Strategic Default, Loan Modification and Foreclosure*

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Abstract

We study borrower strategic default in the residential mortgage market. We exploit a discontinuity in the eligibility criteria of the Home Affordable Modification Program (HAMP), a large federal government program that incentivized lenders to renegotiate mortgages for borrowers who were more than 60 days delinquent on their loans. In contrast to prior literature, we find that HAMP increased rates of delinquency by 13% among eligible borrowers and that the effect is driven primarily by underwater loans. At the same time, the program succeeded in its stated purpose of lowering foreclosure rates among borrowers that were already delinquent and increasing the likelihood that they return to making payments. Our results suggest that borrower strategic response is an important consideration in designing debt relief policies.

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1 Introduction

The 2008 housing crisis, which began with falling home prices, created a vast increase in both the number of delinquent borrowers and the share of delinquent loans that ended in foreclosures. Foreclosure - the process through which a house is repossessed and sold following default - creates a significant amount of waste. Lenders incur administrative and legal costs to seize the house from the borrower. Borrowers, anticipating that the property will be repossessed, stop investing to maintain the house. Lenders are typically unable to hold the asset because of regulatory requirements, and so sell the property at a substantial discount.[1] Finally, the foreclosure process can last two to three years in some states, during which time the borrower may not make any payments.[2]

Because of the significant waste in the foreclosure process, the borrower and lender may mutually benefit from renegotiating the loan contract to lower the borrower's monthly payment (called a mortgage modification). A modification may avoid foreclosure proceedings and keep the borrower in the house making a reduced payment. However, if borrowers behave strategically, a lender who offers many modifications to loans in default may induce more borrowers to become delinquent to seek more favorable terms on their loans. Public policy during the housing crisis sought to incentivize modifications through generous subsidy programs, such as the Home Affordable Modification Program (HAMP), but these policies resulted in less modifications than expected (Agarwal et al., 2017).

Borrowers are subject to income and liquidity shocks which might make them unable to make mortgage payments on their house. However, borrowers may also have an incentive to miss payments even if they are able to pay. If their house goes "underwater", so that the value of the house declines below the outstanding balance on their mortgage, they may be better off allowing the lender to foreclose. Not only does foreclosure force the lender

[1] Recent empirical work estimates the discount given to foreclosed homes as high as 27% (Campbell et al., 2011). See also Anenberg and Kung (2014) and (Mian et al., 2010).

[2] http://www.baltimoresun.com/news/data/bal-average-length-of-foreclosure-by-state-by-number-of-days-20140924-htmlstory.html

to absorb the loss from the decline in the property value, in most cases the borrower can continue to live in the house without making payments until the lender takes possession of the property. Not all underwater borrowers become delinquent since such strategic incentives are counterbalanced by significant costs associated with default: being shut out of credit markets for up to seven years, transaction costs and stress from the foreclosure process and finding a new home, and ethical concerns.

This paper focuses on the strategic interaction between borrowers and lenders around these loan modifications. We first examine the observable determinants of default. Using detailed loan-level panel data, we show that borrowers who were underwater on their loan are 16-17 percentage points more likely to become delinquent and 10-13 percentage points more likely to enter foreclosure. This represents an increase of two to three times over the mean delinquency rate. We take this as suggestive evidence that strategic behavior by borrowers is a materially important consideration in the mortgage market during this time period.

Next, we utilize variation created by the HAMP policy that increases the incentives for borrowers to default. HAMP is a large government program implemented in 2009 to encourage loan modifications for distressed borrowers. It provides lenders with significant incentives (in the form of upfront payments and additional payments tied to loan performance) to reduce monthly payments for qualifying borrowers. However, in order for a borrower to be eligible for a modification under HAMP, her mortgage must be delinquent by "60 days or more ... or at risk of imminent default."[3] As a result, the program may induce additional loan delinquency by borrowers seeking more favorable terms on their loans.

We test this hypothesis using a regression discontinuity design. Utilizing variation created by the eligibility requirements of the policy, we ask whether borrowers that were eligible for HAMP defaulted at higher rates than those that were not. Our results suggest that the structure of HAMP increased the rate of overall delinquency by approximately one percentage point (on an average delinquency rate of 7.5%). Moreover, this effect was driven entirely by

[3] https://www.fhfa.gov/PolicyProgramsResearch/Policy/Documents/PF_FreddieMac73112.pdf

underwater borrowers, whose delinquency rate increased by nearly 6 percentage points; the policy had no measurable effect on non-underwater borrowers. The effect was particularly strong in states where deficiency judgment is allowed. In these states, the lender can sue the borrower following the foreclosure for the remaining balance of the debt. Deficiency judgment makes foreclosure more costly for borrowers, and thus since HAMP decreases the probability of foreclosure conditional on delinquency, it also makes default less costly in these states. We find that HAMP did diminish the flow between serious delinquency and foreclosure by encouraging loan servicers to increase the number of mortgage modifications. Moreover, due to possible measurement error in the date of origination of the loan, our estimates may understate the effects of HAMP on the rate of strategic default.

Our results suggest that borrowers reacted strategically to the policy change, and that the magnitude of this response is strong enough to undo part of the change that the policy seeks to induce. Moreover, it suggests one possible explanation for why the policy resulted in fewer modifications than expected; lenders may have worried that a more generous loan modification policy would induce additional delinquency.[4] However, we emphasize that our estimates are by their nature "local" to the subpopulation of first-lien mortgages originated between the end of 2008 and the beginning of 2009 on owner-occupied properties: we have no means to test the external validity of our results to the whole population of borrowers targeted by HAMP.

Finally, we discuss potential threats to our identification strategy and evaluate alternate explanations in the context of our results. The primary concern is that banks changed their lending behavior concurrently with the policy change, so that our estimates confound the effect of HAMP and the tightening credit market. We find some evidence for this hypothesis in that we observe small changes in the credit scores of borrowers before and after the eligibility cutoff. However, we note that these fluctuations are still relatively small in the context of the relatively large effect that HAMP had on the delinquency rate for borrowers

[4]See, for example, the discussion in Adelino et al. (2013).

that were eligible for modifications.

Our primary result—that HAMP increased the rate of delinquency for borrowers that received loans at the peak of the financial crisis—runs contrary to the findings of prior studies of HAMP. In particular, Agarwal et al. (2017) employ an empirical strategy based on other HAMP eligibility criteria and find no evidence of strategic delinquency. The difference between our results and the findings of Agarwal et al. (2017) stem from our focus on a different population of borrowers that may be more likely to respond to strategic concerns. Their empirical strategy uses the HAMP requirements that the property be owner-occupied and that the balance of the loan be less than $729,750. Properties that are not owner-occupied might indicate that the borrower owns more than one property, which could increase the cost of foreclosure in states where deficiency judgment is allowed. Moreover, the average outstanding balance is well below the $729,750 threshold: more expensive properties are bought by richer borrowers, who might have different costs of defaulting, for instance because a larger fraction of them need access to credit for other things. In light of these arguments, it may be unsurprising that our analysis—which instead compares loans originated a few months before and a few months after the eligibility date cutoff—finds a larger strategic response. We find heterogeneity in the effect of the treatment that is consistent with this hypothesis; borrower strategic response is driven almost entirely by underwater borrowers, who have the most to gain from default.

Other literature has documented the role of strategic concerns for borrowers. Mayer et al. (2014) leverages variation induced by a legal settlement with Countrywide to show that some borrowers choose to strategically become delinquent in order to exploit new favorable renegotiation conditions. Cost of a strategic default is heterogeneous across borrowers and determined by both pecuniary and non-pecuniary factors, as documented by Guiso et al. (2013). Based on surveys of borrowers, they estimate that 26% of defaults are strategic, rather than based on liquidity concerns.

The paper proceeds as follows. In section 2, we describe the eligibility criteria of the

HAMP policy. Section 3 discusses our data. Section 4 presents descriptive statistics on house prices and loan performance over time. In section 5, we examine observable variables that correlate with foreclosure and default. Section 6 tests for borrower strategic response to HAMP. Section 7 concludes.

2 HAMP

HAMP is a government program enacted in 2009 that provided significant financial incentives to loan servicers to modify loans. It included upfront payments of between \$500-\$2000, as well as performance-based incentive payments to mortgage servicers, investors, and borrowers if the borrower continued to make payments on the modified mortgage. The program provided these incentives for servicers to reduce monthly payments for borrowers down to 31% of their income. To be eligible for the program, loans had to meet four requirements:

1. It must be a "financial hardship" for the borrower to pay her mortgage and the borrower must be either delinquent or about to stop making payments
2. The loan must have originated on or before January 1st, 2009
3. Property must be owner-occupied and be the borrower's primary residence
4. The outstanding balance must be at most $\$729,750$ for one unit house (larger thresholds for multi-unit properties)

3 Data

We use loan-level data from the Corelogic database, which spans from 1990-2014 and includes data on 180 million loans in the United States. Corelogic is a firm that collects loan data from US mortgage services and sales data from public records. The Corelogic data is divided into two datasets that cannot be linked - loan-level and transaction-level. We use only the

loan-level data, and supplement it with data on quarterly house prices at the three-digit zip code level from the Federal Housing Finance Agency (FHFA).

The Corelogic data includes information collected at the time of loan origination, as well as data about the loan's performance over time. From the loan origination, we have the date the loan was issued, whether it was subprime or prime, appraisal value and sale price of the house when it was purchased, borrower's FICO credit score, loan balance at origination, loan-to-value ratio (debt divided by appraisal price), loan type, original investor type (government sponsored enterprise (GSE), securitized, portfolio-held), and zip code. Over time we observe the loan's monthly payment status (Current, 30, 60, 90+ days delinquent, Foreclosure proceedings, Real Estate Owned[5]), current balance, monthly payment broken into interest and principal, current interest rate, and current investor type. The data does not include the identity of the lender or the monthly income of the borrower over time.

We supplement the loan-level time series with county-level unemployment data from the BLS and quarterly house price index data from the FHFA. We use the house price data to impute a current house price in the loan data by inflating the sales or appraisal price by the average price growth within that three-digit zip code. We then calculate the borrower's equity in the house as the current price minus the outstanding debt.

We construct two samples. In the descriptive analysis in the first section of the paper, we focus on loans from three states that were differentially affected by the housing crisis: Florida, Wisconsin, and Arizona. We taken a 7% random sample of all loans in these states that were active between 2005 and 2014. We use this sample to illustrate some of the heterogeneity across states in the intensity of the crisis.

In our analysis of the HAMP policy, we construct a nationally representative sample of loans that were originated near the eligibility cutoff date of January 1, 2009. To do this, we randomly sample 12.5% of US zipcodes.[6] We use all first-lien and owner-occupied Prime loans with a balance less than $729,750 from this set of zipcodes and include monthly loan

[5]REO means the lender has already repossessed the property

[6]We sample only zip codes who had at least 100 new Prime mortgages in the period 2007-2010.

performance data for these mortgages between June 2009 and April 2014.[7] In our primary specification, we look at loans that were originated in a four month window on either side of the cutoff (between August 2008 and April 2009).

