis here is close in spirit to a Center for Responsible Lending research report by Quercia et al. (2012). In Quercia et al., the authors focus on the potential socio-economic effects of narrowing the definition of a QRM beyond QM. Specifically, Quercia et al. focus on low-income minority borrower groups in estimating a benefit-cost ratio as the percent reduction in the number of defaults to the percent reduction in the number of loans. We construct a similar benefit-cost ratio as the percent reduction in the number of seriously delinquent loans to the percent reduction in the total dollar volume of originations.

Although our measures are similar, any discrepancies of our findings to Quercia et al.'s analysis could be a result of these authors drawing from a sample that includes non-securitized and agency loans, both of which academic literature has identified as being less likely to default (Elul, 2016; Keys et al., 2012). For example, Quercia et al. find the serious delinquency rate is reduced from 11.0% to 5.8% when adding the QM criteria. We find the overall serious delinquency rate is reduced from 44.4% to 33.6% when focusing on non-agency securitizations with full information on debt-to-income. Also, since Quercia et al. do not include debt-to-income ratio restrictions in their definition of QM, the change in number of loans excluded when applying the QRM definition could differ sub-

stantially. Our study ameliorates these concerns by focusing only on the sample of loans impacted by the QRM definition (i.e., non-agency securitized loans).

In our calculation of the benefit-cost ratio, the percentage decline in serious delinquency is viewed as a benefit, while the percentage decline in loans not meeting the definition of a QRM is viewed as a strict cost. Overall, a higher benefit-cost ratio is preferred. However, several notes of caution are in order. The cost calculation ignores reductions in systematic risk as riskier loans are eliminated from tightening the QRM standards. The benefit calculation ignores the advantages of simplifying the definition and scope of the QRM definition by equating it to QM.[35] Moreover, since the benefits and costs are not measured in identical units, the benefit of a percentage decrease in serious delinquency may not be fully comparable to the cost of a percentage decline in borrower access to a QRM loan. Also, we refrain from establishing a threshold value for the benefit-to-cost ratio that could be considered acceptable from a socio-economic point of view. We replicate this measure both as a proxy for the tradeoffs in narrowing the definition of a QRM beyond QM, and to highlight differences when focusing only on loans impacted by the QRM definition versus pooling agency and non-agency securitizations.

Figs. 5–7 present graphs of the benefit-cost ratio across additional credit score, combined loan-to-value ratio, and debt-to-income ratio restrictions to QM-eligible loans in our sample. Given that QRM can be no broader than QM, we use the ratio from

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[34] Contemporaneous work by Courchane et al. (2015) notes that balancing access to capital and default risk remains a concern even after regulators define QM and QRM.

