Mortgage Underwriting Standards in the Wake of Quantitative Easing

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Abstract

While the large-scale asset purchases (LSAPs) have funneled vast amounts of capital into the secondary market for mortgages, the direct effect of these programs on the primary mortgage market is not yet clear. We present evidence that while the LSAPs may have improved conditions for the least risky borrowers, they have not improved conditions for all borrowers. For example, the average FICO score of agency securitized mortgages increased from below 720 (low risk) in 2008 to above 760 (extremely low risk) in 2012. What explains this dramatic shift in the average quality of agency securitized mortgages, and why did it persist even with the flood of capital into the secondary mortgage market from the LSAPs? We argue that the change in the probability of buy back requests on Fannie and Freddie mortgage backed securities can explain the tightening of mortgage credit standards.

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1 Introduction

In response to the extraordinary collapse of the mortgage market in 2008, the United States Federal Reserve embarked on quantitative easing (QE) programs of unprecedented scale. Between 2008 and 2012, in what have become known as QE1, QE2 and QE3, or collectively the large-scale asset purchases (LSAPs), the Fed purchased over $2 trillion dollars of mortgage-backed securities and treasury bonds. Given that at least one of the goals of the LSAPs was "to facilitate the extension of credit to households,"[1] it is important to assess the consequences for consumer credit markets, and in particular the prime-mortgage market.

While the LSAPs may have improved conditions for the least risky borrowers, we present evidence that they have not done so for all borrowers. For example, the average FICO score of agency-securitized mortgages increased from below 720 (low risk) in 2008 to above 760 (extremely low risk) in 2012. What explains this dramatic shift in the average quality of agency-securitized mortgages, and why did it persist even with the flood of capital into the secondary mortgage market from the LSAPs? We argue that lowering the cost of funds for mortgage originators, a consequence of the LSAPs, may make them more sensitive to the probability of a mortgage repurchase request.

Coincident with the LSAP programs there has been, and continues to be, considerable controversy concerning lender-repurchase liability, or the degree to which a given violation of a GSE insurance representation and warranty will trigger a repurchase request to a lender. Since 2008, Fannie Mae and Freddie Mac have maintained aggressive repurchase and indemnification programs as part of their efforts to address their own massive balance sheet loss reserves. Many elements of the representations and warranties of agency securitized loans never sunset until the loan principal has fully amortized. The conditions for triggering repurchases include misstatements, misrepresentations, omissions, and data inaccuracies in the loan documents; lack of clear title or first-lien enforceability; lack of compliance with relevant mortgage lending laws and GSE underwriting standards; and ex post trig-

[1] `http://www.federalreserve.gov/newsevents/press/monetary/20090128a.htm`

gers related to delinquencies for mortgages that are significantly seasoned. Some of these trigger events are uncovered as a result of random searches on significantly seasoned loans that are currently both performing and non-performing.[2] As of the third quarter of 2012, the government-sponsored enterprises (GSEs) had $18.28 billion in pending and disputed buy-back demands, up 9.3 percent from the previous quarter.[3] Currently, the GSEs have successfully closed on repurchases, indemnifications, and negotiated settlements valued in aggregate at $46.12 billion of direct liability costs to the lenders who securitized with them.[4] Over and above the potential liability expenses, the GSEs also have the right to exercise their lender termination option, which allows for the permanent expulsion of intransigent lenders from the secondary mortgage market.

In addition to potential liabilities associated with the GSEs' repurchase and indemnification programs, there are also evolving legal precedents and new regulations, which have increased lenders' life-of-loan liability exposure. In recent filings, the U.S. Treasury Department has argued that because it was forced to bail out the two GSEs, losses suffered by the GSEs can be recovered under the False Claims Act,[5] a federal law that provides for treble damages and penalties.[6] Regulatory risk has also increased under the Bank Secrecy Act and the Secure and Fair Enforcement for Mortgage Lending Act, as well as state versions of these laws.

1.1 Related Literature

This paper relates to the ongoing literature on the effect of the Federal Reserve Board's policy of purchasing mortgage-backed securities (MBS) and other long-term securities, known

[2]Our analysis of the pool specific SEC 15GA disclosures by Fannie Mae and Freddie Mac from Q1 2011 through Q1 2014 indicates that loans from pools that were securitized as far back as 1985 are now involved in repurchases and indemnifications.

[3]See *Inside Mortgage Finance*, January, 2013.

[4]See *The Complete Guide to Mortgage Buyback Strategies*, 5^{th} Edition, Bethesda, MD, Inside Mortgage Finance Publications, 2013.

[5]31 U.S.C. §§3729-33

[6]See *The Complete Guide to Mortgage Buyback Strategies*, 5^{th} Edition, Bethesda, MD, Inside Mortgage Finance Publications, 2013, p. 27.

as Quantitative Easing (QE1 and 2), or the Large Scale Asset Purchase Programs (LSAPs), on the mortgage market. While this literature finds that rates in the markets for the securities purchased by the FRB declined, it is not yet clear what the effect has been on the primary mortgage market. Krishnamurthy and Vissing-Jørgensen (2011) examine several channels through which the LSAPs might affect spreads in the MBS market. They find that QE1 lowered MBS yields due to a decrease in both prepayment- and default-risk premia. Scharfstein and Sunderam (2013) find that the decline in MBS spreads had a smaller impact on primary mortgage market spreads in locales with more concentrated mortgage markets. This indicates that while the LSAPs may have lowered the cost of borrowing for mortgage originators, they did not necessarily lower the cost of borrowing for households. Stroebel and Taylor (2012) argue that any decline in credit spreads in the primary mortgage market during the period of the LSAPs is due primarily to an increase in the credit quality of the mortgages originated during that period. For the case of GSE-insured mortgages, this effect operates through an increase in the credit quality of the GSEs themselves. Fuster and Willen (2010) document changes in the mortgage market around the first round of quantitative easing. They find results consistent with ours but settle on a different explanation for the mechanism causing the increase in quality of securitized loans.

Aside from the literature on the effect of recent monetary policy on mortgage markets, our paper also contributes to the literature on credit rationing and mortgage underwriting standards. In two seminal papers, Jaffee and Russell (1976) and Stiglitz and Weiss (1981) introduce the idea that borrower private information can lead to rationing in credit markets. Besanko and Thakor (1987b) show that when discount rates fall, credit rationing can increase. In our model, mortgage underwriters implement an increase in rationing by tightening underwriting standards.

2 The Model

To guide our empirical investigation of the effect of the LSAPs on mortgage underwriting standards, we present a stylized model of mortgage origination. Our model highlights the role of so-called "put-back" options embedded in the mortgage default insurance written by Fannie Mae and Freddie Mac. Put-back options allow the GSE to hold the original securitizer of a mortgage liable for default risk if it can be shown that there was some characteristic of the original mortgage that should have disqualified it from GSE insurance.

The model consists of a mortgage borrower; a mortgage underwriter; a GSE; and outside investors, who will only buy risk-free assets. While many different entities may be involved in the underwriting and origination of a mortgage, we collapse them into a single agent for simplicity. The market participants that most closely match the role of the underwriter in our model are the aggregators responsible for forming pools of mortgages, which are then guaranteed by the GSEs. Although these aggregators might not actually do the paper work associated with origination and underwriting, they are typically setting underwriting standards that are implemented by the actual originators.

There are two dates, and all agents use the common risk-free rate, r. At date $t = 0$ the borrower applies for a mortgage of \$1 from the underwriter in exchange for a payment of $1 + c$ at date $t = 1$, where c is the mortgage coupon rate. The borrower will default on the mortgage with probability $q \in \{q_L, q_H\}$ with $q_L < q_H$. The probability that the borrower is type q_L is θ. When the borrower applies for the mortgage, the underwriter observes a signal $x \in [0, 1]$. The distribution of x is given by a probability density function $f(x|q_i)$ that satisfies the strict monotone likelihood ratio property

$$\frac{\partial}{\partial x}\left(\frac{f(x|q_L)}{f(x|q_H)}\right) > 0, \tag{1}$$

for all $x \in [0, 1]$.