4 Descriptive Analysis

Here we present descriptive evidence documenting basic trends in delinquency rates over time. We focus on three states, Florida, Wisconsin, and Arizona, from which we take 7% random samples of all loans that were active between 2005 and 2014.

4.1 Summary Statistics

In Table 1, we present basic summary statistics from the sample. Summary statistics are calculated at the loan-month level. Among subprime loans, about 33% of loan-months were in delinquency and 12% were in foreclosure during our sample, while 10% of prime loan-months were delinquent and 4% were in foreclosure.

4.2 Delinquency

First, we show that delinquency rates, defined as the proportion of active loans whose payment status was not listed as "current,"[8] rise over the period of interest, peaking a few years after the financial crisis at nearly 60% of subprime loans and nearly 20% of prime loans, shown in Figure 1. In the figure, each observation is the average over all outstanding loans in a given month. The delinquency rate starts increasing in 2007 and peaks in 2010.

Figures 2-4 show that the proportion of houses with any missed payments in the previous 12 months also increased during the crisis. Here, we plot only loan-month combinations that

[7]We focus on Prime loans only because key borrower observables, such as FICO credit score, are missing for subprime loans in our dataset.

[8]The status of the loan is defined according to Mortgage Banker Association standards. The word "Current" indicates that the loan is in line with scheduled payments and it is used here as the opposite of delinquent status.

were present for the last 12 months. The share of subprime mortgages missing at least one payment during 2010 is almost 60% in Florida.

4.3 Housing prices

Since a large part of foreclosures are driven by declining house prices, in the next section we document trends in the prices of the properties tied to loans in our sample. Figure 5 shows the average price in each month of the houses in our sample. The price of a house in each period is calculated as the appraisal price when the property was purchased inflated by the average change in house prices between the current period and the purchase date. To get the average change in house prices over time, we use the House Price Index from the FHFA, provided at the 3-digit zip code level.

Using the measure of house prices described above, we calculate the borrower's equity in the house as the house value minus the outstanding debt. In Figure 6, we present the proportion of houses that were underwater in each month, defined as the share of houses with negative equity.

4.4 Borrower "cure" rate

Next, we document some interesting patterns of behavior observed within borrowers over time. Non-repayment is not a one-time decision, but rather a dynamic problem in which the borrower chooses whether to make a payment in each month. In the data, we frequently observe borrowers become delinquent for a short period and then return to Current status, either through making payments or through the modification process. The act of returning to Current status from being delinquent by making payments for past months is known as a "cure." In Figure 7, we plot the borrower cure rate over time, defined as the proportion of loans who become current in each month conditional on being delinquent in the previous month.

5 Determinants of Default

In this section, we present descriptive evidence that suggests borrowers may behave strategically by looking at whether underwater borrowers were more likely to default than those that were not underwater.

5.1 Which loans become delinquent?

Table 2 presents results from a linear probability model. We include month, zip code, and month of loan origination fixed effects.

$$y_{itz} = \alpha + \gamma_t + \delta_z + \beta_1 X_i + \beta_2 Underwater_{it} + \beta_3 CurrentBalance_{it} + \beta_4 RatioUnpaid_{it} + \beta_5 InterestRate_{it} + \psi CurrentInvestor_{it} \quad (1)$$

- $Underwater_{it}$ Is a dummy variable equal to one if the current balance exceeds $\tilde{P}_{it}$, our proxy for house value
  - $\tilde{P}_{it}$ is calculated from the appraisal value[9] of the house at the time the loan was issued inflated by the quarterly House Price Index provided by Federal Housing Agency at the 3-digit Zipcode level
- $y_{itz} = 1$ if loan i in month t in zip code z is delinquent, in foreclosure proceedings or Real Estate Owned (REO, already repossessed by bank)
- X_i is a vector of loan-level controls including the log of the property's appraisal value, borrower's credit score, loan-to-value ratio at origination and a vector of dummies for loan product type (reference category is Fixed Rate Loan)
- $CurrentBalance_{it}$ is the size of the outstanding debt

[9]For several loans we observe also the actual sale price, but such information is missing for all subprime loans. In our dataset the appraisal value is in general higher than the sale price when both are present

- $RatioUnpaid_{it}$ is the outstanding debt divided by the loan amount at origination
- $CurrentInvestor_{it}$ is a vector of dummies for each investor type: reference category is Portfolio Held (non-securitized)

In columns (1) and (2) of each table, the dependent variable is a dummy that equals 1 if the status of the loan is delinquent, REO or foreclosure. In columns (3) and (4), the dependent variable equals 1 if the status of the loan is foreclosure. Columns (1) and (3) are for subprime loans only, columns (2) and (4) are for prime loans only.

Even after controlling for zip code, time, and month of origination fixed effects, we see that loans that are underwater are significantly more likely to be delinquent or in foreclosure - between 10-17% in our sample. As expected, borrowers with higher credit score at loan origination are less likely to be delinquent. Loans taken out on more expensive properties (as reported by the appraised value) and with a higher loan-to-value ratio are more likely to skip payments. Moreover, larger current balance is more likely to be associated with delinquency.

The positive and significant coefficient for the underwater dummy is consistent with some delinquency being generated by strategic behavior. However, the estimate could also be driven by correlation of liquidity and income shocks with house prices: a negative economic shock in a specific zip code can decrease the value of properties, pushing more loans underwater, and at the same time decrease the ability of borrowers to make their mortgage payment. However the size of the coefficient does not decrease dramatically when we run the regression with month x zipcode fixed effects, which should fully capture (at least in mean) the effect of local shocks. This finding would also be consistent with a story where houses that were underwater were purchased in the run-up to the financial crisis when credit rules were loosened, and so they were a priori more likely to default.

5.1.1 Which delinquent loans get foreclosed?

Tables 3 presents results from a linear probability model on the probability that a loan enters foreclosure conditional on the loan being delinquent in the previous period. The variables on

the right hand side are the same as in the previous regression, while the dependent variable and sample selection is different. Month and zipcode fixed effects are included.

In all four columns the dependent variable is equal to one if loan i was in foreclosure status in month t. Only the loans in delinquency during status in month $t-1$ enter the sample. Moreover, columns (3) and (4) include only the loans that were delinquent but not foreclosed during the previous month. Therefore, the last two columns are effectively describing the flow of mortgages from delinquency to foreclosure.

The results of this specification are less stable over columns and states than in the previous subsection. In column (3), where we test the effect of underwater status on the probability that subprime loans transition from delinquency to foreclosure, we find that the effect is not significantly different from zero. Therefore being underwater has a smaller effect (or, it is less correlated with) the probability that any loans become delinquent than on the conditional probability of being foreclosed given past delinquency. This finding would be consistent with underwater borrowers being delinquent mainly for strategic reasons: they are not foreclosed upon because either they become delinquent when they can get a modification or because they self cure before the risk of foreclosure becomes too high.

It is also interesting to notice that the FICO credit score does not have a negative sign. High credit score borrowers are less likely to skip payment, but are not less likely to get foreclosed when they become delinquent. This is consistent with a story in which the better risks only enter delinquency when they receive a very serious shock.

The correlation between the conditional probability of foreclosure and the appraised value of the house changes across different subsamples, while the effect of current balance, loan-to-value ratio and interest rate is constantly positive: loans which are more difficult to be repaid are more likely to end up in foreclosure.

6 HAMP and borrowers strategic response

In the next section, we test whether HAMP, by incentivizing more generous modification policies on the part of lenders, encouraged additional borrowers to default. We exploit a sharp discontinuity in program eligibility rules - lenders could only receive the modification subsidy for renegotiation with borrowers who purchased their homes before January 1st, 2009. We estimate a local linear regression around the discontinuity. The primary HAMP eligibility criteria, as discussed earlier, are:

1. It must be a "financial hardship" for the borrower to pay her mortgage and the borrower must be either delinquent or about to stop making payments
2. The loan must have originated on or before Jan 1^{st} 2009
3. Property must be owner-occupied and be the borrower's primary residence
4. The outstanding balance must be at most $\$729,750$ for one unit house (larger thresholds for multi-units houses)

The third and fourth criteria have been used to implement a differences in differences strategy in previous literature (most notably Agarwal et al. (2017)). However, we believe these differences might not be appropriate for our research goals. For instance, owner-occupied status might indicate that the borrower owns more properties, which might potentially increase the cost of foreclosure in states where deficiency judgment is allowed. Moreover, the average outstanding balance is well below the $\$729,750$ threshold: more expensive properties are bought by richer borrowers, who might have different costs of defaulting, for instance because a larger fraction of them need access to credit for other things. We instead exploit the sharp discontinuity of the policy implied by the second criterion: loans originated on and after January 2, 2009 are not eligible to be modified under the program. Since our data contains the month each loan was originated, we can compare the two subgroups of

loans which differ only in their origination date (before and after January 2009) and attribute the difference in probability of modification to the presence of this policy.

However, a simple comparison would not be a satisfactory estimation. Over time, banks relaxed borrower requirements to receive mortgages, a factor widely believed to contribute to the wave of mortgage delinquency from 2006 onward. When the crisis hit, lending criteria were sharply restricted as default rates increased. Therefore a simple comparison of the loans granted before and after January 2009 may confound the effect of HAMP with the effect of changing borrower quality over time. Thus, we implement a local linear regression-discontinuity approach. We analyze a sub-sample of loans originated in the last quarter of 2008 and in the first quarter of 2009. We control for a "local" time trend by including a linear time trend and allowing it to vary on the two sides of the threshold. One limitation is that we are only able to observe an integer proxy (month of origination) for the actual continuous forcing covariate (time of origination).

In figure 8, we plot the delinquency and foreclosure rates by month of origination. The figure shows the share of months that each group of loans was in default status during 2013. The vertical line indicates the last month of the "treated" group (those loans that were eligible for modifications under HAMP). We observe a clear drop around the policy change, with the rate of any delinquency falling about 5 percentage points between loans that originated in December 2008 versus those that originated in January 2009. The effects are similar for serious delinquency and foreclosure.

In figures 9 and 10, we show the delinquency rates over calendar time for loans that originated in different time periods. In figure 9, each line represents the serious delinquency rate for loans of a given origination month. The two months around the policy change are drawn with solid lines, while the other months are dashed lines. We observe that the delinquency rate begins higher with a difference that grows over time for loans that originated in December 2008 (treatment) compared to those who originated in January 2009 (control). While there is a small gap between loans issued in November and December 2008 and January

and February 2009, both differences are smaller than at the discontinuity. In figure 10, we observe the same dynamics when we consider the foreclosure rate.