[35] A comment letter on QRM by the Consumer Federation of America (October 30, 2013) argues that aligning the QRM and QM definition could streamline the mortgage process by applying the same criteria to all mortgage loans as they move from origination to securitization. See https://www.sec.gov/comments/s7-14-11/s71411-386.pdf.
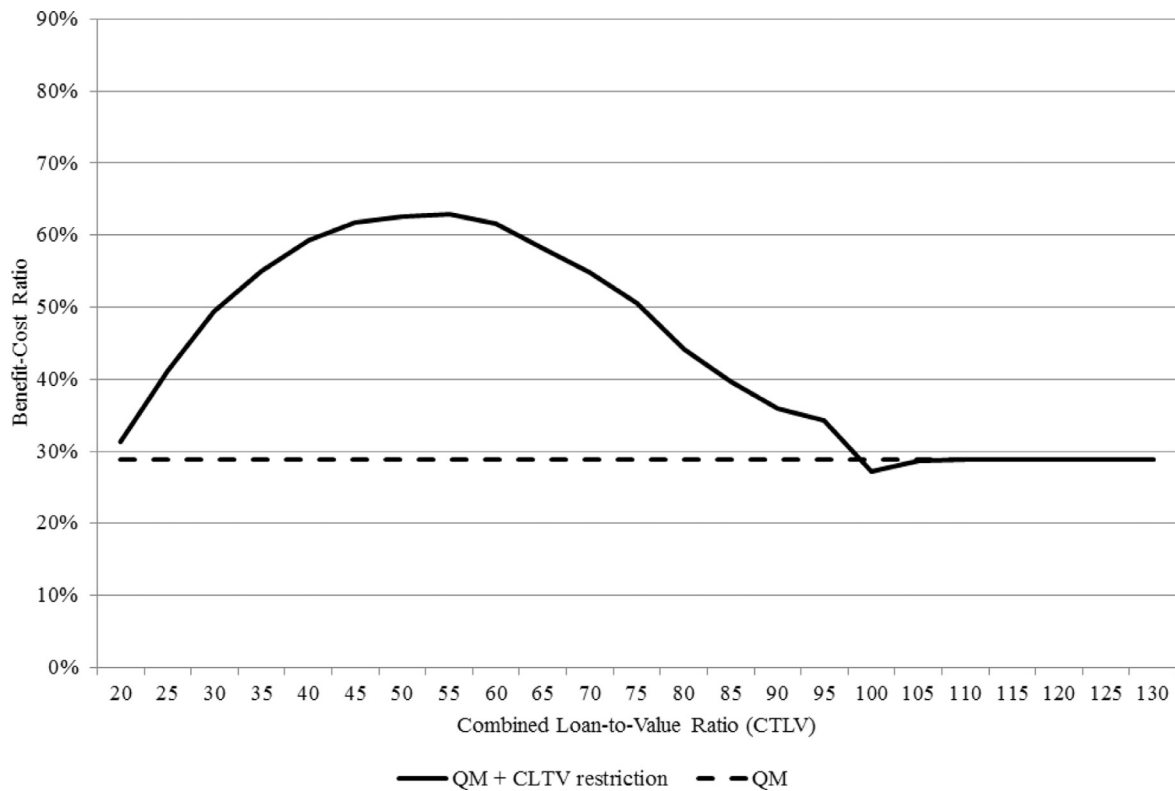
Fig. 6. Combined loan-to-value benefit-cost ratio. This figure presents the benefit-cost ratio for a range of combined loan-to-value (CLTV) ratios among QM-eligible loans. The solid line shows the benefit-cost ratio for each loan with a combined loan-to-value ratio less than or equal to the value on the horizontal axis. The dotted line shows the benefit-cost ratio for all QM-eligible loans regardless of the combined loan-to-value ratio. We designate a loan as QM-eligible if the loan term is less than or equal to 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is less than or equal to 43%.
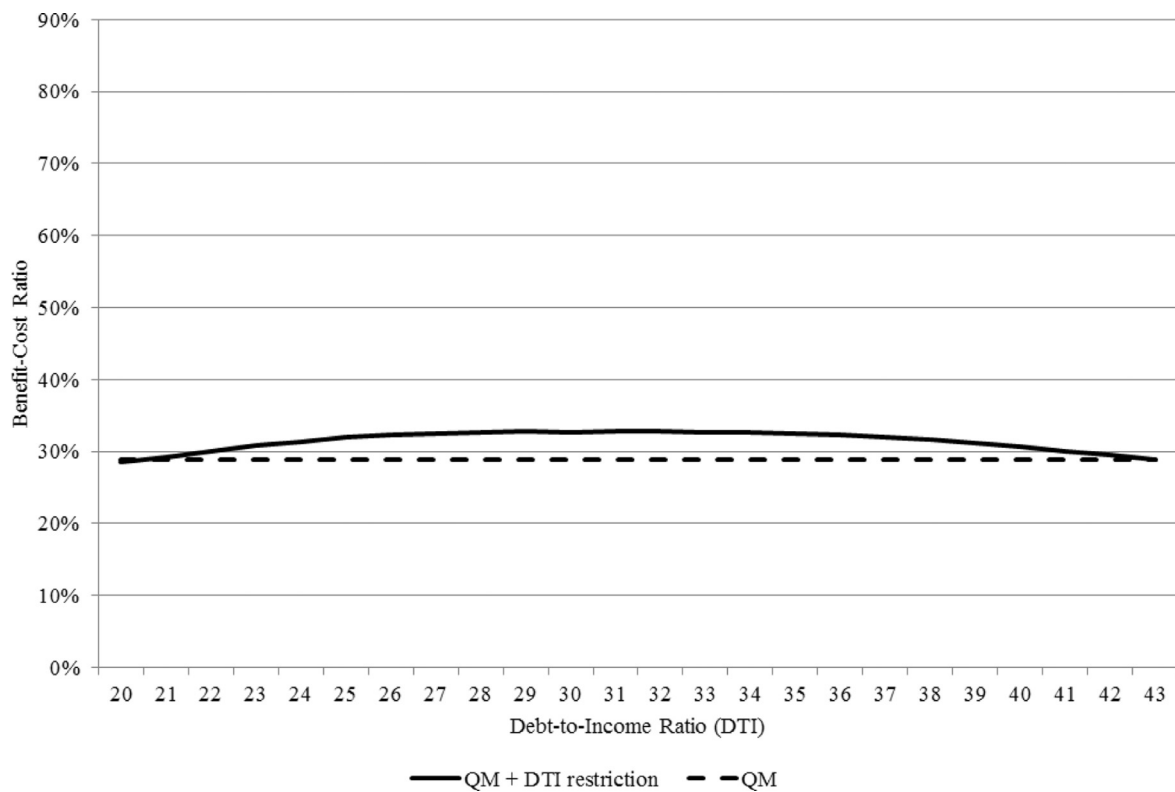
Fig. 7. Debt-to-income benefit-cost ratio. This figure presents the benefit-cost ratio for a range of debt-to-income (DTI) ratios among QM-eligible loans. The solid line shows the benefit-cost ratio for each loan with a debt-to-income ratio less than or equal to the value on the horizontal axis. The dotted line shows the benefit-cost ratio for all QM-eligible loans regardless of debt-to-income ratio. We designate a loan as QM-eligible if the loan term is less than or equal to 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is less than or equal to 43%.