We interpret the signal x to be the aggregate of all the observable characteristics of

the borrower that predict default, including, for example, FICO score, loan-to-value (LTV) and debt-to-income (DTI) ratios, and employment history. If the underwriter approves the mortgage application, the GSE will insure the mortgage against default, at which point it will be considered risk free from the standpoint of outside investors. If the borrower does default on the mortgage, the GSE will uncover the borrower's true type, and if the type is q_L, the GSE will require that the underwriter repurchase the mortgage for the original face value of \$1. That is, the GSE insurance only covers type q_H borrowers. We call this arrangement the put-back agreement.

For simplicity, we assume that c is exogenously given by a spread over the risk-free rate such that the underwriter's net proceeds from the sale of the mortgage to investors are given by some markup $\pi(r)$. For simplicity, we assume that the markup does not depend on the signal x. The expected profit of the underwriter conditional on observing the signal x is then

$$V(r,x) = \pi(r) - q_H(1-\rho(x))\frac{1}{1+r} \tag{2}$$

where $\rho(x)$ is the probability the borrower is type q_L given the signal x, which by Bayes' rule is given by

$$\rho(x) = \frac{\theta f(x|q_L)}{\theta f(x|q_L) + (1-\theta) f(x|q_H)}. \tag{3}$$

Finally, we assume that the markup $\pi(r)$ is high enough that the underwriter gets positive expected profits from originating a loan when she receives a signal $x = 1$. That is, we assume

$$\pi(r) > q_H(1-\rho(1))\frac{1}{1+r} \tag{4}$$

for all r.

To study the effect that the LSAPs may have on underwriting standards, we assume that the primary effect of these programs will be to lower the risk-free rate r. We then consider

the effect on $V(r, \rho)$ of a decrease in the risk-free rate. We have

$$-\frac{\partial V(r,x)}{\partial r} = \underbrace{-\frac{\partial \pi(r)}{\partial r}}_{\text{price effect}} - \underbrace{q_H(1-\rho(x))\frac{1}{(1+r)^2}}_{\text{information sensitivity effect}} . \tag{5}$$

The first term in Equation (5) is the effect of a change in the risk-free rate on the value of a mortgage due to a change in the markup that the underwriter can charge. Indeed, when the risk-free rate changes, there could be an effect on the net proceeds from sale in the secondary mortgage market.[7] The second term in Equation (5) is the effect of a change in the risk-free rate on the value of a mortgage due to a change in the present value of the put-back agreement. When the risk-free rate declines, the value of the put-back agreement becomes more negative from the stand point of the underwriter, and this serves to make her more sensitive to the signal of borrower quality.

We now characterize the approval policy of the underwriter. Since $V(r, x)$ is increasing in ρ and $V(r, 1) > 0$, the underwriter will make positive expected profits as long as x is above some quality threshold $\overline{x}(r)$, which we interpret as the minimum underwriting standard. For example, $\overline{x}(r)$ could be a minimum FICO score or maximum LTV for which the underwriter will earn weakly positive profits. We have

$$\rho(\overline{x}(r)) = 1 - \frac{1}{q_H}\pi(r)(1+r). \tag{6}$$

To see the effect of a change in the risk-free rate on the minimum underwriting standard, we take the derivative of Equation (6) with respect to r to get

$$\frac{\partial \overline{x}(r)}{\partial r} = -\frac{1}{\rho'(\overline{x}(r))q_H}(\pi'(r)(1+r) + \pi(r)). \tag{7}$$

Note that since $f(\cdot|\cdot)$ satisfies the monotone likelihood ratio property, $\rho'(x) > 0$ and we can

[7] See Scharfstein and Sunderam (2013) for evidence that mortgage underwriter profits can increase with a decrease to the risk-free rate due to the LSAPs.

rearrange terms in Equation (7) to find the following proposition:

Proposition 1. *The minimum underwriting standard is decreasing in the risk-free rate,*

$$\frac{\partial \overline{x}(r)}{\partial r} < 0, \tag{8}$$

if and only if the elasticity of the markup to the risk-free rate is low enough:

$$-\frac{\pi'(r)}{\pi(r)} \leq \frac{1}{1+r}. \tag{9}$$

Again we can see the price effect and the information-sensitivity effect. The left hand side of Inequality (9) is the elasticity of the mortgage markup with respect to interest rates, and measures the price effect. The right hand side is the discount factor on the insurance payment, and thus measures the information sensitivity effect. If lowering the risk-free rate allows the underwriter to earn a much higher markup, then the price effect will outweigh the information-sensitivity effect, and the LSAPs should lead to a decrease in underwriting standards. On the other hand, if the markup is relatively insensitive to changes in the discount rate, then the information sensitivity effect will overcome the price effect and the LSAPs should lead to an increase in underwriting standards.

Proposition 1 motivates three main hypothesis that we will test in the data. First, the model indicates that the sign of the effect of the LSAPs on underwriting standards will be determined by the effect of these programs on the markup charged by the underwriter. Since the overall trend, as illustrated by figure 1, appears to be that underwriting standards have tightened during the period of the crisis, we test the following hypothesis:

Hypothesis 1. *The credit quality of approved borrowers, as measured by FICO score, Loan-to-Value and Debt-To-Income, increases around the announcement of LSAP programs.*

Finally, the model suggests that the increases in underwriting standards should be greater when markups are less sensitive to decreases in the risk-free rate.

Hypothesis 2. *The credit quality of approved borrowers, as measured by FICO score, Loan-to-Value and Debt-To-Income, increases more for borrowers when markups are less sensitive to changes in the risk-free rate.*

3 Mortgage Market Data Sources

We use several data sources to test our model. The first source is loan-level origination and performance data that have recently been released by Fannie Mae and Freddie Mac under the conservatorship. These data include all fixed-rate mortgages with loan length 300–420 months securitized by either Fannie Mae or Freddie Mac between 1999 and 2012.[8] In the data set there are 20,403,774 loans securitized by Fannie Mae[9] and 15,699,483 loans securitized by Freddie Mac.[10]

Our second data set includes loan applications, loan rejections, and loan origination data obtained from the Home Mortgage Disclosure Act (HMDA) surveys. The HMDA surveys account for approximately 90% of mortgage originations in the U.S. HMDA reporting is not required for institutions with assets (when combined with the assets of any parent corporation) below $10 million on the preceding December 31, or institutions that originate 100 or more home-purchase loans (including refinancings of home-purchase loans) in the preceding calendar year.[11] HMDA reported 143,651,832 loan originations between 1999 and 2012. Of the 297,883,285 loan applications reported in HMDA over the period, 50,119,827 were reported as rejected, 18,961,277 were reported as approved by the lender but not accepted by the applicant, and 29,754,080 applications were withdrawn by the applicant before approval or rejection by the lender.

[8]The agencies do not release similar information for adjustable-rate or 15-year-maturity mortgages securitized over the same period. Many of these mortgage were originated by Countrywide and Washington Mutual, and are involved in the repurchase legal dispute initiated by the Agencies.

[9]These were obtained from the Fannie Mae website (see `http://www.fanniemae.com/portal/funding-the-market/data/loan-performance-data.html`).

[10]These were obtained from the Freddie Mac website (see `http://www.freddiemac.com/news/finance/sf_loanlevel_dataset.html`).

[11]See `http://www.ffiec.gov/hmda/pdf/2010guide.pdf`.

Our third data set comprises the ex post pool-level putback payouts to Freddie Mac and Fannie Mae by mortgage originators. These data were obtained by downloading all the quarterly Securities and Exchange Commission (SEC) 15G forms for Fannie Mae and Freddie Mac from the SEC website and then merging these data by pool CUSIP with the origination information for each pool using data obtained from the Fannie Mae and Freddie Mac websites.