While there do appear to be some changes in the one month before and after the discontinuity (November to December 2008, January to February 2009), it is possible that some measurement error in the data could generate these results. First, the policy is applicable for loans issued on or before January 1st, 2009. Thus, loans that were issued on January 1st appear in our "control" group, despite being eligible for modifications under HAMP. Second, there may be differences between the origination date reported by the banks and that recognized by the policy. For example, if the origination month is determined by the month in which the bank reported the loan to Corelogic and there is a delay between when the paperwork is signed and the loan is processed, there could be a delay between the issue date and the reported origination date. This source of measurement error is consistent with our results and may explain part of the observed change right before and after the policy change.

Next we turn to the regression discontinuity. In the first step of our analysis, we test whether loans who were eligible for modifications under HAMP are more likely to become delinquent. Let y_{izt} be the outcome of interest, such as delinquency status or serious delinquency (>90 days delinquent) for loan i in zipcode z during month t. Let $\tau_{[i]}$ be the month of origination of loan i and let τ^* be January 2009. Let $\mathcal{P}(t - \tau_{[i]}, \psi)$ be a third order polynomial (with parameters ψ) in the loans' month since origination. Then, we estimate the R-D model:

$$y_{itz} = \alpha + \gamma_1(\tau_{[i]} - \tau^*) + \gamma_2(\tau_{[i]} - \tau^*)\mathbb{1}_{[\tau_{[i]}<\tau^*]} + \theta\mathbb{1}_{[\tau_{[i]}<\tau^*]} + \\ + \delta_z + \beta_1 X_i + \beta_2 Z_{it} + \beta_3 UW_{it} + \mathcal{P}(t - \tau_{[i]}, \psi) + \eta_{itz} \quad (2)$$

The effect of the policy is estimated by the discontinuity parameter θ. The γ's capture a

linear time trend, which is allowed to vary on the two sides of the discontinuity. [10] Loan's time invariant covariates are collected in X_i (FICO at origination, original loan-to-value ratio, initial investor type, initial back-end ratio, log of original appraised value) while time-varying covariates are collected into Z_{it} (monthly scheduled payment, current interest rate, current balance and ratio between current and original balance). Covariates in Z_{it} are included with a one-period-lag, in order to avoid mechanical correlation in case of modification (for instance, we might infer modification by looking at changes in monthly payment). We also include UW_{it} which is a dummy indicating whether the property was underwater, computed as described in the previous section, and zip code fixed effects.

As in every R-D setting, our identifying assumption is that any unobservable varying over loan origination date is continuous around the threshold. Such assumption would be violated if, for example, banks changed abruptly some credit requirement starting from January 2009. A further threat to identification of the causal effect of HAMP would arise if borrowers were aware that HAMP would establish Jan 1st, 2009 as the eligibility cutoff. If this were the case, we might be worried that borrowers with higher risk of default might have bunched around the cutoff. However, from our initial research, it does not appear that this date was announced in advance of the HAMP's enactment in 2009. Moreover, we do not think it is very common for mortgage borrowers to take out a loan in anticipation of becoming delinquent.

We use loans generated in a window around the date of the policy change, that is between August 2008 to April 2009, de facto running a "local" specification. We experiment below with different band size. We observe only an integer proxy for the underlying continuous forcing covariate origination time. This setting prevents us from using the appropriate "optimal bandwidth". It also forces us to use a simple linear trend in origination date, since we have only eight different values for this variable in our preferred specification.

[10] Since we observe only the month of origination but not the exact date, we impute the mass to the middlepoint of the month: therefore, the variable $\tau_{[i]}$ gets values $-4.5, -3.5, -2.5, -1.5, -0.5$ for treatment loans and $0.5, 1.5, 2.5, 3.5, 4.5$ for control loans.

6.1 Effect of HAMP on delinquency

Table 6 contains the results of the estimations described above. One observation is a loan-month, where we use all first-lien and owner-occupied loans generated between August 2008 and May 2009 in a random sample of 12.5% of US zip codes[11]. We include loan performance data for this sample from June 2009 to April 2014. We focus here on results from prime mortgages. The dependent variable is equal to one if loan i in month t was delinquent - in columns (1) and (2) we use any delinquency while in columns (3) and (4) we use serious delinquency. We drop loans which are already in foreclosure process. The dummy HAMP indicates loans which originated before Jan 2009 and, therefore, satisfied the HAMP origination constraint. This variable does not indicate whether the loan is definitely eligible for the program, since we are not able to observe some important characteristics, for instance the current income-to-debt-ratio. Moreover, some loans on the other side of the threshold might still be eligible, either because they were issued on January 1st or because of measurement error in the origination date. All standard errors are clustered at the 3-digit zip code level.

The coefficients at the top of columns (1) and (3) indicate that the program increased the likelihood of borrowers to be delinquent in any month by about 1%, and the likelihood to become seriously delinquent by 0.3%. The unconditional probabilities to be in delinquent and serious delinquent status are, respectively, 7.3% and 4.3% for loans originated between August 2008 and May 2009. Although the overall effect is not huge, it is particularly strong in some subset of borrower populations. We test for heterogeneity in the treatment effect for loans who were underwater and for those in states with judicial foreclosure and those that allow recourse. Prior work by Mian et al. (2010) established that foreclosure is significantly less common in judicial states, where the lender must take the borrower to court to remove her from the house, raising the administrative and legal fees associated with the process. In recourse states, the lender can sue the borrower in some circumstances if she defaults on the loan and the sale of the collateral is not sufficient to cover the outstanding debt, so the cost

[11] We sample only zip codes who had at least 100 new Prime mortgages in the period 2007-2010

of foreclosure is higher for the borrower in recourse states. Because of this, HAMP should have a larger effect in inducing strategic default among loans in recourse states, since HAMP decreases the probability of foreclosure and therefore makes default comparatively less costly. In Columns (2) and (4) the HAMP treatment is interacted with the previously described set of dummies: underwater loans, loans in states with judicial foreclosure (according to Realtytrac.com) and a dummy for loans originated in "non recourse" states. The estimates suggest that HAMP eligibility had a strong effect on underwater loans in recourse states, as we might expect. In fact, these loans are 6% more likely to be in any delinquency status and 4% more likely to be seriously delinquent. These estimates suggests that HAMP increased the number of strategic defaults, especially in recourse states.

6.2 Effect of HAMP on foreclosure

Table 7 reports our RD estimates of the effect of HAMP on foreclosure and exit from delinquency status. In columns (1) to (4) the dependent variable is one if loan i is in foreclosure state in month t. The sample in columns (1)-(2) includes all the first-lien and owner-occupied loans generated between August 2008 and May 2009 in a random sample of 12.5% of US zip codes, and their performance between June 2009 and April 2014. It therefore represents the unconditional probability that any active loan is in the foreclosure process or already REO (it is a stock). Our estimate shows that the effect of HAMP is very small in magnitude - 0.01% versus a mean probability of 1.7% - and not statistically different from zero[12]. Once we allow for the policy to have heterogeneous effects for different groups of loans (column (2)), we estimate that loans which are underwater in recourse states, are significantly more likely to be in foreclosure states because of HAMP, by 0.3%.

The specification presented in columns (3)-(4) have the same dependent variable as the previous regressions, but are estimated from a different sample. We include only those loans who were in serious delinquency but not in foreclosure in the previous month. That is,

[12]Estimates are larger and more significant when we widen the "bandwidth" by including loans originated in all of 2008 and 2009.

we aim to estimate the effect of HAMP on the flow between delinquency and foreclosure. In fact, by encouraging renegotiation of loan terms, HAMP provides a viable alternative to foreclosure. As expected, the loans who are potentially eligible for HAMP are, each month, 0.7% less likely to enter foreclosure from serious delinquency. The effect is, however, significantly weaker for loans which are underwater in non-recourse states.

The dependent variable in the regressions presented in columns (5) - (6) is one if the loan i in month t is in current status (not delinquent). The sample is all loans that were in serious delinquency in the previous period, but not yet in foreclosure. In columns (5)-(6), the dependent variable is one if the loan was in delinquency last month and returned to current status this month, and the sample includes all loans who were delinquent last month. We estimate that HAMP has a small (0.3%) positive impact on the probability of exiting serious delinquency by resuming payment, but this effect is not significantly different from zero. Some of this effect could be the result of (unobserved) modifications, since loans are typically reset to current following a successful renegotiation. However, the estimates are larger, 0.12%, and statistically different from zero, for the subsample of loans underwater. These estimates are consistent with our theory of strategic default.

The results presented so far suggest that HAMP was indeed able to encourage modification in lieu of foreclosure for serious delinquent loans, and therefore increased the probability that borrowers return to pay. However, it also encouraged more borrowers to become delinquent to seek modification. Therefore, the overall effect of the policy was small if not zero, at least for loans originated around the cutoff date. It is worth noticing that one category of loans, underwater in recourse states, is particularly sensitive to HAMP incentives: these loans are much more likely to become delinquent because of the policy change, and they are also more likely to be in foreclosure. Moreover, they are more likely to exit serious delinquency by returning to payment, which might indicate they are receiving modifications.

6.3 HAMP and borrowers strategic response: Robustness

To complete our assessment of HAMP, we perform a series of robustness tests to support the validity of our estimates.

6.3.1 Changing the bandwidth

In the specification presented in the previous section, we include loans originated in proximity of the cutoff date. We observe the timing of the loan origination only approximatively: Corelogic reports only the month of origination. Therefore, since we only observe a few values of the "forcing variable" we are limited in choosing which loans to include and in the flexibility of our control for loan origination. In the main specification, presented above, we include 5 months on each side of the cutoff.

In table 8 we repeat some of the specifications presented above using a full year of loans orginated around the eligiblity cutoff (those that were originated between January 2008 and December 2009). The main findings are confirmed: HAMP increases the average probability of borrowers to be delinquent or seriously delinquency (columns (1)-(2)). Moreover, HAMP decreases the probability of flowing from serious delinquency to foreclosure as shown in the first row of column (4). The effect of HAMP on overall foreclosure, as reported in column (3), is larger than what we previously found using only a 5-month window (Table 7) and statistically different from zero. Therefore, the main dynamics are relatively robust to the choice of bandwidth size.

6.3.2 Placebo Test

To test the robustness of our regression discontinuity analysis, we look at the change in delinquency probabilities for loans originating around the December/January cutoff one year before and one year after. Figures 11 and 12 plots the trend in serious delinquency and foreclosure probability over the loan's life cycle for loans originated in December 2007, 2008 and 2009 and in January 2008, 2009 and 2010. We do not see the same discontinuity in 2008

and 2010. This graph should confirm that there is effectively a discontinuity at the end of 2008 and that we are not capturing just a yearly difference or seasonal pattern. To further confirm our statement, we run a formal placebo test, by creating a "fake" policy change with eligibility threshold at Jan 1^{st} 2010. Table 9 reports the results: no outcome is significantly affected by the fake treatment at the 5% confidence level.