Table 7
Timing of first serious delinquency.

	Full sample	QM-eligible sample			
	Any CLTV Any FICO	Any CLTV Any FICO	CLTV ≤ 90% FICO ≥ 690	CLTV ≤ 80% FICO ≥ 690	CLTV ≤ 70% FICO ≥ 690
Months since origination					
≤ 12 months	6.3	4.8	0.9	0.7	0.6
≤ 24 months	18.5	13.1	2.1	1.2	1.1
≤ 36 months	30.6	21.2	3.9	2.3	1.9
≤ 48 months	37.3	26.5	5.8	3.5	2.7
≤ 60 months	40.9	29.7	7.5	4.6	3.5

This table presents serious delinquency percentages based on the number of months from origination until the first spell of delinquency. Column 1 presents the results for the full sample. Columns 2–5 present the results for loans designated as QM-eligible with increasing restrictions on combined loan-to-value (CLTV) ratios and credit scores (FICO). Variables are defined in Appendix A.

QM-eligible loans as a lower-bound for comparison. Recall from Table 4 that QM-eligible loans have a serious delinquency rate of 33.6%, which is a 24.3% decline from the full sample serious delinquency rate of 44.4%. QM-eligible loans reduce the total dollar volume of full sample loans by 83.7%. Thus, the benefit-cost ratio for QM-eligible loans is 0.243 / 0.837 = 29%. The dotted line in Figs. 5–7 depicts the benefit-cost ratio of 29% for all QM loans regardless of changes in credit score, or combined loan-to-value and debt-to-income ratios.

Fig. 5 shows that an increase in the credit score leads to an increase in the benefit-cost ratio. The ratio reaches its maximum value of 79% when the credit scores are restricted to be no less than 760. At this level, each percentage decline in the loan volume is associated with a 0.8% decline in serious delinquency. As credit scores are tightened beyond 760, we find that the benefit-cost ratio begins to decline.

Fig. 6 shows additional combined loan-to-value ratio restrictions result in an increase of the benefit-cost ratio beyond the definition of a QM. The peak benefit-cost ratio is for loans with a maximum combined loan-to-value ratio of 55%. Comparing Figs. 5 and 6, we see that the maximum benefit-cost ratio for credit scores ≥ 760 exceeds the maximum benefit-cost ratio for combined loan-to-value ratios ≤ 55%. This suggests that credit scores better tradeoff the costs and benefits of narrowing the definition of QRM beyond QM than combined loan-to-value ratios. These results are consistent with the multivariate analysis presented in Section 4.5.

In Fig. 7, we see that a range of debt-to-income ratios beyond the 43% debt-to-income restrictions in QM is not noticeably different from the reported QM benefit-cost ratio. This result is also consistent with multivariate results in Section 4.5, which show the marginal effect of additional restrictions on debt-to-income ratios have a smaller impact on serious delinquency than other factors such as credit scores or combined loan-to-value ratios.