3.1 Trends in GSE Underwriting Standards

The GSE data include all of the loan-by-loan contractual and underwriting characteristics at origination as described in Appendix A.1. Figure 1 presents the underwriting characteristics for loans securitized into 30-year fixed-rate residential mortgage pools by Fannie Mae and Freddie. As shown in Figure 1a, the monthly average debt-to-income ratios at origination for the subsample of fixed-rate GSE loans used in this study rose gradually between September 2003 and November 2008. Then in November 2008 the average DTIs fell substantially and these lower DTIs persisted through 2012. The interquartile ranges were essentially the same over this period. The GSE FICO scores are reported in Figure 1b. They rose starting in March of 2008, and the interquartile ranges narrowed starting at the same time. The average FICO score has remained persistently high through 2012, at around 750. There is similar evidence for the decrease in average loan-to-value ratios starting in June of 2008, as shown in Figure 1c. Figure 1d presents the time series of the initial balances for newly originated pools, and it clearly shows a large run-up in GSE securitization activity through May 2004, at which time the GSEs were impacted by a serious accounting scandal. After the scandal, the market share of both Fannie Mae and Freddie Mac fell with the growth of private-label securitization and only rose again post crisis with the refinancing boom starting in November 2008. Overall, these graphs indicate that all underwriting standards on conventional, conforming 30-year mortgages tightened after early 2008, despite the aggressive mortgage-backed security buying programs initiated by the Federal Reserve.

3.2 Trends in HMDA Origination and Rejection Underwriting Standards

The advantage of the HMDA data is that it allows us to consider possible sample-selection problems associated with a narrow focus on loans that were successfully originated and securitized by the GSEs over the sample period. Because HMDA is close to the universe of originations in the U.S. mortgage market, and because it includes mortgage applications that were rejected, including information concerning the lender-reported reasons for the rejection, it is ideally suited to address sample-selection problems. The HMDA covariates are described in Appendix A.2.

The underwriting characteristics associated with HMDA origination and rejection rates are reported in Figure 2. Figure 2a shows that the overall percentage of total applications that were rejected was highest in 2000 and then rose again substantially in 2007 at the onset of the mortgage credit crisis. The rejection percentages than declined substantially in 2009 and have then stayed more or less constant since then. Figure 2b shows the percentages of conforming and non-conforming loan applications that were rejected. The rejection percentages are substantially higher for non-conforming loans than for conforming loans, which are usually securitized by the GSEs. Figure 2b shows a similar peak in the percentage of loans rejected in 2007. However, the GSE percentage rejected gradually falls thereafter, whereas the nonconforming percentage of rejections continues to rise until 2009 and then gradually falls.

Figures 2c shows the percentage of rejected conventional, conforming loans for two classes of borrower applicant: Caucasian and non-Caucasian. As shown, the rejection rate is significantly higher for non-Caucasians, but follows the same general trends for both racial groups over time. Figure 2d presents a comparison of the normalized to the 2000 level of the requested loan amount to total annual income for all conventional conforming applicants and for loan applicants who were rejected by the originator because the loan applicant had an excessive debt-to-income ratio. Because the HMDA data does not include a true debt-to-

income ratio for each loan, we use the requested loan amount to the applicants annual income as a proxy for the DTI. As shown, the requested loan amounts to gross annual income were significantly higher for those loans that were rejected due to the unobserved DTI ratio than were the successful loan applications for conventional conforming applicants. Figure 2c and Figure 2d appear to indicate that income constraints are a key censoring factor in mortgage rejections and that these effects differentially impact non-Caucasian applicants.

Overall, the GSE and HMDA underwriting trends suggest that middle-class loan applicants appear to be significantly censored from the conventional, conforming loan market. Clearly, as discussed above the debt-to-income ratios of borrowers appear to be an important censoring factor in leading mortgage applications to be denied. This channel has led to dramatic increases in both the FICO scores and debt-to-income ratios of borrowers who successfully get mortgages. Of course, FICO scores of 760 are hardly a typical middle-class score, and it is the middle class that is the intended borrower from the conventional conforming mortgage market. It is of particular note that all underwriting criteria have become more stringent, including loan-to-value ratios, which are currently around 78%, and there is little evidence that lenders are willing to increase standards in some dimensions and to allow more flexibility in others. As a result the current conventional, conforming borrower is a significantly higher-quality applicant than has traditionally been the case in the U.S.

3.3 Putback Trends

In Figure 3, we focus on the putback activity for conventional conforming 30 year pools securitized by Fannie Mae and Freddie Mac. These pools represent the universe of loans reported in our prior figures and in all of our subsequent analyses. Figure 3 reports the payments, in millions of dollars, arising from the successful putback demands of Fannie Mae and Freddie Mac for specific loans within their pools. The data are organized by the origination date of the pool. The aggregate putback activity reported in Figure 3 is about $22.4 billion dollars of payouts from the originators and sellers of these conventional

conforming 30 year loans to Fannie Mae and Freddie Mac. As shown, the vintage of newly originated pools that were most affected by the putbacks were those originated in December of 2007. However, since that time putbacks continue to be demanded from newly originated pools. For example, there was a spike in putbacks for pools originated in August 2008.

4 Quantitative Easing and Its Effects

Table 1 presents the dates of the Federal Open Market Committee of the Federal Reserve announcements of QE purchase programs. As shown in the table, there have been three quantitative easing programs, which involved MBS and Treasury security purchases at different announcement dates. Under QE3, the program announcement date was September 13, 2012, for monthly purchases of $80 billion dollars over a period of time to be determined by the improvement in unemployment rates to below 6.5%.[12]

4.1 QE Announcements and Underwriting Standards: Event Studies

In this section we examine Hypotheses 1 and 2 by conducting event studies on the announcements given in Table 1. For each announcement date t,[13] we construct a subsample of all loans purchased by the GSEs consisting of loans originated in a window around the announcement date. Specifically, a loan enters the subsample for event t if it was originated within the period 90 days before the event itself or within the period 30 to 120 days after the event. Figure 4 gives a graphical depiction of this sample construction. We omit loans originated in the immediate 30 days following the event because it is unlikely that a change in underwriting policy can occur within that time frame. Indeed, an underwriter's decision

[12]These were reduced to $40 billion per month in the spring of 2014 and the unemployment cut-off has been further reduced.

[13]We omit the December 1, 2008 announcement date due to its proximity to the prior announcement on November 25, 2008.

to originate a loan is often set well in advance of the origination date. Once we have constructed the subsample for each event, we construct the variable Post, a dummy variable for loans originated after the event t. We then run the following regressions:

$$y_{ijkl} = \alpha_j^{\text{gse}} + \alpha_k^{\text{state}} + \alpha_l^{\text{seller}} + \beta_0 \text{ Post} + \epsilon_{ijkl}, \tag{10}$$

where y is one of three underwriting characteristics, FICO, DTI, or LTV, and the α terms are GSE, state, and seller fixed effects. Hypothesis 1 states that the QE announcements tightened underwriting standards. In turn, this should imply that loans purchased by the GSEs should be of higher quality after the QE announcement. So in the context of regression (10), Hypothesis 1 is that β_0 is positive for FICO and negative for DTI and LTV since a higher FICO score, lower DTI, or LTV all correspond to higher quality.

Table 2 present results for regression (10). In those tables, each column corresponds to an event study for the date listed at the top of the column. The first result of interest is that each of the QE1 announcement dates corresponded to a notable increase in the quality of the loans sold to the GSE as measured by FICO score, DTI, or lower LTV. For example, the first announcement of QE1, November 25th, 2008, led to a 16.676 point increase in FICO score, a decrease in debt-to-income ratio of 4.270%, and a decrease in loan-to-value ratio of 5.217%. To give some idea of the economic magnitude of these effects, note that the overall shift in FICO score from 2007 to 2008 was from around 720 to around 770 — about 50 points. This means that around a third of the total increase in FICO score that followed the financial crisis happened around the announcement of QE1. Thus, although one stated goal of the QE programs was to improve conditions in the mortgage market, QE1 did not lead to relaxed credit standards. In contrast, the QE2 announcements are associated with much smaller changes in loan characteristics. This is consistent with evidence presented in Krishnamurthy and Vissing-Jørgensen (2011) that QE2 had a much smaller effect on the mortgage market than QE1. Indeed, in QE2 the Fed purchased treasury securities rather

than MBS. Finally QE3 did not appear to have much effect on underwriting standards.