6.3.3 Balancing Tests

We present three graphs showing the mean of the appraised value (in log), original loan-to-value ratio and credit score at origination, for loans originated between the end of 2007 and the middle of 2010. Figures 13 and 14 show that both the value of property posted as collateral and the average loan to value ratio widely fluctuate over time, with an apparent pseudo-seasonal pattern. These graphs provide additional motivation for the placebo test run above, in order to check that our specifications are not just capturing the effect of end-of-year seasonal patterns. We observe a change around our discontinuity, which is a concern for our identification strategy since it might imply a change in bank lending behavior over the same time frame.

Figure 15 shows the average credit score by time of loan origination. We see an increase around the policy change, so that borrowers who received loans after the policy change had higher credit scores by around 30 points. The pattern seems to be consistent across US states, indicating the possibility of changing lending standards during the time period, though larger around the event. However, we note that the fluctuation represents a change of only half a standard deviation (or 5%), while the change in the delinquency rate represents a change of more than 50%. In addition, we control for observable borrower characteristics in two ways. First, we include these borrower and loan-level observables as covariates in the regression discontinuity. Thus, our empirical strategy allows for differences in these variables over time, as long as our model is correctly specified and the effect of these variables on loan performance remains constant around the policy change. Second, we include separate linear

time trends before and after the policy change. This allows for unobservable factors that change with loan origination date to vary linearly over time. Therefore, threats to our identification would require a sharp change in unobservable factors at the exact month of the policy change.

7 Conclusion

This paper tests for evidence of strategic response by borrowers to HAMP, a large government intervention in the mortgage renegotiation market. This policy provided substantial subsidies to both mortgage servicers that reduced borrowers' monthly payments, primarily for borrowers that were more than 60 days delinquent on their loan. In contrast to the prior literature, we find evidence that the policy encouraged additional borrower delinquency. Our baseline estimates suggest that the policy increased delinquency rates in the set of loans originated in late 2008 by about one percentage point (a 13% increase), with significantly larger effects for borrowers that were underwater or that lived in recourse states. However, we also find that loans that were eligible for mortgage modifications under HAMP were less likely to be foreclosed, conditional on becoming delinquent.

Our results indicate that the HAMP program was successful in one of its stated goals - to reduce the flow of delinquent borrowers into foreclosure proceedings. However, many observers noted that the policy induced fewer loan servicers to make modifications than was initially expected. Our results suggests a simple reason for this shortcoming; lenders may have worried a more generous modification policy would induce additional borrowers to become delinquent.

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8 Tables and figures

Table 1: Descriptive Statistics for sample AZ, FL and WI

Stats	Foreclosed	Delinquent	Unemployment	Underwater	Log of Appraised Value	FICO Score at Origination
			Subprime			
mean	.117	.328	6.465	.166	12.064	625.002
p50	0	0	6	0	12.117	623
p25	0	0	3.8	0	11.752	576
p75	0	1	8.7	0	12.462	668
sd	.322	.470	3.029	.372	.862	68.733
max	1	1	30.3	1	16.678	900
min	0	0	1.9	0	0	300
N	3146311	3146311	3111983	3146311	2305703	2930631
			Prime			
mean	.041	.103	7.164	.133	12.189	719.458
p50	0	0	7.1	0	12.181	727
p25	0	0	4.3	0	11.775	679
p75	0	0	9.5	0	12.578	770
sd	.198	.304	3.042697	.339	.663	62.367
max	1	1	30.3	1	16.777	900
min	0	0	1.9	0	0	300
N	2.67e+07	2.67e+07	2.65e+07	2.67e+07	2.08e+07	2.25e+07

The table shows summary statistics for our descriptive analysis sample used in Section 5, which includes a 7% random sample of all loans that were active between 2005 and 2014 from Florida, Wisconsin, and Arizona. One observation in the underlying dataset is a loan x month. We show the quantiles of seven key variables. "Foreclosed" and "delinquent" are indicator variables that equal one if the loan was listed as in foreclosure or if its status was listed as delinquent in that loan-month. Unemployment is the county-level unemployment rate from the BLS. "Underwater" is an indicator variable equal to 1 if the outstanding balance on the loan exceeds the estimated appraised value. We calculate the estimated appraised value in each month by inflating the appraisal value of the house at the time the loan was issued by the average house price growth rate calculated from the price index provided by the FHFA. FICO score at origination was the credit score of the borrower at the time the loan was issued. The top panel shows summary statistics on each of these variables for subprime loans and the bottom panel shows statistics for prime loans. The number of observations differs across columns because some loans have missing values for some variables.

Table 2: Probability of Delinquency and Foreclosure: AZ, FL, WI

VARIABLES	(1) Delinquent REO or Foreclosed	(2) Delinquent REO or Foreclosed	(3) Foreclosed	(4) Foreclosed
GRADE	Subprime	Prime	Subprime	Prime
Underwater	0.174***	0.163***	0.131***	0.103***
	[0.008]	[0.011]	[0.012]	[0.010]
Log of Appraised Valuation	0.027***	0.023***	0.015***	0.01***
	[0.001]	[0.003]	[0.001]	[0.002]
FICO Score at Origination	-0.001***	-0.001***	-0.0002***	-0.0002***
	[0.000]	[0.000]	[0.000]	[0.000]
Current Interest Rate	0.039***	0.040***	0.027***	0.0275***
	[0.003]	[0.003]	[0.002]	[0.003]
Current Balance	0.0000002***	-0.00000001*	0.0000002***	0.00000001
	[0.000]	[0.000]	[0.000]	[0.000]
Current over Original Balance	0.393***	0.190***	0.212***	0.111***
	[0.022]	[0.015]	[0.014]	[0.011]
Original LTV	0.001***	0.001***	0.001***	0.00007**
	[0.000]	[0.000]	[0.000]	[0.000]
Unemployment Rate	0.010***	0.008***	0.014***	0.006***
	[0.003]	[0.002]	[0.003]	[0.001]
Observations	2,021,730	12,745,933	2,021,730	12,745,933
R-squared	0.285	0.231	0.190	0.155

The table shows regression results from the estimation of the linear probability model described in Section 5 using our descriptive analysis sample, which includes a 7% random sample of all loans that were active between 2005 and 2014 from Florida, Wisconsin, and Arizona. Each observation in the data is a loan x month. In columns (1) and (2), the dependent variable is an indicator for whether the loan's status in that month was listed as delinquent, real estate owned, or in foreclosure. In columns (3) and (4), the dependent variable is an indicator for whether the loan's status was in foreclosure. "Underwater" is an indicator variable equal to 1 if the outstanding value of the loan was greater than the estimated value of the property, calculated as the appraisal value of the property at loan origination inflated by the house price growth rate at the 3-digit zipcode level. The current interest rate was the interest rate in that month. The current balance is the debt remaining on the loan. The current over original balance is the ratio of the outstanding debt in that month to the value of the loan at the time it was originated. The Original LTV is the ratio of the initial amount of the loan to value of the property at the time the loan was originated. The unemployment rate is the county-level unemployment rate from the BLS data in that month. In addition to the covariates described above, the regression includes month, zip code, and month of loan origination fixed effects, as well as a vector of dummies for the loan's current investor and the loan's product type. Standard errors are clustered at the 3-digit zipcode level.

Table 3: Probability of Foreclosure given delinquency status in previous month: AZ, FL, WI

	(1)	(2)	(3)	
VARIABLES	Foreclosed	Foreclosed	Foreclosed	Foreclo
GRADE	Subprime	Prime	Subprime	Pri
Conditional on	Delinquent at $t-1$	Delinquent at $t-1$	Serious Delinquent at $t-1$	Serious Delinquent at t
Underwater	0.01***	0.008***	-0.009	-0.007
	[0.002]	[0.001]	[0.006]	[0.0
Log of Appraised Valuation	-0.001	-0.001	-0.015***	-0.017
	[0.001]	[0.001]	[0.005]	[0.0
FICO Score at Origination	0.00003***	0.0001***	0.00005**	0.0002
	[0.000]	[0.000]	[0.000]	[0.0
Current Interest Rate	0.001***	0.005***	-0.004***	0.00
	[0.000]	[0.000]	[0.001]	[0.0
Current over Original Balance	0.026***	0.044***	0.042***	0.055
	[0.003]	[0.002]	[0.009]	[0.0
Current Balance	0.00000008***	0.00000002***	0.0000002***	0.00000005
	[0.000]	[0.000]	[0.000]	[0.0
Original LTV	0.0004***	0.001***	0.001**	0.001
	[0.000]	[0.000]	[0.000]	[0.0
Unemployment Rate	0.002***	0.001**	0.005*	-0.0
	[0.001]	[0.001]	[0.002]	[0.0
Observations	379,953	836,710	146,888	392,5
R-squared	0.020	0.020	0.073	0.0

The table shows regression results from the estimation of a linear probability model described in Section 5. Each observation in the data is a loan x month. The dependent variable is an indicator equal to 1 if the loan's status was in foreclosure in the current month. In columns (1) and (2), we include only loan-months in which the loan was delinquent in the previous month (30, 60, or 90+ days delinquent, but not yet in foreclosure). In columns (3) and (4), we include only loan-months in which the loan was seriously delinquent in the previous month (90+ days delinquent). "Underwater" is an indicator variable equal to 1 if the outstanding value of the loan was greater than the estimated value of the property, calculated as the appraisal value of the property at loan origination inflated by the house price growth rate. The current interest rate was the interest rate in that month. The current balance is the debt remaining on the loan. The current over original balance is the ratio of the outstanding debt in that month to the value of the loan at the time it was originated. The Original LTV is the ratio of the initial amount of the loan to value of the property at the time the loan was originated. The unemployment rate is the county-level unemployment rate from the BLS data in that month. In addition to the covariates described above, the regression includes month, zip code, and month of loan origination fixed effects, as well as a vector of dummies for the loan's current investor and the loan's product type. Standard errors are clustered at the 3-digit zipcode level.

Table 4: Month×Loan level descriptive statistics for HAMP sample

Loans originated from Aug 2008 to May 2009

Stats	**Any Delinquency**	**Foreclosure**	**Serious Delinquency**	**Underwater**	**Ratio Unpaid debt**	**Loan Age**	**Current Interest Rate**	**Sheduled Payment**	**Log of Current Balance**
mean	.0758856	.0170858	.0425423	.1710572	.9513735	26.4706	5.269421	1176.012	12.03105
p50	0	0	0	0	.967786	24	5	1032.92	12.04789
sd	.264815	.1295913	.2018227	.3765589	.0754408	17.37911	.7747912	765.7921	.6125396
max	1	1	1	1	1.981544	70	15.38	301955.8	15.31959
min	0	0	0	0	1.24e-08	0	0	-11454.37	-4.60517
N	1.66e+07	1.66e+07	1.66e+07	1.66e+07	1.66e+07	1.66e+07	1.66e+07	1.66e+07	1.66e+07

The table shows summary statistics at the loan-month level for the sample we use to estimate the effect of HAMP on loan delinquency and foreclosure rates. To construct this sample, we take a random sample of 12.5% of US zipcodes and include all prime loans for those zipcodes. We include loan-months between June 2009 and April 2014. One observation in the underlying dataset is a loan x month. "Any delinquency" is an indicator variable equal to 1 when a loan-month is marked as delinquent by 30, 60, or 90+ days or in foreclosure. "Serious delinquency" is an indicator equal to 1 when a loan-month is marked as delinquent by 90+ days or in foreclosure. "Foreclosure" is an indicator equal to 1 when a loan-month is marked as in foreclosure. "Underwater" is an indicator variable equal to 1 if the outstanding balance on the loan exceeds the estimated appraised value. We calculate the estimated appraised value in each month by inflating the appraisal value of the house at the time the loan was issued by the average house price growth rate calculated from the price index provided by the FHFA. The ratio of unpaid debt is the ratio of the remaining debt in a given month to the total loan balance at origination. Loan age is the number of months since loan origination. The current interest rate is the interest rate faced by the borrower in that month. The scheduled payment is the amount due by the borrower in that month. The current balance is the remaining debt on the loan in that month.