Overall, Figs. 5–7 indicate that any additional restrictions on credit score, combined loan-to-value ratio, and debt-to-income ratio beyond QM reduces serious delinquency rates faster than the loss of loan volume, and that credit score and combined loan-to-value ratio restrictions are more efficient at this tradeoff than debt-to-income ratio restrictions. The differences between the benefit-cost ratio and serious delinquency rates in Quercia et al. (2012) and our paper provide evidence of the stark contrast in agency and non-agency securitizations. Unlike Quercia et al., we find additional restrictions beyond QM to combined loan-to-value ratio and credit score result in an increased benefit-cost ratio when focusing only on non-agency securitizations. These differences highlight the risk of confounding empirical results when agency and non-agency securitizations are pooled (Keys et al., 2012).

4.8. Timing of default

In this section, we first examine the timing of default by measuring the number of months from origination to the first spell of serious delinquency. We find a relatively low percentage of loans default for the first time between 61 and 180 months after origination. This finding motivates the analysis of the relationship between risk characteristics and the number of months until serious delinquency within the first five years of origination.

Table 7 presents the yearly percentage of loans seriously delinquent within the first 60 months after loan origination, and for loans that are not seriously delinquent through the end of five years. For the full sample, 6.3% of loans are seriously delinquent by the end of the first 12 months of origination. The serious delinquency rate nearly triples by the end of 24 months to 18.5% and rises through the end of 60 months to 40.9%. More than half of all defaults occur within 36 months of origination (30.6%). The change in serious delinquencies are similar between 12 and 24 months (18.5−6.3% = 12.2%) and between 24 and 36 months (12.1%). However, this rate declines to 6.7% and 3.6% as the loan matures to 48 and 60 months. One interpretation of this result is that any weaknesses in underwriting or moral hazard due to incentives misalignment are likely to surface within three years of origination. Thus, risk retention beyond three years might be unnecessarily burdensome for non-QM loans.

Columns (2) to (5) reveal the impact of the QM and proposed QRM definitions on historical loan performance. For loans that are QM-eligible, the serious delinquency rate is 4.8% by the end of the first year following origination. The serious delinquency rate exceeds 21% by the end of 36 months for QM-eligible loans. However, column (4) reveals the serious delinquency rate for QM-eligible loans with a credit score ≥ 690 and a combined loan-to-value ratio ≤ 80% within 60 months (4.6%) is lower than the serious delinquency rate for all QM-eligible loans within 12 months (4.8%). This again demonstrates the effectiveness of restrictions on credit scores and loan-to-value ratios in reducing mortgage default.

Next, we examine the loan and borrower factors at origination that are associated with expediting or delaying serious delinquency by employing a Cox proportional hazard modeling framework. We estimate the Cox regression of the probability of serious delinquency within the first 60 months after loan origination controlling for origination year.[36] We focus on this period because we observe in Table 7 that most serious delinquency events occur within

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[36] One caveat of this analysis is that we do not measure performance following the first serious delinquency event. Thus, our analysis does not identify loan characteristics associated with the re-emergence from serious delinquency. However, Ambrose and Capone (2000) find loans that recover from serious delinquency tend to re-enter serious delinquency at a higher rate than those having never been delinquent.

Table 8
Timing of first serious delinquency.