That the QE programs were associated with an improvement in the quality of the loans sold to the GSEs may seem somewhat counterintuitive at first glance, in that one would have expected that cheaper funding for mortgage originators would make them relax standards rather than tighten them. However, we argue that this intuition ignores a key driver in the decision to originate a mortgage and sell it to the GSEs. In our model of underwriting, originators care about the markup they can charge on a given loan, as well as the value of the implicit insurance they write to the GSEs in the form of the put-back agreement. It predicts that when a policy change lowers the cost of funding the mortgage, underwriting standards can increase if the markups do not change too much; we call this the information-sensitivity effect. The results of Tables 2 are then consistent with our model up to a condition on the markup charged to borrowers.

We note that Fuster and Willen (2010) document similar announcement effects for QE1. Our results differ from theirs in two important ways. First, their results are limited to announcements associated with QE1, while ours also include QE2 and QE3. Second, we attribute the change in originated loan characteristics to a tightening of underwriting standards, while their preferred explanation for the change is that the improvement had to do mainly with "Loan-Level Price Adjustments" (LLPAs) that introduced a higher costs for less credit worthy borrowers, effectively limiting the incentive of low quality borrowers to apply for a new mortgage. While we cannot observe the contract interest rate for mortgages that were not originated, we do observe the rate for the mortgages in our sample. If LLPAs caused the increase in FICO score shown in Table 2, then the spread between rates for high- and low-FICO-score borrowers should increase around the QE announcements. Table 3 documents the opposite finding. We first form a dummy variable for loans with a FICO score below a threshold (e.g., 680), then regress contract interest rate on the interaction of that dummy variable with the Post variable for a given announcement. The coefficient on the interaction term is then the change in the spread between the average contract interest rate

for high and low borrowers. This change is consistently negative or insignificant across different specifications of the low FICO score threshold, meaning that the spread between low and high FICO borrowers actually went down after the first QE announcement.

To further investigate the source of the increase in underwriting standards around the events documented in Tables 2, we now turn to testing Hypothesis 2. That hypothesis states that the information-sensitivity effect should be more pronounced in mortgages markets for which the elasticity of the markup with respect to the risk-free rate is smaller in absolute magnitude. To proxy for the elasticity of the markup, we measure competition in local mortgage markets following Scharfstein and Sunderam (2013). They find that prices in primary mortgage markets adjust more in response to changes in the risk-free rate in more competitive local markets. Thus, we argue that the elasticity of the mortgage markup to the risk-free rate should be lower in absolute terms in more competitive markets. We measure local mortgage market competition in two ways. First, we construct Herfindahl-Hirschman Index (HHI) index at the three digit zip code level at each observation date. Second, we construct the dummy variable Top 4, which equals 1 if the largest 4 lenders in a given zip code account for 75% of the origination volume in that zip code.[14] We then regress FICO, DTI, and LTV on the Post variable for Event 3, the HHI index (or Top 4) and the interaction of the two, as follows:

$$y_{ij} = \alpha_j + \beta_0 \text{ Post}_3 + \beta_1 \text{ HHI}_i + \beta_3 \text{ Post}_t \times \text{HHI}_i + \epsilon_{ij}, \tag{11}$$

$$y_{ij} = \alpha_j + \beta_0 \text{ Post}_3 + \beta_1 \text{ Top4}_i + \beta_3 \text{ Post}_t \times \text{Top 4}_i + \epsilon_{ij}, \tag{12}$$

where α_j is a vector of fixed effects. Table 4 presents the results of regressions (11) and (12). The main coefficients of interest are those on Post $\times$ HHI$_i$ and Post $\times$ Top 4$_i$. For each of the three underwriting variables, these coefficients have the opposite sign of that on Post. A higher value of HHI or a value of one for Top 4 corresponds to a less competitive local

[14]This is similar to the four-lender concentration ratio used by Scharfstein and Sunderam (2013).

mortgage market. So this means that the tightening of underwriting standards was less severe in less competitive markets. For example, in a perfectly monopolistic market (HHI= 1), the announcement of QE1 is associated with increase in FICO score of $18.448 - 9.475 = 8.973$, versus the average increase of 16.676 points documented in Table 2. The effects on DTI and LTV are similar. These results are consistent with Hypothesis 3. Moreover, they cannot easily be explained by the introduction of the Loan-Level Pricing Program emphasized by Fuster and Willen (2010), as it is not clear why this program should differentially impact zip codes based on HHI in a manner which is not accounted for by the state-level fixed effects we include in the regression.

While the results in Tables 2 and 4 indicate that QE was related to an apparent improvement in the ex ante quality of loans originated for sale to the GSEs, it is not clear whether this change would lead to an ex post improvement in performance. Given that our main explanation for these results is that originators sought to decrease their exposure to repurchase requests, its natural to ask whether ex post performance improved as a result of the tightening of credit. To answer this question, we run regressions similar to (10) with two ex post measures of loan quality on the left hand side: loan delinquency and repurchase requests. Table 5 reports the result of a linear probability model with the same Post variable as in Table 2. As shown in the table, mortgages originated after QE announcements are less likely to become delinquent than those originated before the announcements. Table 6 displays results for event studies with repurchase requests at the pool level, measured as a percentage of the original principal balance requested for repurchase. Specifically, we take all GSE fixed-rate mortgage pools issued within a 90-day window of each QE announcement, and calculate the percentage of the original pool balance that later was subject to a repurchase request. For the first announcement date, this was an average of .4%. Table 6 shows that this percentage decreased by .2%, or half the average, directly after the announcement of QE1.

One might be concerned that effects we document in the event studies are not due to the

QE announcements themselves, but rather are simply due to trends in mortgage underwriting during that time period. To deal with this concern, we perform placebo event studies using event dates 3 months after each period of quantitative easing: June 18, 2009, November 21, 2010, and November 13, 2012. Table 7 shows the results for these regressions. In most cases, the coefficients have the opposite sign tp those in the main event studies. For example, FICO score actually decreases around each of the placebo events.

5 Changes in Demand and Sample Selection Bias

A possible cause for the apparent tightening reported in the Agency securitization rates above could be the known sample-selection bias associated with the analysis of mortgage originations. To control for this, we now consider the application rates of mortgages that are reported under the Home Mortgage Disclosure Act (HMDA). The advantage of these data is that they provide information on the rejection rates on all mortgage applications. To further control for other important underwriting factors, we estimate a linear probability model of the probability that a borrower applicant will have their loan application rejected. Results are reported in Table 8, and include state and lender fixed effects.

As shown in Table 8, if the borrower's race is Caucasian, the borrower is a male, or the borrower has higher income, his or her loan application is more likely to be accepted. The ratio of the requested loan amount to annual income, our proxy for the DTI, also shows that higher ratios, implying higher debt-to-income ratios are more likely to be rejected. The interaction of the year fixed effects and the DTI proxy, the ratio of requested loan amount to annual income, indicates a revealing switch in signs from essentially zero to a highly statistically significantly positive coefficient that jumps in magnitude starting in 2008, reaching a maximum in 2011. The year fixed effects show a very similar pattern of switching to statistically significant positive values starting in 2006 and reaching a maximum in 2008, which is only very slowly decreasing in the later periods of the QE mortgage-purchase

periods.