Table 5: Loan level descriptive statistics for HAMP sample

Loan variables at origination: loans originated from Aug 2008 to May 2009

Stats	**Log of Appraised Value**	**FICO credit score**	**Loan to Value Ratio**	**Debt to Income Ratio**
mean	12.43251	728.4251	77.68209	34.7533
p50	12.40901	743	80	35.422
p75	12.83615	782	96.66	44.664
sd	.6340837	63.21668	21.1536	14.51711
max	16.55635	900	200	150
min	0	300	.01	0
N	304656	398141	425838	224254

The table shows summary statistics at the loan level for the sample we use to estimate the effect of HAMP on loan delinquency and foreclosure rates. To construct this sample, we take a random sample of 12.5% of US zipcodes and include all prime loans for those zipcodes. All variables in the above are recorded at the loan origination date.

Table 6: HAMP: effects on Delinquency status

VARIABLES	(1) Any Delinquency	(2) Any Delinquency	(3) Serious Delinquency	(4) Serious Delinquency
HAMP	0.01044251***	-0.00051356	0.00271619**	-0.00628990***
	[0.002]	[0.002]	[0.001]	[0.002]
HAMP×Underwater		0.05889823***		0.04237370***
		[0.004]		[0.003]
HAMP×Judicial		-0.00471382		-0.00219469
		[0.003]		[0.002]
HAMP×Non-Recourse		-0.00619428*		-0.00193621
		[0.004]		[0.002]
HAMP×Underwater×Non-Recourse		-0.02219163***		-0.01506260***
		[0.007]		[0.005]
Log of Appraised Valuation	0.07998982***	0.08022072***	0.07048085***	0.07067297***
	[0.002]	[0.002]	[0.002]	[0.002]
Underwater	0.03951995***	0.01764062***	0.02974387***	0.01379593***
	[0.002]	[0.002]	[0.001]	[0.002]
FICO Score at Origination	-0.00094277***	-0.00094501***	-0.00038592***	-0.00038781***
	[0.000]	[0.000]	[0.000]	[0.000]
Current Interest Rate (Lagged)	0.00257650**	0.00347360***	0.00177261**	0.00243134***
	[0.001]	[0.001]	[0.001]	[0.001]
Scheduled Monthly Payment (Lagged)	0.00000598***	0.00000602***	0.00000611***	0.00000612***
	[0.000]	[0.000]	[0.000]	[0.000]
Log of Current Balance (Lagged)	-0.07083901***	-0.07240068***	-0.06466491***	-0.06582414***
	[0.002]	[0.002]	[0.002]	[0.002]
Current balance / original balance (Lagged)	0.35809274***	0.35586639***	0.27114507***	0.26963387***
	[0.010]	[0.010]	[0.009]	[0.008]
Original LTV	0.00117889***	0.00122580***	0.00105042***	0.00108533***
	[0.000]	[0.000]	[0.000]	[0.000]
Unemployment Rate	0.00317822***	0.00307031***	0.00223682***	0.00216359***
	[0.000]	[0.000]	[0.000]	[0.000]
Back-End Ratio	-0.00023682***	-0.00022197***	-0.00004692**	-0.00003656*
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	8,268,364	8,268,364	8,268,364	8,268,364
R-squared	0.140	0.142	0.085	0.087

The table shows results from the regression discontinuity estimation described in Section 6.1. The sample includes prime loans that were originated in the four months on either side of the January 2, 2009 cutoff for HAMP (August 2008-December 2008 and January 2009-April 2009). We use their payment status during calendar months between June 2009 and April 2014 and drop loans that are already in foreclosure. In columns (1) and (2), the dependent variable in the regression is an indicator equal to 1 if a loan-month was in any delinquency status and 0 otherwise. In columns (3) and (4), the dependent variable is an indicator equal to 1 if the loan-month was seriously delinquent (90+ days delinquent). In columns (2) and (4), we interact the effect of the HAMP policy with whether state law allows for recourse loans, whether the state requires judicial action to foreclose, and whether the property was underwater. The variable HAMP is an indicator that takes value 1 if the loan was originated prior to January 2009. The regression includes a vector of time-invariant loan characteristics, including the borrower's FICO score at origination, original loan-to-value ratio, initial investor type, initial back-end ratio, loan product type, and log of original appraised value. We also include a set of time-varying covariates, including monthly scheduled payment, current interest rate, current balance, and ratio between current and original balance, all with a one-period lag. We further include a linear time trend that varies on either side of the origination threshold, zipcode fixed effects, and a third degree polynomial in age of the loan. Standard errors are clustered at the 3-digit zipcode level.

Table 7: HAMP: effects on Foreclosure and Exit from Serious Delinquency

VARIABLES	(1) Foreclosure Status	(2) Foreclosure Status	(3) Foreclosure Status	(4) Foreclosure Status	(5) Return in Current Status	(6) Return in Current Status
HAMP	-0.00010514	-0.00088404***	-0.00771636***	-0.00824283**	0.00310797	-0.00570826**
	[0.000]	[0.000]	[0.003]	[0.004]	[0.002]	[0.003]
HAMP×Underwater		0.00293288***		0.00304960		0.01152474***
		[0.000]		[0.003]		[0.002]
HAMP×Judicial		0.00011611		-0.00186787		0.00381784*
		[0.000]		[0.003]		[0.002]
HAMP×Non-Recourse		0.00020636		0.00605699		0.00780576*
		[0.000]		[0.006]		[0.005]
HAMP×Underwater×Non-Recourse		-0.00140947***		-0.01143426*		-0.00715237
		[0.000]		[0.007]		[0.006]
Log of Appraised Valuation	0.00211508***	0.00212646***	-0.00899286***	-0.00903219***	-0.01930141***	-0.01944539***
	[0.000]	[0.000]	[0.003]	[0.003]	[0.002]	[0.002]
Underwater	0.00210960***	0.00103405***	0.00014091	-0.00072447	0.00535728**	-0.00055527
	[0.000]	[0.000]	[0.002]	[0.003]	[0.002]	[0.002]
FICO Score at Origination	-0.00002354***	-0.00002366***	0.00020834***	0.00020840***	-0.00002995***	-0.00003045***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Original LTV	0.00002075***	0.00002317***	-0.00060262***	-0.00060006***	-0.00067842***	-0.00068579***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Unemployment Rate	0.00007534**	0.00007119**	-0.00318086***	-0.00317005***	0.00083836	0.00082646
	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Sample Conditional on Serious Delinquency			*Yes*	*Yes*	*Yes*	*Yes*
Observations	8,275,894	8,275,894	225,891	225,891	225,891	225,891
R-squared	0.006	0.006	0.038	0.038	0.018	0.018

The table shows results from the regression discontinuity estimation described in Section 6.1, focusing on the transition of loans from delinquency to foreclosure and delinquency to current status. The sample includes prime loans that were originated in the four months on either side of the January 2, 2009 cutoff for HAMP (August 2008-December 2008 and January 2009-April 2009). We use their payment status during calendar months between June 2009 and April 2014 and include loan-months that were delinquent in the previous month. In columns (1)-(4), the dependent variable in the regression is an indicator equal to 1 if a loan-month was in foreclosure status and 0 otherwise. In columns (5) and (6), the dependent variable is an indicator equal to 1 if the loan-month was current (i.e. if it returned to making payments about being seriously delinquent in the previous month). In columns (2), (4) and (6), we interact the effect of the HAMP policy with whether state law allows for recourse loans, whether the state requires judicial action to foreclose, and whether the property was underwater. The variable HAMP is an indicator that takes value 1 if the loan was originated prior to January 2009. The regression includes a vector of time-invariant loan characteristics, including the borrower's FICO score at origination, original loan-to-value ratio, initial investor type, initial back-end ratio, loan product type, and log of original appraised value. We also include a set of time-varying covariates, including monthly scheduled payment, current interest rate, current balance, and ratio between current and original balance, all with a one-period lag. We further include a linear time trend that varies on either side of the origination threshold, zipcode fixed effects, and a third degree polynomial in age of the loan. Standard errors are clustered at the 3-digit zipcode level.

Table 8: HAMP: Robustness test, 12 months on each side

VARIABLES	(1) Any Delinquency or Foreclosure	(2) Serious Delinquency	(3) Foreclosure Status	(4) Foreclosure Status
HAMP	0.01178967***	0.00628279***	-0.00991192***	-0.00903121***
	[0.004]	[0.002]	[0.003]	[0.002]
Log of Appraised Valuation	0.10259628***	0.07317708***	0.05177610***	-0.00835832***
	[0.003]	[0.002]	[0.003]	[0.002]
Underwater	0.05937974***	0.03026257***	0.02550834***	0.00303738**
	[0.003]	[0.001]	[0.002]	[0.001]
FICO Score at Origination	-0.00108701***	-0.00040665***	-0.00018122***	0.00022849***
	[0.000]	[0.000]	[0.000]	[0.000]
Current Interest Rate (Lagged)	0.01832764***	0.00730209***	0.01335556***	-0.00035597
	[0.002]	[0.001]	[0.002]	[0.001]
Scheduled Monthly Payment (Lagged)	0.00000295**	0.00000367***	0.00000022	-0.00000039***
	[0.000]	[0.000]	[0.000]	[0.000]
Log of current Balance (Lagged)	-0.07996077***	-0.06262898***	-0.04081555***	-0.00101065
	[0.001]	[0.001]	[0.002]	[0.001]
Current balance as a fraction of original balance (Lagged)	0.45702003***	0.25988123***	0.19206055***	0.10524712***
	[0.012]	[0.008]	[0.009]	[0.010]
Original LTV	0.00141273***	0.00106515***	0.00065585***	-0.00066989***
	[0.000]	[0.000]	[0.000]	[0.000]
Unemployment Rate	0.00474901***	0.00244393***	0.00200782***	-0.00200852***
	[0.000]	[0.000]	[0.000]	[0.001]
Back-End Ratio	-0.00031619***	-0.00004947***	-0.00022114***	-0.00026606***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	-0.20595502***	-0.26047616***	-0.34059527***	0.13692013***
	[0.050]	[0.025]	[0.037]	[0.031]
Observations	21,263,906	20,790,182	21,263,906	640,272
R-squared	0.175	0.081	0.075	0.022