Panel A. Combined loan-to-value (CLTV) stratification

	Full sample	QM-eligible sample			
	Any CLTV Any FICO	Any CLTV Any FICO	CLTV ≤ 90% Any FICO	CLTV ≤ 80% Any FICO	CLTV ≤ 70% Any FICO
Debt-to-income	2.19***	1.77***	1.94***	2.41***	2.32***
	(0.023)	(0.053)	(0.074)	(0.155)	(0.202)
Combined loan-to-value	9.92***	5.24***	4.27***	3.30***	2.29***
	(0.082)	(0.103)	(0.106)	(0.127)	(0.123)
Credit score	1.00***	0.99***	1.00***	1.00***	1.00***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Interest rate	1.06***	1.11***	1.17***	1.22***	1.26***
	(0.001)	(0.003)	(0.003)	(0.005)	(0.007)
Private mortgage insurance	0.99	1.01	1.12***	1.13*	1.20***
	(0.006)	(0.013)	(0.020)	(0.075)	(0.128)
Teaser rate	1.12***	1.12***	1.11***	1.02	1.01***
	(0.003)	(0.006)	(0.008)	(0.012)	(0.017)
First lien	1.13***	1.05***	1.12***	0.99	0.93
	(0.004)	(0.009)	(0.015)	(0.020)	(0.025)
Prepayment penalty	1.38**	1.36***	1.39***	1.46***	1.59***
	(0.003)	(0.007)	(0.010)	(0.018)	(0.026)
Owner occupied	0.84***	0.72***	0.70***	0.80***	0.84***
	(0.002)	(0.005)	(0.006)	(0.014)	(0.021)
Jumbo loan	1.20***	1.02**	0.97*	1.02	1.04***
	(0.004)	(0.012)	(0.013)	(0.022)	(0.033)
Affiliated	0.75***	0.71***	0.69***	0.64***	0.60***
	(0.001)	(0.004)	(0.005)	(0.007)	(0.009)
Full documentation	0.69***				
	(0.001)				
Long-term loan	1.12***				
	(0.006)				
Negative amortization	1.38***				
	(0.008)				
Interest-only	1.26***				
	(0.003)				
Balloon payment	1.23***				
	(0.003)				
Observations	2,689,143	599,388	366,072	168,539	101,080
Year fixed effects	Yes	Yes	Yes	Yes	Yes
LR χ²	666,282	100,588	68,847	29,997	18,196
Log likelihood	−17,049,226	−2,581,792	−1,359,857	−449,033	−226,962

Panel B. Credit score (FICO) and combined loan-to-value (CLTV) stratification

	QM-eligible					
	Any CLTV FICO ≥ 660	Any CLTV FICO ≥ 690	Any CLTV FICO ≥ 720	CLTV ≤ 90% FICO ≥ 690	CLTV ≤ 80% FICO ≥ 690	CLTV ≤ 70% FICO ≥ 690
Debt-to-income	2.31***	2.82***	3.41***	4.75***	9.10***	7.50***
	(0.146)	(0.243)	(0.403)	(0.596)	(1.944)	(2.241)
Combined loan-to-value	3.57***	4.16***	4.61***	4.41***	3.33***	1.33*
	(0.133)	(0.209)	(0.315)	(0.333)	(0.362)	(0.211)
Credit score	0.99***	0.99***	0.99***	0.99***	0.99***	0.99***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Interest rate	1.09***	1.11***	1.14***	1.25***	1.48***	1.55***
	(0.04)	(0.006)	(0.008)	(0.013)	(0.025)	(0.031)
Private mortgage insurance	1.17***	1.14***	1.12***	1.22***	1.33	1.01
	(0.025)	(0.030)	(0.039)	(0.056)	(0.426)	(0.722)
Teaser rate	1.18***	1.23***	1.30***	1.13***	1.00	0.91
	(0.015)	(0.022)	(0.031)	(0.033)	(0.059)	(0.087)
First lien	0.94***	1.01	1.08***	1.27***	1.38***	1.40***
	(0.014)	(0.020)	(0.029)	(0.040)	(0.068)	(0.094)
Prepayment penalty	1.63***	1.72***	1.77***	1.92***	2.16***	2.34***
	(0.014)	(0.027)	(0.038)	(0.049)	(0.093)	(0.143)
Owner occupied	0.72***	0.79***	0.86***	0.80***	0.97	1.01
	(0.018)	(0.013)	(0.019)	(0.021)	(0.047)	(0.073)
Jumbo loan	1.00	0.93***	0.87***	0.96	1.11**	1.19***
	(0.009)	(0.022)	(0.027)	(0.029)	(0.051)	(0.078)
Affiliated	0.69***	0.67***	0.66***	0.66***	0.59***	0.55***
	(0.007)	(0.009)	(0.013)	(0.015)	(0.023)	(0.032)
Observations	238,619	174,721	122,914	101,030	57,636	36,635
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
LR χ²	35,801	21,289	12,046	10,781	4,504	2,332
Log likelihood	−532,118	−291,645	−153,417	−113,457	−39,018	−20,460

This table presents a Cox proportional hazard model of months to serious delinquency within five years of origination. Panel A presents the hazard ratios of parameter estimates, $exp(\hat{\beta})$, for the full sample and for QM-eligible loans and by combined loan-to-value stratification. Panel B presents credit score and combined loan-to-value stratification for QM-eligible loans. We control for origination year. and present standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Variables are defined in Appendix A.

five years of origination. Specifically, we estimate the hazard rate h of serious delinquency for loan i at month t since origination using the following conditional hazard function:

$$h_i(t, X_i') = h_0(t) \exp(\beta X_i') \qquad (3)$$

where $h_0(t)$ is the baseline hazard function, which is dependent only upon the months since origination. No particular shape is assumed for the baseline hazard, $h_0(t)$, which is non-parametrically estimated. X_i' is a vector of non-time varying covariates for loan i that includes all of the borrower and loan characteristics at origination from Eqs. (1) and (2). Loans that experience one spell of serious delinquency during this period are non-censored. For loans that do not experience one spell of serious delinquency through the end of five years following origination, the hazard equals zero, and thus these data are right-censored.