What is perhaps more interesting is the coefficient on the interaction between year fixed effects and Requested Loan Amount to Annual Income ratio (RLA/AI), which is positive and significant for 2006–2012. A significant positive coefficient on this interaction means that rejection was more sensitive to RLA/AI in that year than on average. Moreover, the coefficient is significantly larger from 2009–2011, the years corresponding to the QE programs, then in 2008. Overall, the linear probability model results strongly suggest that the QE programs are associated with increased tightening for conventional, conforming mortgage borrowers. Our interpretation of these results is that the information-sensitivity effects identified in the model, probably associated with lender concerns about repurchase and indemnification liability, have led to important and coincident tightening in conventional, conforming mortgage underwriting criteria. This tightening effect more than offsets the possible beneficial effects of the QE programs in lowering the costs of mortgage origination to borrowers.

6 Conclusions

We present evidence that the LSAPs may have made mortgage underwriting standards stricter. We present a model in which lowering the risk-free rate can make mortgage originators more sensitive to borrower credit quality when they must partially guarantee mortgages against default. Consistent with our model, mortgage underwriting standards became stricter in zip codes with more competitive mortgage markets.

These results call into question whether the LSAPs were an optimal policy response to the mortgage market freeze. Indeed, they suggest that lowering the cost of funds for originators without ameliorating the originators' concern about future default will not have the desired effect of easing credit availability in mortgage markets.

A Data Appendix

A.1 GSE Data

The GSE data includes all of the loan-by-loan contractual structure of the mortgages as well as loan-by-loan underwriting information at origination with certain caveats, as described below.

- *Debt-to-Income Ratio (DTI):* A ratio calculated at the origination date of the mortgage by dividing the borrowers total monthly obligations (including housing expense) by his or her stable monthly income.[15]
- *Loan-to-Value Ratio:* A ratio which is calculated at the time of origination by dividing the original loan amount by either (1) in the case of a purchase, the lower of the sales price of a mortgaged property or its value at the time of the sale, or (2) in the case of a refinancing, the value of the mortgaged property at the time of refinancing.[16]
- *Fair Isaac Company (FICO) Score:* A number generated by the Fair Isaac Company that summarizes the borrowers credit-worthiness, which may be indicative of the likelihood that the borrower will make timely payments on their future obligations. Generally, the credit score disclosed is the score known at the time of acquisition and is the score used to originate the mortgage.[17]
- *Three digit zip code of the residence*: For reasons of confidentiality, the GSEs report the residential address of the loan at the level of a 3 digit zip code.
- *Quarter that the loan was contributed to the grantor trust*: The GSEs do not have the exact loan origination date of the loans that they insure and securitize. Instead, they report the quarter in which the loan was contributed to the pool. Usually, GSE securitized loans are contributed to pools within three months of their origination, so

[15]Fannie Mae and Freddie Mac report loans with values of DTI that are equal to zero or greater than or equal to 65 as missing.

[16]Fannie Mae and Freddie Mac exclude from their respective datasets all mortgage loans with Original LTVs that are greater than 97.

[17]FICO Scores vary between 300 and 850.

this value is a reasonable approximation to the origination date of the loan.

- *Seller*: The lender or aggregator that sold the loan to the GSEs. The GSEs report the name of the loan originator if the loan is originated through retail channels or they report the loan aggregator if the loan is originated through a warehouse or correspondent channels.
- *Loan Channel* Whether the loan was originated through a retail bank, broker, or correspondent lender.
- *Loan purpose* Whether the loan was used for a purchase, no-cash-out refinance, or cash-out refinance

A.2 HMDA Data

The HMDA data are available at the loan and loan application level, and include the following information:

- *Borrower/applicant Income* Gross Annual Income Income in HMDA is reported as the total gross annual income an institution relied upon in making the credit decision. "NA" is used 1) when an institution does not ask for the applicant's income, and nor is income used in the credit decision, 2) the loan application is for a multifamily dwelling, 3) the applicant is not a natural person (a business, corporation or partnership, for example), or 4) the applicant information is unavailable because the loan was purchased by the institution. "NA" is also used for loans to an institution's employees to protect their privacy.
- *Borrower/applicant race* The race of the applicant is reported for originated loans and for loan applications that do not result in an origination. Institutions may, but are not required to, report these data for purchased loans. When the applicant is not a natural person (a business, corporation or partnership, for example) or when the applicant information is unavailable because the loan has been purchased by the institution, the numerical code for "not applicable" is reported.

- *Borrower/applicant gender* The sex of the applicant is reported for originated loans and for loan applications that do not result in an origination. Institutions may, but are not required to, report these data for purchased loans. When the applicant is not a natural person (a business, corporation or partnership, for example) or when the applicant information is unavailable because the loan has been purchased by your institution, the numerical code for "NA" is reported.
- *Originated/Requested Amount of the Loan* The dollar value of the requested loan principal.
- *Lender namer* The entity that makes the credit decision and provides the funding for the loan.
- *Reasons for Denial* The HMDA data allows lenders to reveal up to three reasons for denying a loan application. These include debt-to-income ratio, employment history, credit history collateral, insufficient cash (down payment, closing costs), unverifiable information, credit application incomplete, mortgage insurance denied, and other. We use the first cited reason since it is reported for all rejected loans and it is considered the primary reason for rejection

A.3 Putback Data

The putback data were downloaded from the U.S. Securities and Exchange Commission, forms ABS-15G and ABS-15GA, Asset-Backed Securitizer Report Pursuant to Section 15G of the Securities Exchange Act of 1934 for Fannie Mae and Freddie Mac.[18] The SEC 15G forms for Fannie Mae and Freddie Mac are filed quarterly and report the dollar amount of all of the repurchases and replacements by pool CUSIP. For the preponderance of the CUSIPS the 15GA forms also provide the name of the seller/originator of the loans in the pools. No other pool level information is available from these forms.

[18]See `https://www.sec.gov/Archives/edgar/data/310522/000031052214000301/0000310522-14-000301-index.htm` one through 39 for Fannie Mae and `https://www.sec.gov/Archives/edgar/data/1026214/000102621414000081/0001026214-14-000081-index.htm` one through 39 for Freddie Mac.

- *CUSIP* The CUSIP number for the Fannie Mae or Freddie Mac special purpose vehicle.
- *Name of the Originator* These are the sellers of the loans for correspondent origination since these sellers are typically responsible for the accuracy of mortgage loan representations and warranties and for repurchase covenants. For loans that sellers report to Freddie Mac as "retail" in origination, Freddie Mac discloses the seller as being the identity of the originator. For those mortgage loans for which sellers reported the involvement of a third party in origination or an unknown origination, Freddie Mac discloses "Unavailable" for the identity of the originator.
- *Dollar amount of assets that were repurchased or replaced* The outstanding balance of mortgage loans where the seller has (1) paid full or partial repurchase funds, (2) entered into a monetary settlement with Freddie Mac covering certain liabilities or potential liabilities associated with breaches or possible breaches of representations and warranties related to origination of the mortgage loans delivered to Freddie Mac over a certain time period and Freddie Mac agreed, subject to certain exceptions, to release a seller from such liabilities or potential liabilities associated with such breaches or possible breaches of representations and warranties or (3) resolved the repurchase demand without the immediate payment of repurchase funds; for example, a seller may agree to be recourse on the mortgage loan or to provide indemnification to Freddie Mac if the mortgage loan subsequently defaults.

We then downloaded from the Freddie Mac and the Fannie Mae websites all of the origination details for all 30-year maturity conventional, conforming Fannie Mae and Freddie Mac securitized pools.[19] This information was needed to obtain the pool origination dates for each pool along with additional information about the pools such as the name of the pool originator/seller and all of the origination characteristics such as the principal weighted average loan-to-value rates and the principal weighted average FICO scores for each pool.