The table shows results from the regression discontinuity estimation described in Section 6.1, using an expanded sample that includes 12 months of origination dates around the discontinuity (our baseline uses 4 months). The sample includes prime loans that were originated in the twelve months on either side of the January 2, 2009 cutoff for HAMP (January 2008-December 2008 and January 2009-December 2009). We use their payment status during calendar months between January 2010 and April 2014 and drop loans that are already in foreclosure. In columns (1) and (2), the dependent variable in the regression is an indicator equal to 1 if a loan-month was in any delinquency status and 0 otherwise. In columns (3) and (4), the dependent variable is an indicator equal to 1 if the loan-month was seriously delinquent (90+ days delinquent). In columns (2) and (4), we interact the effect of the HAMP policy with whether state law allows for recourse loans, whether the state requires judicial action to foreclose, and whether the property was underwater. The variable HAMP is an indicator that takes value 1 if the loan was originated prior to January 2009. The regression includes a vector of time-invariant loan characteristics, including the borrower's FICO score at origination, original loan-to-value ratio, initial investor type, initial back-end ratio, loan product type, and log of original appraised value. We also include a set of time-varying covariates, including monthly scheduled payment, current interest rate, current balance, and ratio between current and original balance, all with a one-period lag. We further include a linear time trend that varies on either side of the origination threshold, zipcode fixed effects, and a third degree polynomial in age of the loan. Standard errors are clustered at the 3-digit zipcode level.

Table 9: HAMP: Placebo test, fake event Jan 1^{st} 2010

VARIABLES	(1) Any Delinquency or Foreclosure	(2) Serious Delinquency	(3) Foreclosure Status	(4) Foreclosure Status
Placebo HAMP	0.02120396*	0.00105449	0.00425382	0.03638719
	[0.011]	[0.008]	[0.004]	[0.041]
Log of Appraised Valuation	0.07894986***	0.06536362***	0.03226666***	-0.03354552***
	[0.003]	[0.003]	[0.003]	[0.011]
Underwater	0.02723431***	0.02063029***	0.00813592***	0.01045566***
	[0.002]	[0.001]	[0.001]	[0.003]
FICO Score at Origination	-0.00066335***	-0.00028080***	-0.00007912***	0.00020683***
	[0.000]	[0.000]	[0.000]	[0.000]
Current Interest Rate (Lagged)	-0.00049837	-0.00041240	0.00155033***	0.00495165*
	[0.001]	[0.001]	[0.000]	[0.003]
Scheduled Monthly Payment (Lagged)	0.00000627***	0.00000346***	0.00000151***	0.00001507
	[0.000]	[0.000]	[0.000]	[0.000]
Log of Current Balance (Lagged)	-0.08279244***	-0.06518021***	-0.03364062***	-0.00199469
	[0.003]	[0.003]	[0.003]	[0.002]
Current balance as a fraction of original balance (Lagged)	0.30763357***	0.22775460***	0.09496767***	0.13663857***
	[0.011]	[0.009]	[0.007]	[0.030]
Original LTV	0.00126268***	0.00099326***	0.00048734***	-0.00103992***
	[0.000]	[0.000]	[0.000]	[0.000]
Unemployment Rate	-0.00014239	-0.00007794	-0.00019096	-0.00624217***
	[0.000]	[0.000]	[0.000]	[0.001]
Back-End Ratio	0.00029477***	0.00017347***	0.00005473***	-0.00010850
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.07709769***	-0.12666105***	-0.07836799***	0.46516558***
	[0.022]	[0.017]	[0.011]	[0.144]
Observations	8,411,478	8,411,478	8,411,478	110,431
R-squared	0.083	0.053	0.025	0.053

The table shows results from a placebo test of the regression discontinuity estimation described in Section 6.1. The sample includes prime loans that were originated in the four months on either side of January 1, 2010 (the actual HAMP policy affected loans after January 1, 2009). We use their payment status during calendar months between April 2009 and April 2014 and drop loans that are already in foreclosure. In columns (1) and (2), the dependent variable in the regression is an indicator equal to 1 if a loan-month was in any delinquency status and 0 otherwise. In columns (3) and (4), the dependent variable is an indicator equal to 1 if the loan-month was seriously delinquent (90+ days delinquent). In columns (2) and (4), we interact the effect of the HAMP policy with whether state law allows for recourse loans, whether the state requires judicial action to foreclose, and whether the property was underwater. The variable HAMP is an indicator that takes value 1 if the loan was originated prior to January 2009. The regression includes a vector of time-invariant loan characteristics, including the borrower's FICO score at origination, original loan-to-value ratio, initial investor type, initial back-end ratio, loan product type, and log of original appraised value. We also include a set of time-varying covariates, including monthly scheduled payment, current interest rate, current balance, and ratio between current and original balance, all with a one-period lag. We further include a linear time trend that varies on either side of the origination threshold, zipcode fixed effects, and a third degree polynomial in age of the loan. Standard errors are clustered at the 3-digit zipcode level.

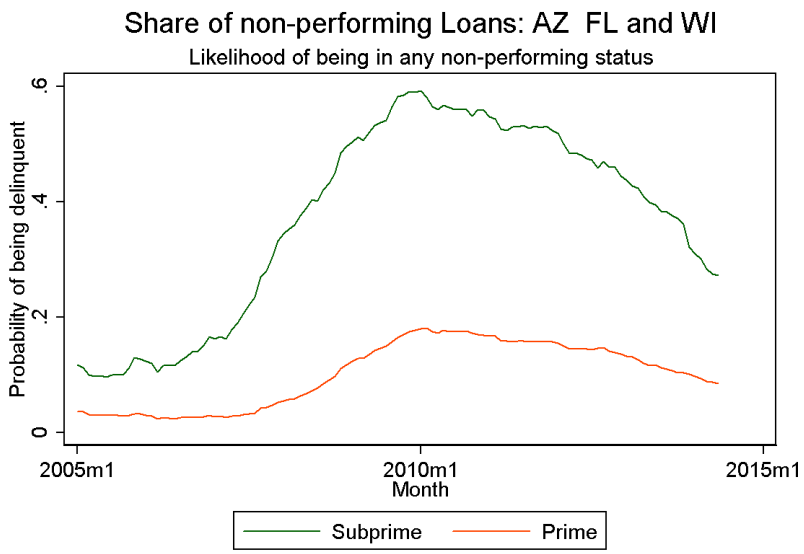

Figure 1: Delinquency rate from 2005-2014, AZ, FL, WI

The figure shows the average delinquency rate in our sample over time for subprime and prime loans. A loan is delinquent in a given month if its status is listed as delinquent by 30, 60, or 90+ days, in foreclosure proceedings, or real estate owned (property has already been repossessed by the lender). Each point in the figure reports the average delinquency rate over all outstanding loans present in the data in that month.

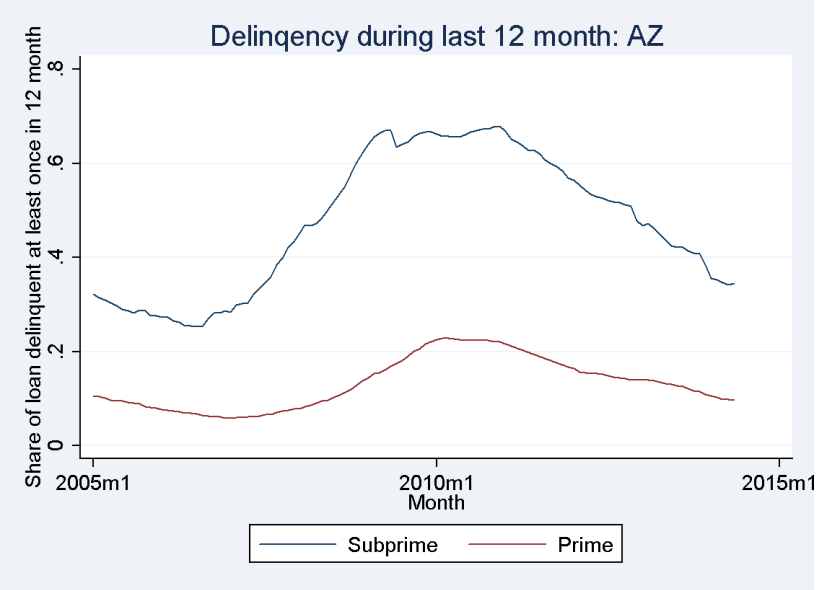

Figure 2: Share of houses delinquent in the last 12 months from 2005-2014, Arizona

The figure shows the share of loans that were delinquent at any point in the previous 12 months for sample loans in Arizona. A loan is delinquent in a given month if its status is listed as delinquent by 30, 60, or 90+ days, in foreclosure preoceedings, or real estate owned (property has already been repossessed by the lender).

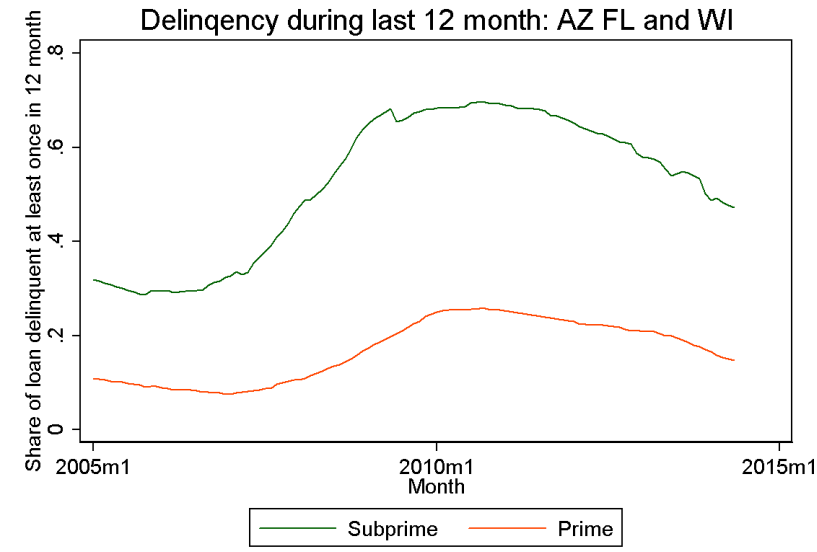

Figure 3: Share of houses delinquent in the last 12 months from 2005-2014, Florida

The figure shows the share of loans that were delinquent at any point in the previous 12 months for sample loans in Florida. A loan is delinquent in a given month if its status is listed as delinquent by 30, 60, or 90+ days, in foreclosure preoceedings, or real estate owned (property has already been repossessed by the lender).