In Table 8, we present the hazard ratio parameter estimates, $\exp(\hat{\beta})$, and corresponding standard errors for each risk factor. In this framework, hazard ratios are assumed to be constant over time. The reported hazard ratio parameter estimates correspond to a one-unit increase in the borrower or loan factors. Hazard ratios greater than one expedite the occurrence of serious delinquency, while those less than one delay it.[37]

Similar in construct to Table 5, we analyze the loan characteristics for the full sample, QM-eligible, and varying thresholds of combined loan-to-value ratios and credit scores. In Panel A, we present the results of the hazard model for the full sample and stratified by combined loan-to-value ratios. Among all loan and borrower factors, we note that the combined loan-to-value ratio has a relatively large and significantly positive effect on the speed of serious delinquency for both the full sample and QM-eligible loans. Similar in spirit to results from the logistic model of default in Section 4.5, greater levels of debt-to-income and the presence of a prepayment penalty, negative amortization, interest-only and balloon payments are associated with expedited serious delinquency. Higher credit scores, owner-occupied loans, affiliated loans, and loans with full documentation have a delayed instance of serious delinquency within the first five years. Interestingly, the first lien position also expedites the serious delinquency event. This result is consistent with notion of strategic default (Jagtiani and Lang, 2011), where borrowers default on the first loan based on a low probability of foreclosure, but remain current on second liens to maintain access to other lines of credit. Overall, the results of the hazard model provide additional evidence that many of the risk characteristics that significantly expedite the instance of serious delinquency, such as combined loan-to-value, are absent from the final definition of a QRM.

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[37] In untabulated results, we re-estimate Eqs. (1) and (2) replacing the dependent variable with the number of months to default for loans that experience at least one serious delinquency spell within five years of origination. Results from this OLS regression are similar to those reported using the Cox hazard modeling A' framework.

5. Conclusion

After the financial crisis, Congress mandated risk retention rules under Dodd–Frank to align incentives and reduce moral hazard in the non-agency residential mortgage-backed securities markets. Yet, Dodd–Frank provides an exemption from all risk retention for securitizations of loans meeting the QRM definition. Congress instructed regulators to define a QRM by examining factors that historical loan performance data associates with a lower risk of default. Regulators initially proposed a QRM definition with restrictions on credit history, down payments, and loan-to-value ratios. In response to lobbying by housing market participants, regulators chose to drop these requirements and widened the QRM exemption to the loosest possible definition under Dodd–Frank.

We examine historical non-agency securitizations to determine which borrower and loan characteristics are the most important determinants of the occurrence and timing of serious delinquency. We find that credit scores and combined loan-to-value ratios are among the most significant factors associated with default risk and timing. The explanatory power of credit scores and combined loan-to-value ratios in predicting historical default is robust to loans with and without riskier product types, and in settings where the potential for moral hazard is the greatest. Yet, both factors are absent from the final QRM definition.

We show that even modest restrictions on credit scores and combined loan-to-value ratios reduce historical default rates faster than they reduce qualifying loan volume. Moreover, we find that these factors more efficiently tradeoff default risk and access to capital than those included in the final QRM definition. Thus, our findings suggest that regulators ignored the most important and efficient risk factors in determining which loans to exempt from risk retention. Our results also indicate that most non-agency defaults occur within three years from origination. Thus, requiring risk retention for loans not meeting the QRM definition might be unnecessarily burdensome on originators and sponsors.

Overall, our analysis has important present and future policy implications. We identify the most important factors in determining non-agency mortgage defaults. These factors are important for regulators to consider when reviewing the QRM definition or establishing loan characteristics that must be disclosed to potential investors in residential mortgage-backed securities issuances.