[19]See `http://www.freddiemac.com/mbs/` and `http://www.fanniemae.com/portal/funding-the-market/mbs/single-family/index.html`

- *Pool origination date* Since mortgage loans are usually seasoned by about two and one half months, the pool origination date minus 90 days as a proxy for the loan origination date.
- *Name of the originator* This is the name of the retail originator or the correspondent seller of the loans.

We then merged this information together with the putback data to construct a measure for the percentage of each pool that was put back as of 2014. The putback and pool sample contains 50,589 pools originated from 2000 through the end of 2012.

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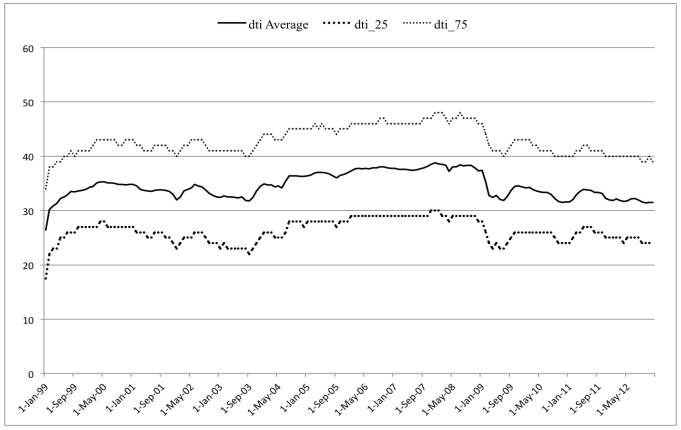
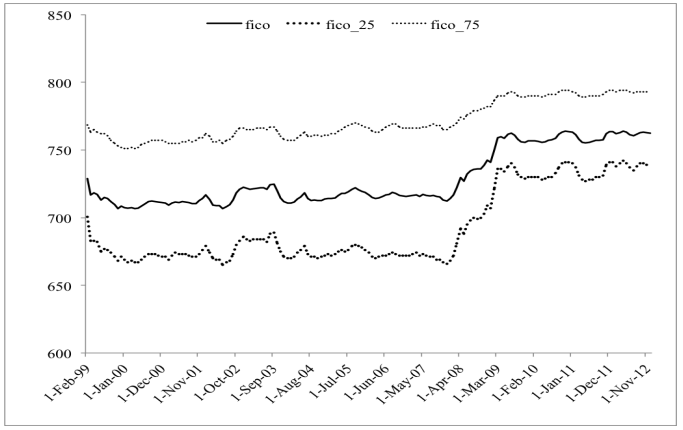
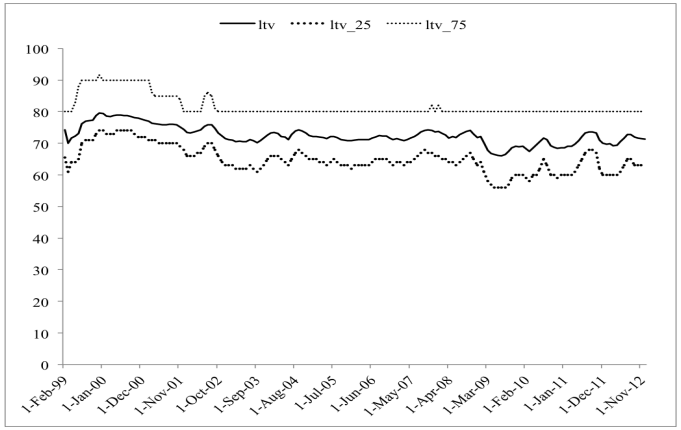


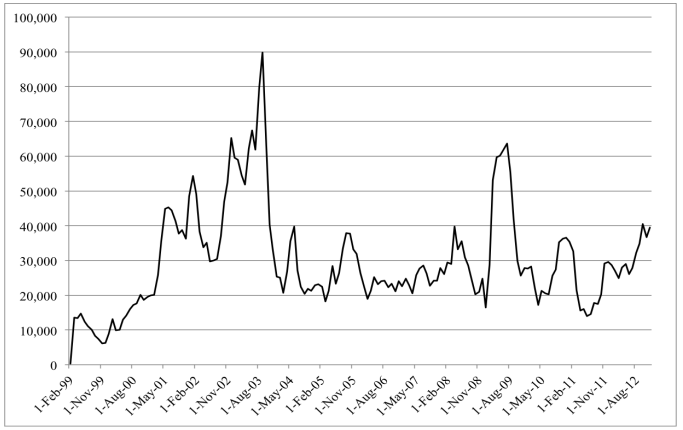
(a) Debt-to-Income (DTI) ratios



(b) FICO scores

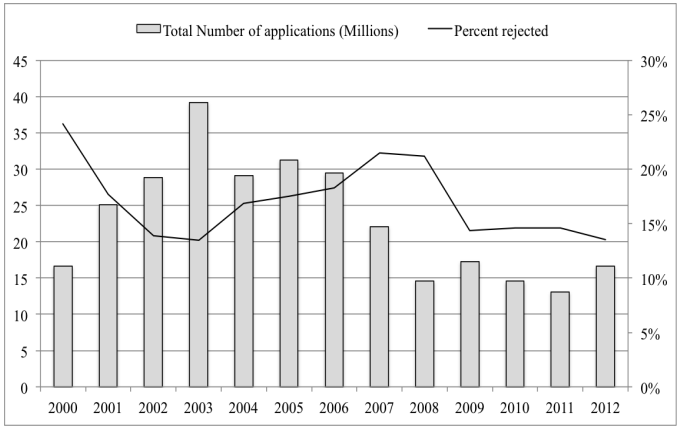


(c) Loan-to-Value (LTV) ratios

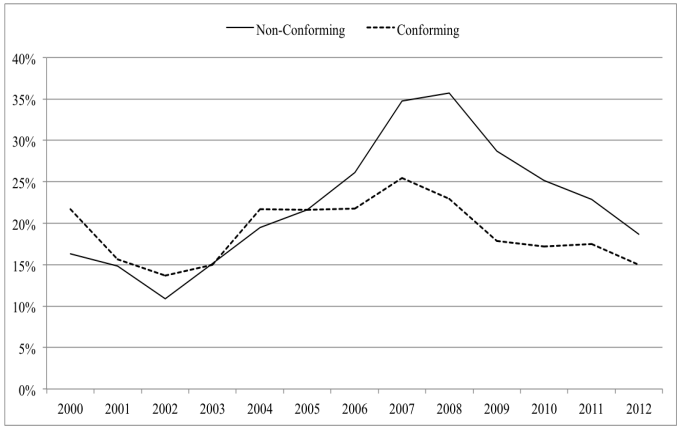


(d) Pool origination balances

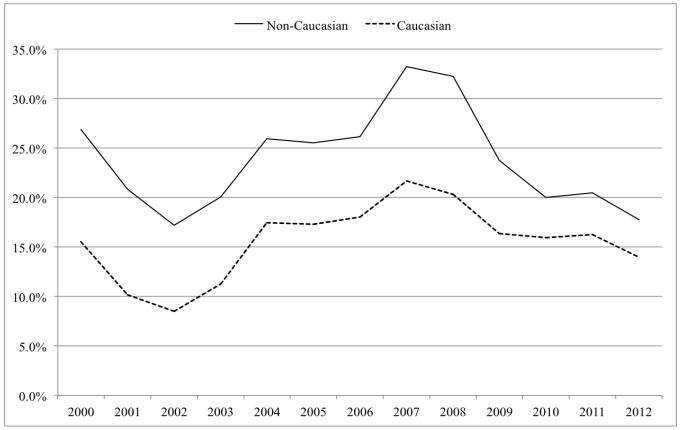
Figure 1: **Monthly averages and interquartile ranges for the underwriting characteristics of the sample of 30 year fixed-rate mortgage pools securitized by Fannie Mae and Freddie Mac.** This figure provides the average and interquartile ranges the debt-to-income (DTI) ratios, the FICO scores, and the loan-to-value (LTV) ratios for the sample of all the 30 year maturity fixed-rate mortgage pools securitized by Fannie and Freddie from 1999–2012.