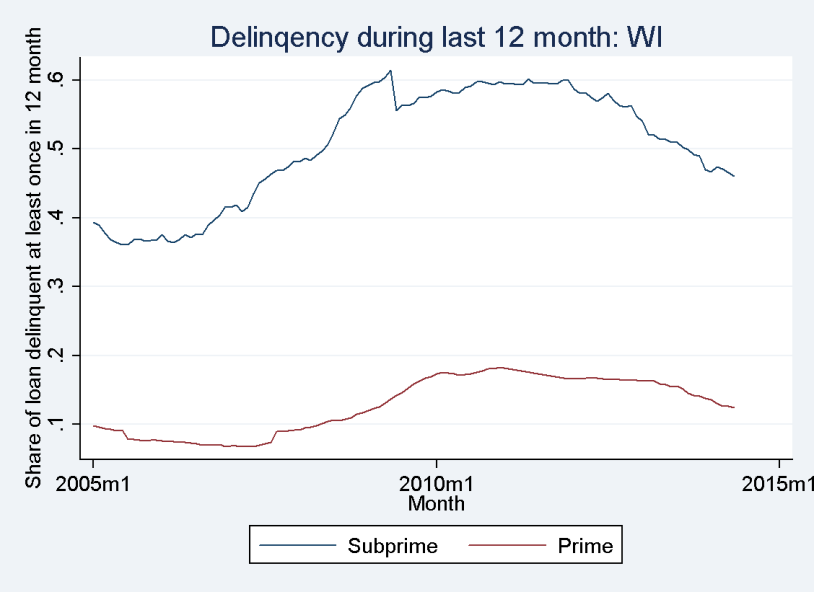

Figure 4: Share of houses delinquent in the last 12 months from 2005-2014, Wisconsin

The figure shows the share of loans that were delinquent at any point in the previous 12 months for sample loans in Wisconsin. A loan is delinquent in a given month if its status is listed as delinquent by 30, 60, or 90+ days, in foreclosure preoceedings, or real estate owned (property has already been repossessed by the lender).

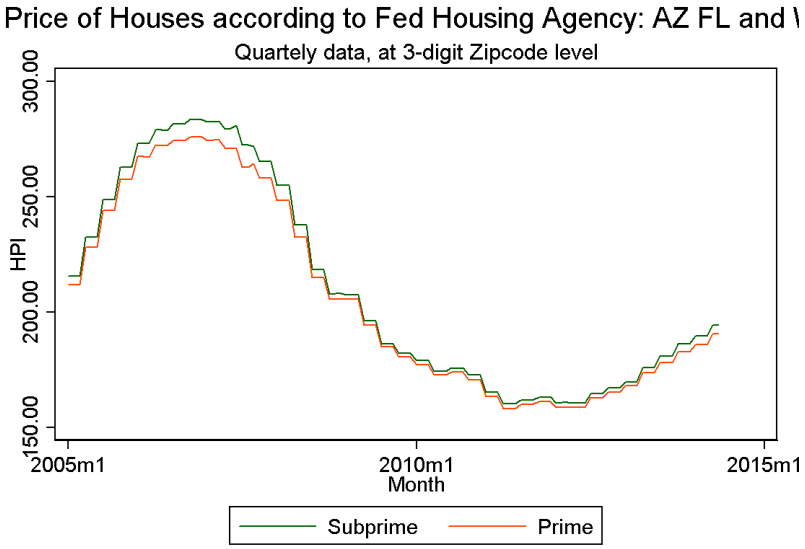

Figure 5: House prices for loans in sample from 2005-2014, AZ, FL, WI

The figure shows the average estimated price of the properties in our sample over time. The FHFA housing price indices are provided quarterly.

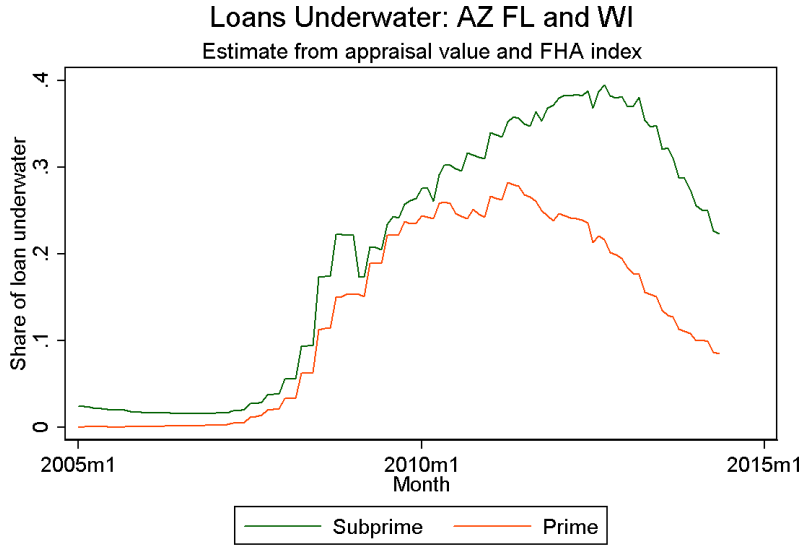

Figure 6: Proportion of houses underwater from 2005-2014, AZ, FL, WI

The figure shows the share of outstanding loans that were underwater over time. We define a property as underwater if the outstanding debt on the property was higher than the estimated property value. We calculate the estimated appraised value in each month by inflating the appraisal value of the house at the time the loan was issued by the average house price growth rate calculated from the price index provided by the FHFA (available quarterly at the 3-digit zipcode level).

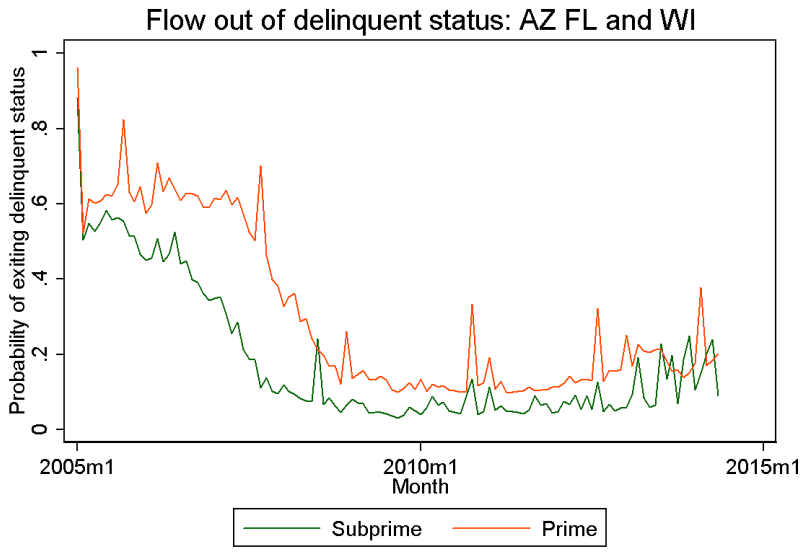

Figure 7: Proportion of houses returning to current status from delinquency from 2005-2014, AZ, FL, WI

The figure shows the borrower "cure rate" over time. A cure is defined as the action of a borrower moving from Delinquent status in the one month to Current in the next month. Each observation in the underlying data is a loan-month. The figure shows the proportion of loans who become current in each month conditional on being delinquent in the previous month.

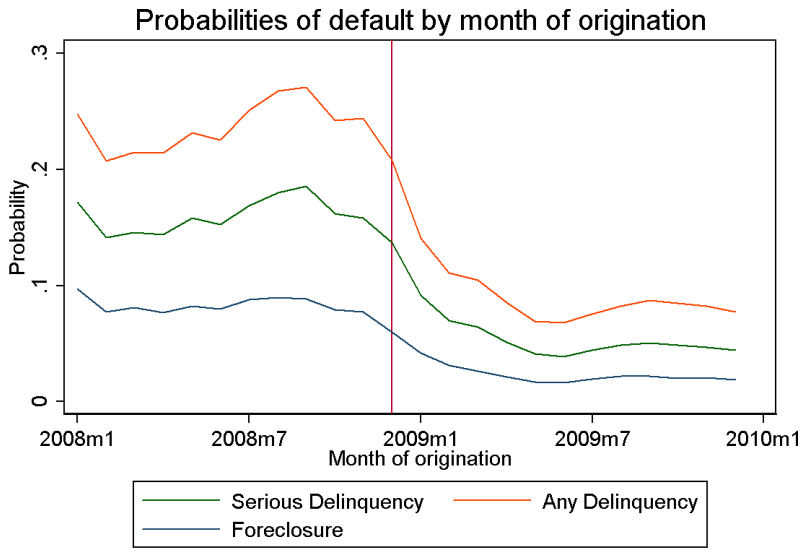

Figure 8: Share of 2013 loan-months in default by month of origination (prime loans only)

The figure shows the share of loan-months in 2013 that were in different states of non-payment by date of loan origination. For example, the left-most point on the red line indicates that 24% of loan-months that originated in January 2008 were in some form of delinquency in 2013. A loan-month is considered delinquent if its payment status is listed as 30, 60, or 90+ days delinquent or in foreclosure. A loan is considered seriously delinquent if it is delinquent by 90+ days or in foreclosure. The vertical line indicates the last month of the "treated" group (those loans that were eligible for modifications under HAMP).

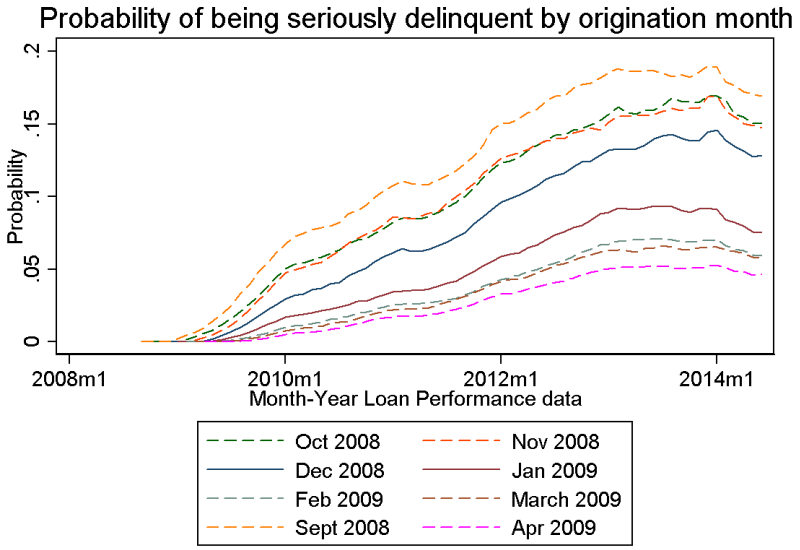

Figure 9: Serious delinquency rates over time for loans of different originations

The figure shows the share of loans that were seriously delinquent (90+ days delinquent or in foreclosure) over time. Each line in the figure represents a month of origination between September 2008 and April 2009. The HAMP policy applies to loans that originated prior to January 2, 2009. The blue solid line and the brown solid line show the delinquency rates on either side of this threshold, with blue denoting loans originating in December 2008 and brown denoting loans originating in January 2009. The x-axis denotes calendar time.