A few notes of caution are in order. Our analysis does not speak to the effectiveness of risk retention in reducing conflicts of interest in residential mortgage securitizations, nor to the optimal amount of mandatory or voluntary risk retention to both reduce moral hazard and signal the quality of an asset-backed securities issuance (Begley and Purnanandam, 2015; Guo and Wu, 2014). Moreover, we do not speak to the complementary or substitute role of disclosure versus risk retention in both reducing conflicts of interest and assisting investors in appropriately pricing default risk. Each of these areas should be a promising topic for future research as the non-agency securitization market continues to recover in the post-crisis period.

Appendix A. Variable definitions

Dependent	
Serious delinquency	Equals one if loan is ever 90 days late, foreclosed, or real estate owned
Months to default	Number of months from origination until first serious delinquency date

Independent	
Adjustable rate	Equals one if loan has an adjustable interest rate
Affiliated	Equals one if loan originator and servicer are the same entity
Balloon payment	Equals one if loan has a balloon payment
Cash-out refinance	Equals one if loan purpose is cash-out refinance
Combined loan-to-value	Loan-to-value ratio including all liens
Credit score	FICO credit score of the borrower at origination
Debt-to-income	Back-end ratio of the total monthly debt/monthly gross income
First lien	Equals 1 if the loan has the first lien position
Fixed rate	Equals one if loan has a fixed interest rate
Full documentation	Equals one if loan has full documentation
Initial interest rate	Initial interest rate of the loan at origination
Initial interest rate spread	Initial interest rate less average prime offer rate
Interest-only	Equals one if loan includes interest-only payments
Jumbo loan	Equals one if the loan amount exceeds conventional loan limits
Loan-to-value	Ratio of the value of the mortgage to the appraised value
Long-term loan	Equals one if loan term exceeds 30 years at origination
Negative amortization	Equals one if loan includes negative amortization
Owner occupied	Equals one if occupancy status is primary/owner-occupied
Prepayment penalty	Equals one if loan has prepayment penalty
Private mortgage insurance	Equals one if loan includes private mortgage insurance
Purchase	Equals one if loan purpose is purchase
Rate and term refinance	Equals one if loan purpose is rate and term refinance
Teaser rate	Equals one if loan has a teaser rate

Performance	
Ever 90 days late	Equals one if loan has ever been 90 days past due
Foreclosure	Lender forced sale of the property used as collateral
Real estate owned	Property owned by a lender after unsuccessful foreclosure auction

Appendix B. Summary of QM and QRM

Table B-1 presents a summary of the final and proposed definitions of a Qualified Mortgage (QM) and a Qualified Residential Mortgage (QRM). Column (1) presents the 2011 QRM proposed definition. Column (2) presents the re-proposed QRM definition, which was referred to by regulators as "QM plus." Column (3) presents the QM definition. In 2014, regulators chose to equate the QRM definition with the definition of a QM.

Appendix C. Agency and non-agency securitizations

In the economic analysis of the original QRM proposal, regulators focused on agency securitized loans to determine which factors have the largest impact on serious delinquency and total dollar volume. This approach is problematic for two reasons. First, academic literature finds non-agency securitizations are riskier than agency securitized loans (Keys et al., 2012). Elul (2016) finds evidence that non-agency securitized loans are subject to greater adverse selection problems than agency securitized loans, where lenders take advantage of information asymmetry by securitizing riskier loans based on private, non-observable information. Griffin

Table B-1
Proposed and final QRM definitions.

	2011 QRM Proposal	2013 QRM (QM plus) Re-proposal	2014 QRM=QM Final rule
Source	Proposed definition	Re-proposed definition	Final rule
Loan term	≤ 30 years	≤ 30 years	≤ 30 years
Full documentation	Required	Required	Required
Negative amortization	Not allowed	Not allowed	Not allowed
Interest-only payments	Not allowed	Not allowed	Not allowed
Balloon payments	Not allowed	Not allowed	Not allowed
Back-end DTI	≤ 43%	≤ 43%	≤ 43%
Points and fees	3% cap	3% cap	3% cap
Prepayment penalty	Not allowed	Some restrictions	Some restrictions
Credit history	Proxy ≥690 FICO	Proxy ≥690 FICO	No restrictions
CLTV (purchase)	≤ 80%	≤ 70%	No restrictions
CLTV (rate-and-term refinance)	≤ 75%	≤ 70%	No restrictions
CLTV (cash-out refinance)	≤ 70%	≤ 70%	No restrictions
Down payment	20%	30%	No restrictions
Occupancy status	Primary/owner	Primary/owner	No restrictions
Adjustable-rate margins	2/2/6	2/2/6	No restrictions
Lien position	First	First	No restrictions
Property type	1-to-4 family	1-to-4 family	No restrictions

Table C-1
Sensitivity analysis of agency and non-agency loans.