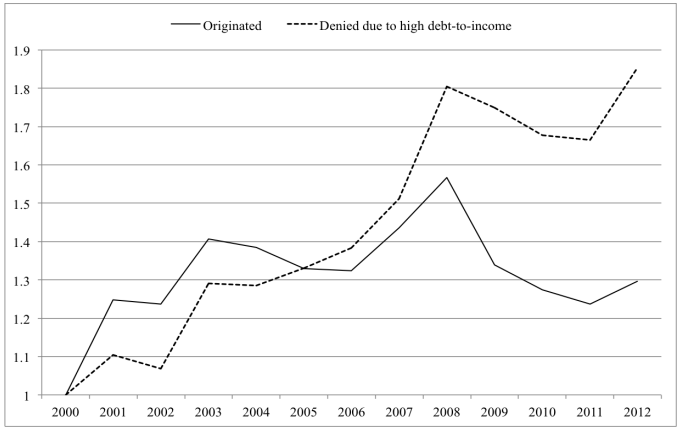
(a) HMDA Loan Origination and Rejection Percentage



(b) Percentages of conforming and non-conforming applications that were rejected



(c) Denial rates by race for conventional conforming mortgage applications



(d) Normalized Ratio of Requested Loan Amount to Annual Income for loans denied due to DTI and for originated conventional conforming loans

Figure 2: **The Home Mortgage Mortgage Disclosure Act (HMDA) data reported rejection ratios for conventional conforming and non-conventional conforming loans.** This figure plots the rejection and acceptance rates for conventional conforming (loans at or below the conventional conforming loan limit levels) and non-conventional conforming by year of origination. The plots use the outcomes from the Home Mortgage Disclosure Act (HMDA) data from 2000–2012.

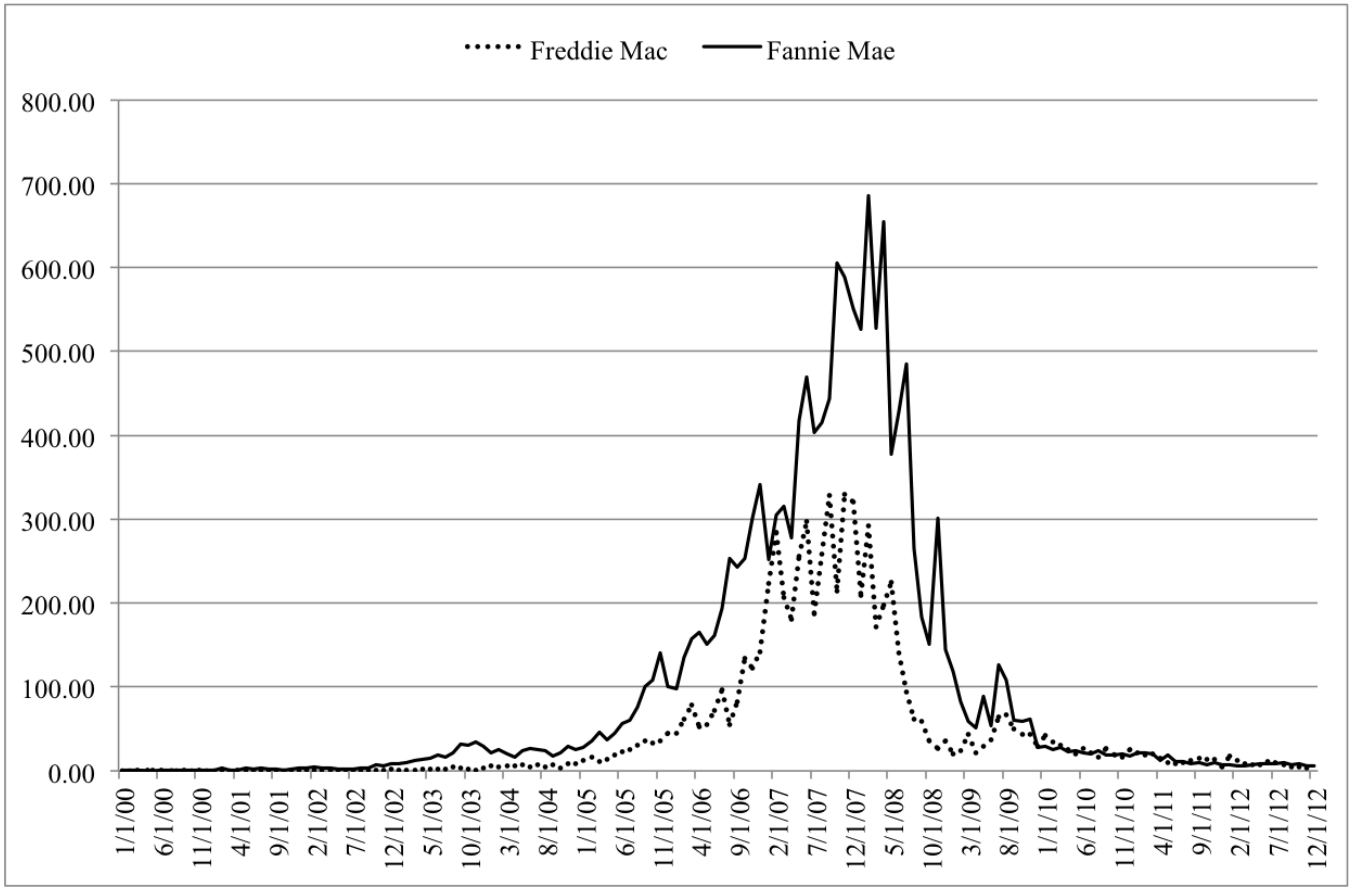


Figure 3: Payments in millions of dollars arising from the successful putback demands of Fannie Mae and Freddie Mac for specific loans within pools identified by CUSIP. The data are reported as the aggregate dollar amount of the putback payments from the affected CUSIPs organized by the origination date of the pool.

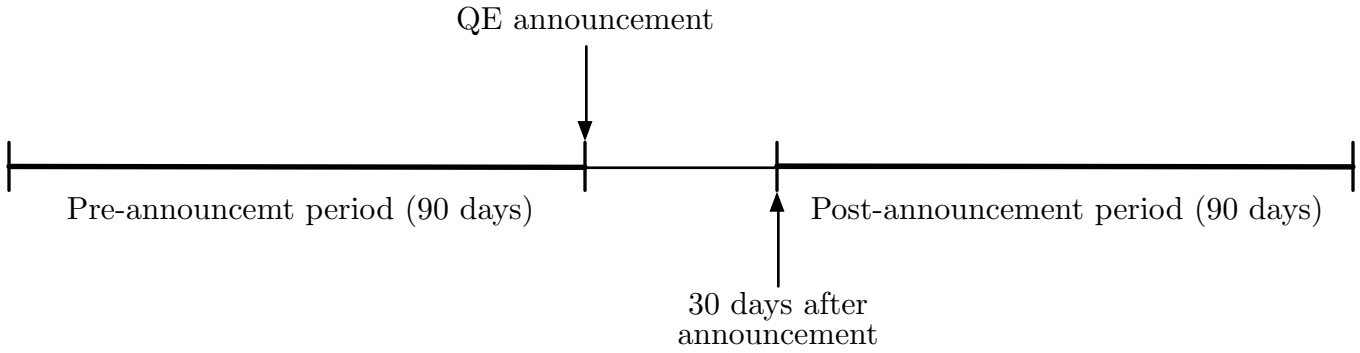


Figure 4: Event Study Sample Construction. For a given QE announcement, a loan enters the event study sample if it was originated in the pre-announcement period (thick line to the left) or the post-announcement period (thick line to the right). Loans originated immediately after the announcement are not included as underwriting decisions are likely made in advance of the actual origination date.