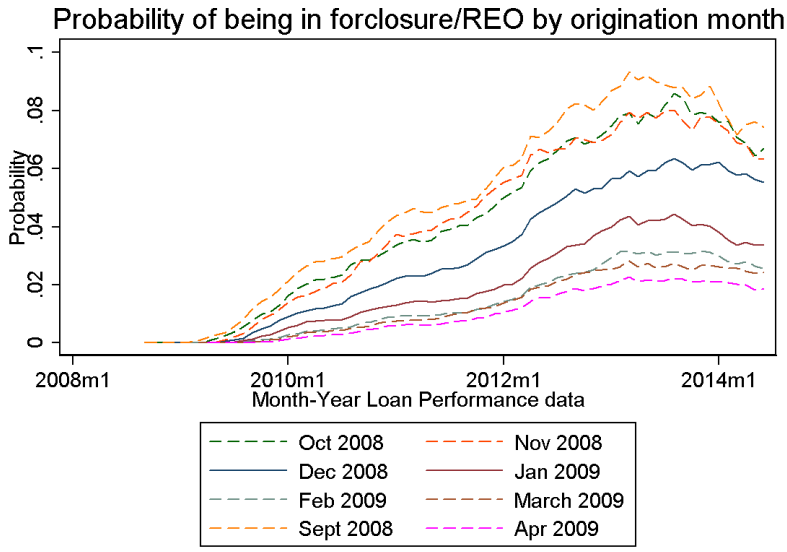

Figure 10: Foreclosure/REO rates over time for loans of different originations

The figure shows the share of loans that were in foreclosure over time. Each line in the figure represents a month of origination between September 2008 and April 2009. The HAMP policy applies to loans that originated prior to January 2, 2009. The blue solid line and the brown solid line show the delinquency rates on either side of this threshold, with blue denoting loans originating in December 2008 and brown denoting loans originating in January 2009. The x-axis denotes calendar time.

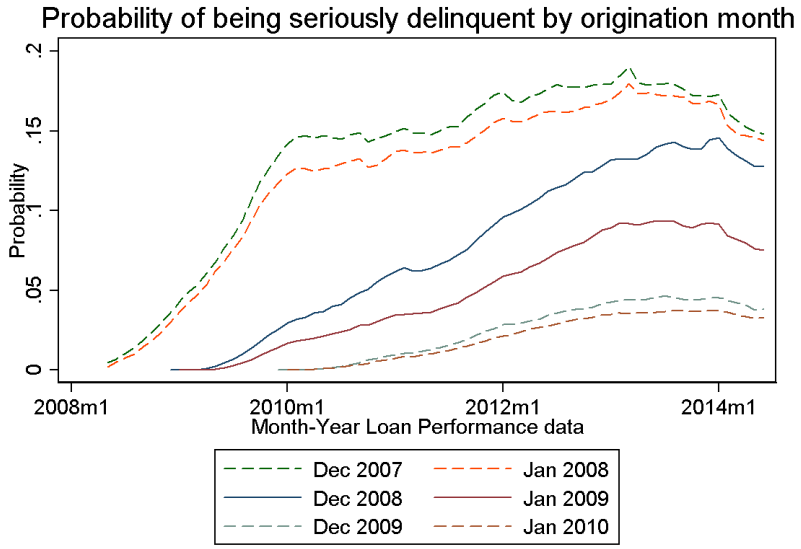

Figure 11: Placebo test: serious delinquency rates over time for loans of different originations

The figure shows the share of loans that are seriously delinquent over time for loans of different origination dates. The HAMP policy affected loans that were originated prior to January 2009. The solid blue and brown lines show the difference in serious delinquency rates for loans on either side of this threshold. The two sets of dotted lines show the differences in delinquency rates for loans in December and January of the previous and following years (2008 and 2010).

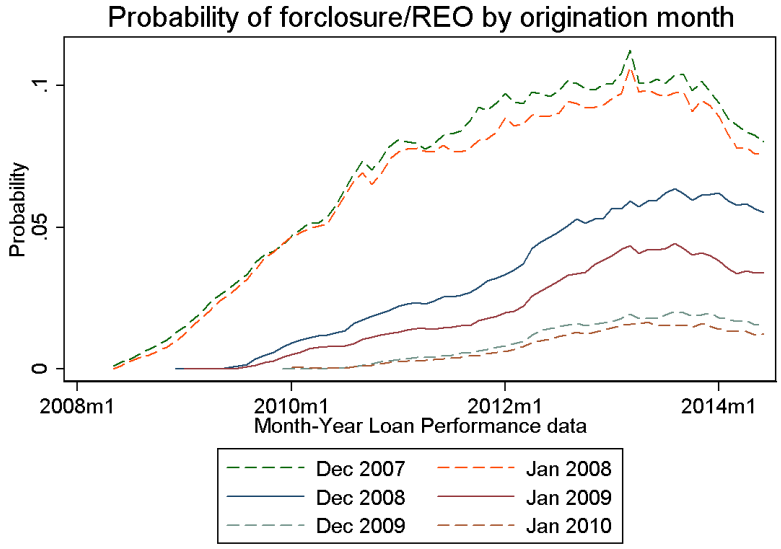

Figure 12: Placebo test: foreclosure/REO rates over time for loans of different originations

The figure shows the share of loans that are in foreclosure or REO status over time for loans of different origination dates. The HAMP policy affected loans that were originated prior to January 2009. The solid blue and brown lines show the difference in serious delinquency rates for loans on either side of this threshold. The two sets of dotted lines show the differences in delinquency rates for loans in December and January of the previous and following years (2008 and 2010).

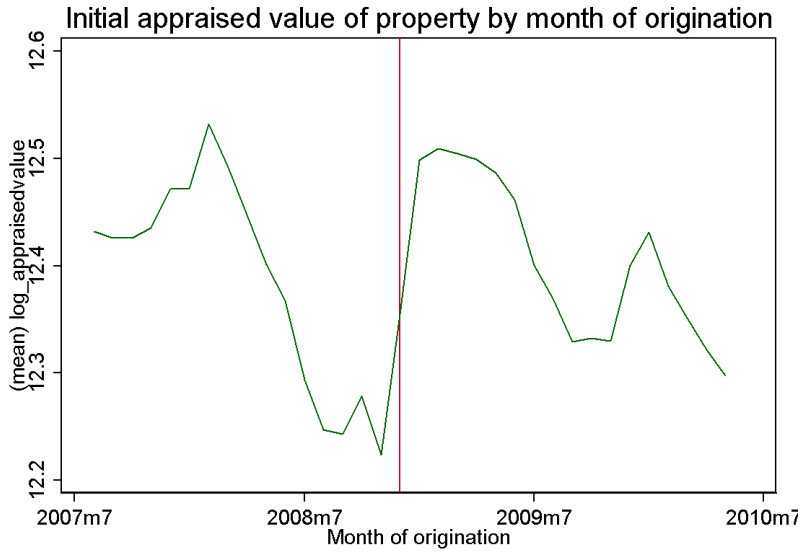

Figure 13: Original appraised value (in log), by origination month

The figure shows the average appraised value at time of origination for loans that originated in different months. The vertical red line shows the cutoff for eligibility for subsidized modifications under HAMP (loans that originated prior to January 2009 were eligible).

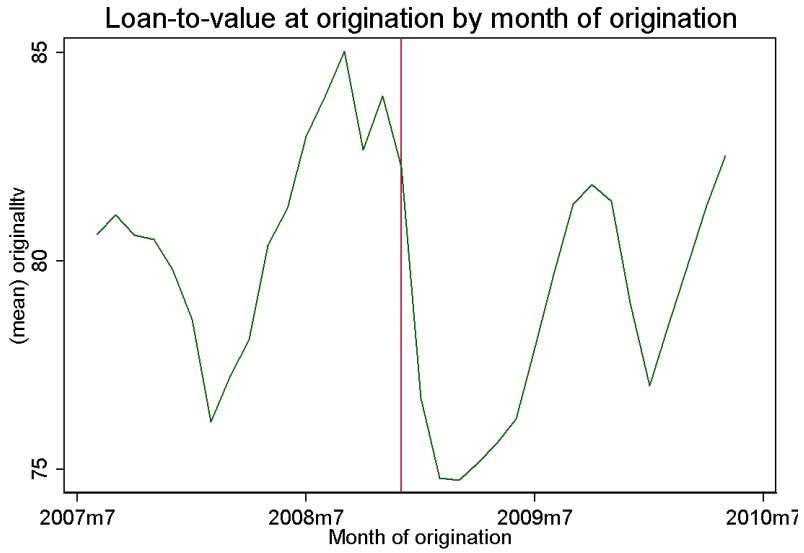

Figure 14: Original Loan-To-Value ratio, by origination month

The figure shows the average loan-to-value ratio at time of origination for loans that originated in different months. The vertical red line shows the cutoff for eligibility for subsidized modifications under HAMP (loans that originated prior to January 2009 were eligible).

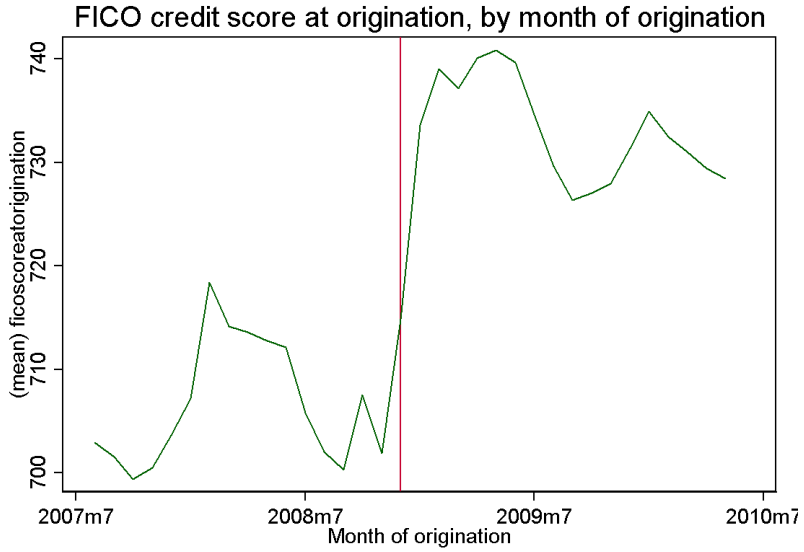

Figure 15: FICO credit score, by origination month

The figure shows the average borrower FICO score at time of origination for loans that originated in different months. The vertical red line shows the cutoff for eligibility for subsidized modifications under HAMP (loans that originated prior to January 2009 were eligible).