	Full sample	QM eligible	2011 QRM eligible	2011 QRM eligible except		
				DTI	CLTV	FICO
Serious delinquency rate (%)						
Non-agency						
1997–2009	44.4	33.6	3.0	4.9	6.5	13.4
2004	20.8	21.5	2.9	4.2	5.8	9.9
2005	39.6	33.7	4.8	7.6	9.3	16.4
2006	57.6	46.1	5.1	8.0	11.1	19.5
2007	55.1	38.8	3.8	6.2	11.3	22.7
Agency						
1997–2009	5.3	n/a	0.7	2.1	1.7	4.4
2004	4.3	n/a	1.0	2.1	2.5	5.2
2005	8.1	n/a	1.9	4.2	4.2	8.3
2006	13.9	n/a	2.7	6.1	6.5	10.6
2007	17.1	n/a	2.4	6.0	6.8	11.0
Loan dollar volume (%)						
Non-agency						
1997–2009	100.0	16.3	1.2	2.3	2.1	1.7
2004	10.5	14.2	12.8	13.2	12.7	12.7
2005	27.8	29.2	17.7	19.8	19.4	20.0
2006	40.6	28.6	19.3	23.1	18.5	22.1
2007	12.1	5.5	4.7	5.7	4.8	5.4
Agency						
1997–2009	100.0	n/a	19.8	37.2	29.7	23.7
2004	7.9	n/a	17.0	34.7	23.3	21.4
2005	7.9	n/a	14.4	33.2	19.9	17.8
2006	7.4	n/a	11.5	29.1	15.4	14.3
2007	8.6	n/a	10.7	26.9	15.7	13.0

and Maturana (2016) and Piskorski et al. (2015) find misrepresentation of reported (i.e., hard) information, such as second lien presence and owner occupancy status, in non-agency securitized loans. In these studies, loans with misreported information experience substantially greater serious delinquency levels. These papers suggest that non-agency securitized loans are riskier than agency securitized loans due to both misreported hard information and lower screening on unreported soft information. Second, agency securitized loans are currently exempted under the risk retention rules. Thus, in our analysis, we focus on non-agency securitized loans to identify risk characteristics associated with default for the purposes of examining QRM.

Table C-1 compares serious delinquency rates and total dollar volume for agency and non-agency securitizations. Data on the

agency loans are from the 2011 QRM proposal.[38] The serious delinquency rate and fraction of dollar volume are presented for the full sample, loans that meet the definition of QM, loans that meet the 2011 proposed definition of QRM, and loans that meet all but the stated threshold for the 2011 proposed QRM definition. We designate a loan as QM-eligible if the loan term does not exceed 30 years; the loan has full documentation; the loan does not have negative amortization, interest-only or balloon payments; and the back-end debt-to-income is $\leq$ 43%. We label a loan as 2011 QRM eligible if the loan term is $\leq$ 30 years; owner is the primary occupant; loan has full documentation; loan does not have negative amortization, interest-only or balloon payments; there is no prepayment penalty; debt-to-income $\leq$ 36%; credit score is $\geq$ 690, and the combined loan-to-value is $\leq$ 80% (purchase), $\leq$ 75% (rate and term refinance), or $\leq$ 70% (cash-out refinance). All other variables are defined in Appendix A.

Of note is the 44.4% SDQ rate for non-agency securitized loans. This value is nearly nine times greater than the 5.3% serious delinquency rate for all agency securitized loans. When restricting the sample to the 2011 proposed QRM thresholds, the default rate declines to 3.0% for non-agency securitizations and 0.7% for agency securitizations. Table C-1 also suggests that serious delinquency rates are more sensitive to credit scores than combined loan-to-value or debt-to-income ratios for both agency and non-agency loans. Overall, these results provide suggestive evidence consistent with Keys et al. (2012) that agency and non-agency securitized loans perform differently and should therefore be analyzed separately when determining mortgage policies.

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[38] See http://www.sec.gov/rules/proposed/2011/34-64148fr.pdf.