Table 1: Federal Open Market Committee Announcements of Agency Mortgage Backed Security purchase programs.

Quantitative Easing Programs (MBS Purchases)	Announcement Dates
QE1	November 25, 2008
QE1	December 1, 2008
QE1	January 28, 2009
QE1	March 18, 2009
QE2	August 10, 2010
QE2	September 21 2010
QE3	September 13, 2012

Table 2: Change in originated loan characteristics around QE announcement dates.

	Dependent variable:					
	FICO					
	11/25/08	01/25/09	03/18/09	08/10/10	09/21/10	09/13/12
Post	16.676***	9.891***	3.003***	2.069***	−0.677*	−0.448
	(0.588)	(1.355)	(0.889)	(0.281)	(0.373)	(0.503)
Observations	972,996	1,181,017	1,408,718	790,116	798,736	699,910
	Dependent variable:					
	DTI					
	11/25/08	01/25/09	03/18/09	08/10/10	09/21/10	09/13/12
Post	−4.270***	−2.549***	−0.483	−0.739***	0.028	−0.047
	(0.220)	(0.575)	(0.300)	(0.103)	(0.089)	(0.059)
Observations	962,977	1,172,273	1,400,188	789,760	798,407	699,923
	Dependent variable:					
	LTV					
	11/25/08	01/25/09	03/18/09	08/10/10	09/21/10	09/13/12
Post	−5.217***	−3.551***	−0.666*	−1.041***	−0.080	−0.589***
	(0.187)	(0.532)	(0.383)	(0.283)	(0.291)	(0.084)
w						
Observations	973,249	1,181,269	1,408,955	790,382	798,970	699,993

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered by Seller.
Includes GSE, Seller, and State fixed effects.

Table 3: Change in Contract Interest Rate around QE1 announcement date (11/25/2008)

	Dependent variable:		
	Contract Interest Rate		
	(1)	(2)	(3)
Post	-1.205^{***}	-1.188^{***}	-1.182^{***}
	(0.029)	(0.028)	(0.026)
FICO≤680	0.385^{***}		
	(0.009)		
Post×FICO≤680	-0.007		
	(0.023)		
FICO≤720		0.284^{***}	
		(0.007)	
Post×FICO≤720		-0.052^{***}	
		(0.014)	
FICO≤760			0.199^{***}
			(0.007)
Post×FICO≤760			-0.061^{***}
			(0.010)
Observations	972,995	972,995	972,995
Note:			*p<0.1; **p<0.05; ***p<0.01
			Standard errors clustered by Seller.
			Includes GSE, Seller, and State fixed effects.

Table 4: Change in FICO score, DTI, and LTV around QE1 announcement date (11/25/2008)

	Dependent variable:					
	FICO	DTI	LTV	FICO	DTI	LTV
	(1)	(2)	(3)	(4)	(5)	(6)
Post	18.448^{***}	-4.655^{***}	-6.144^{***}	17.530^{***}	-4.296^{***}	-5.810^{***}
	(0.804)	(0.305)	(0.289)	(0.613)	(0.232)	(0.205)
HHI	4.086^{*}	-5.564^{***}	4.336^{***}			
	(2.332)	(0.511)	(0.926)			
Post×HHI	-9.475^{***}	3.496^{***}	3.654^{***}			
	(2.274)	(0.911)	(1.352)			
Top 4				0.781^{*}	-0.786^{***}	0.296
				(0.431)	(0.116)	(0.299)
Post×Top 4				-2.592^{***}	0.718^{***}	1.384^{***}
				(0.388)	(0.186)	(0.249)
Observations	972,996	962,977	973,249	972,996	962,977	973,249

Note: *p<0.1; **p<0.05; ***p<0.01
All standard errors clustered by Seller.
All regressions include GSE, Seller, and State fixed effects.

Table 5: Change in delinquency probability around QE announcement dates

	Dependent variable:					
	Delinquency					
	11/25/08	01/25/09	03/18/09	08/10/10	09/21/10	09/13/12
Post	-0.048^{***}	-0.026^{***}	-0.008^{***}	-0.003^{***}	-0.002^{***}	-0.0004^{***}
	(0.004)	(0.003)	(0.001)	(0.0002)	(0.0002)	(0.0001)
Observations	973,261	1,181,286	1,408,978	790,386	798,974	699,998

Note: *p<0.1; **p<0.05; ***p<0.01
All standard errors are robust and clustered by Seller.
All regressions include GSE, Seller, and State fixed effects.

Table 6: Change in Repurchase Requests (as a percentage of pool principal) around QE announcement dates

	Dependent variable:					
	Repurchase Request					
	11/25/08	01/25/09	03/18/09	08/10/10	09/21/10	09/13/12
Post	-0.002^{***}	-0.002^{***}	-0.001^{***}	-0.0003	-0.0002^{***}	-0.0001
	(0.0003)	(0.001)	(0.0003)	(0.0002)	(0.00001)	(0.0001)
Observations	10,333	9,461	10,377	12,368	13,304	22,583
R^2	0.008	0.010	0.006	0.0005	0.001	0.0003

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered by GSE
Includes GSE fixed effects.

Table 7: Change in originated loan characteristics score placebo announcment dates

	Dependent variable:		
	FICO		
	06/18/09	11/21/10	11/13/12
Post	-4.348^{***}	-5.263^{***}	-1.313^{*}
	(0.994)	(0.570)	(0.782)
Observations	870,342	595,049	499,453
	Dependent variable:		
	DTI		
	06/18/09	11/21/10	11/13/12
Post	2.722^{***}	1.276^{***}	0.074
	(0.156)	(0.133)	(0.135)
Observations	865,824	594,740	499,454
	Dependent variable:		
	LTV		
	06/18/09	11/21/10	11/13/12
Post	2.065^{***}	0.979^{***}	-0.292
	(0.455)	(0.196)	(0.298)
Observations	870,502	595,207	499,499

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered by Seller.
Includes GSE, Seller, and State fixed effects.

Table 8: Linear probability model estimation results for the probability that a loan application for either a purchase money mortgage or a mortgage refinancing was rejected as a function of the borrower's race, income, gender, ratio of the requested loan amount to annual income, state location, year, and originator. The data used in this analysis include all loan applications (both accepted and rejected) reported by the Home Mortgage Disclosure Act (HMDA) reports from 2000–2012. The HMDA sample of applications is trimmed at the top 1% of the observations with unreasonably high realizations of the ratio of the requested loan amount to gross annual income.

	Trimmed Sample	
	Coefficient Estimates	Standard Errors
Caucasian	-0.068 ***	0.004
Income (000)	-0.060 ***	0.020
Gender (1 = male)	-0.013 ***	0.001
Ratio Requested Loan Amount to Annual Income R(LA/AI)	0.028 ***	0.009
RLA/AI × 2001	0.006	0.006
RLA/AI × 2002	-0.009	0.009
RLA/AI × 2003	-0.003	0.011
RLA/AI × 2004	-0.005	0.011
RLA/AI × 2005	-0.009	0.010
RLA/AI × 2006	0.025 **	0.011
RLA/AI × 2007	0.028 ***	0.010
RLA/AI × 2008	0.067 ***	0.013
RLA/AI × 2009	0.105 ***	0.010
RLA/AI × 2010	0.112 ***	0.011
RLA/AI × 2011	0.115 ***	0.014
RLA/AI × 2012	0.087 ***	0.014
2001	-0.023 ***	0.008
2002	-0.041 ***	0.011
2003	-0.029 **	0.013
2004	-0.011	0.014
2005	-0.003	0.015
2006	0.034 **	0.017
2007	0.080 ***	0.022
2008	0.113 ***	0.018
2009	0.077 ***	0.016
2010	0.056 ***	0.022
2011	0.068 ***	0.015
2012	0.052 ***	0.016
N	110,293,384	
R^2	0.254	
State Fixed Effects	Yes	
Lender Fixed Effects	Yes	