Harping on about HARP: Consequences of Ineligibility for the Home Affordable Refinance Program

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Abstract

We analyze the impact of being ineligible for the Home Affordable Refinance Program (HARP). Using a comparable sample of borrowers with Freddie Mac loans and privately securitized loans (Bbx) we analyze loan performance and quantify potential wealth, consumption and credit consequences for prime borrowers whose loans were placed in private securitization pools and who were thus ineligible for HARP. We estimate that such private borrowers are annually approximately 9% less likely to prepay their mortgages after the HARP announcement than comparable borrowers whose mortgages are owned or secured by Freddie Mac. We find significant loss in wealth and increase in default for a comparable set of borrowers in the private loan sample. The greatest detriment is documented in CBSAs with the largest housing price declines in the financial crisis.

1 Introduction

2 Introduction

The Home Affordable Refinance Program (HARP) has enabled millions of borrowers to refinance their underwater mortgages following the financial crisis. Agarwal et al. (2015a) show that borrowers who refinanced under HARP received a $3,500 average reduction of their annual mortgage interest payment. The savings resulted in an increase in annual consumption from $600 for least indebted borrowers to $2,870 for most indebted borrowers. Abel and Fuster (2018) find that the take up for eligible borrowers was approximately fifty two percent. Agarwal et al. (2015a) further estimate that over 3 million borrowers refinanced their loans under HARP and increased their consumption in the aggregate by about $20 billion during the first 3 years after refinancing. Our study focuses on prime borrowers that met conforming[1] loan criteria whose loans were ineligble for HARP because they were either held on bank balance sheets or placed in privately secularized pools.

In the first quarter of 2009, when HARP was introduced, there was a total of over eleven trillion dollars of single family mortgage debt outstanding. [2] Of this outstanding amount, thirty nine percent, or four trillion dollars was held either by by Freddie Mac and Fannie Mae. The remaining mortgages, nearly seven trillion outstanding, were not eligible for HARP. Of the ineligible loans approximately 1.8 billion were in private conduits and these are included in

[1] Frame (2015) provides a concise outline of conforming vs non-conforming loans.
[2]Source: Federal Reserve, "one to four family residences".

our analysis. [3] By the time HARP was expanded to include all LTV ratios, more 20 million borrowers were excluded from government-assisted refinance programs due to the ownership of their mortgage(Stiglitz and Zandi, 2012). Goodman (2015) provides a breakdown of the private pool composition, shown in Figure 1. The Prime mortgages reflect both those that would be conforming and jumbo loans. While smaller than sub-prime and Alt-A, there's a significant number of "left-behind" borrowers in the private pools that were not high risk but rather had the misfortune of not being placed into a government backed pool. Goodman et al. (2013) outline the The Merkley Bill (Rebuilding Equity Act of 2012), The Feinstein Bill (Expanding Refinancing Opportunities Act of 2012) and the Obama Proposal which all were introduced to provide relief to the private pool borrowers yet were not implemented. They estimate that of 3.97 million loans in the private RMBS universe, 1.35 million were not eligible due to delinquency and another 540,000 were either jumbo (over $729,750) or non-owner occupied and, therefor ineligible for the proposed programs. Of the remaining loans, approximately 0.99 million were ARMs and thus ineligble, leaving 1.01 million qualifying fixed rate borrowers. Since we are not able to observe loans on bank balance sheets, the private RMBS qualifying borrowers are the main topic of inquiry in our study.

In work examining both bankruptcy and foreclosure policies, Mitman (2016) find that HARP reduced foreclosures and provided substantial welfare gains to households with high loan-to-value mortgages. (Zhu et al., 2015) estimate that a 10% reduction in mortgage payments

[3]Nearly three trillion in mortgages were held on bank balance sheets and the rest by private individuals and life insurance companies.

under the HARP program is associated with an approximately 10–11% reduction in monthly hazard of default. Additional work by (Karamon et al., 2016) uses a fuzzy regression discontinuity design to show that receiving a HARP refinance decreases the expected monthly default rate by 48-62%.

In this study, we provide estimates of the impact of excluding borrowers with loans in PLS from the HARP. We contribute to the literature by comparing two groups of similar borrowers- those who were eligible for refinance through the Home Affordable Refinance Program (HARP) and a matched sample of borrowers who were similar on observable characteristics but were ineligible for HARP. We first estimate neccessary interest savings for each loan to benefit refinancing, using a solution put forward by Agarwal et al. (2013). Subsequently we find that after controlling for observables, non-HARP borrowers had a lower probability of prepayment that HARP eligible borrowers after the program was introduced. Those particularly hard hit were borrowers residing in low property appreciation areas. Additionally, we predict that if this group of non-HARP borrowers had been eligible for the HARP program their default probability would be significantly reduced. In a work complimentary to ours, Passmore and Sherlund (Forthcoming) show that pre-crisis government mortgage programs had a positive impact on economic indicators from house prices to automobile purchases and unemployment. We augment their findings by examining the role played by HARP during the recovery period and describe the other side of the coin, the borrowers left out due to a technical ineligibility. Our hope is that by quantifying these

effects, we provide evidence for an all inclusive relief program in the future.

The remainder of the study is organized as follows: in Section 3 we outline the details of the Home Affordable Refinance Program, in Section 4 we discuss previous work on prepayment, default, and policy interventions designed to modify borrower behavior and outcomes in mortgage payment activity. Next, in Section 5 we discuss the data used and provide summary statistics. In Section 6 we discuss our empirical strategy and findings in Section 7 we report our robustness tests. Finally, Section 8 concludes.

3 HARP

The Home Affordable Refinance Program (HARP) was introduced in April 2009 in response to the financial crisis and accompanying rapid rise in mortgage default rates. As a result of large declines of the collateral value of housing in the Great Recession, many homeowners were in the unfortunate position of owing more on their mortgages than their homes were currently worth. Contemporaneously, market interest rates dramatically declined, providing a substantial opportunity for savings for borrowers who were able to refinance their mortgages. Borrowers without sufficient home equity did not qualify for traditional refinancing opportunities that would have allowed them to significantly lower their monthly payments; with the idea that these potential monthly savings could help spur consumer spending and aid in the economic recovery in the aftermath of the Great Recession, the U.S.

federal government authorized a program to help alleviate this friction. Initially, only loans guaranteed by Fannie Mae or Freddie Mac that had loan to value ratios of 80%–105% were eligible to refinance under the program. Although the program was soon modified to include LTVs of up to 125% and then eventually expanded to remove the LTV cap, the restriction that the loan be guaranteed by Fannie Mae or Freddie Mac remained. This restriction excluded borrowers with mortgages in private-label securizations (PLS) as well as borrowers whose mortgages were held in lenders' portfolios.[4] The HARP program has reached nearly 3.5 million borrowers as of 1Q 2017[5]. The HARP program officially expired on December 31, 2018.

4 Literature Review

4.1 Borrower choice

Each month borrowers must choose from a menu of mortgage options ranging from default to full prepayment. To optimize this choice, borrowers must take into account changing mortgage interest rates as well as the value of the underlying housing asset (Kau and Keenan, 1995). Within this competing risk framework, the heterogeneity of borrowers must be taken into account Deng et al. (2000) to reconcile theory to empirical observations; for example, borrower beliefs on the morality of default can help explain why borrowers default less often than is financially optimal(Guiso et al., 2013; Seiler, 2015) while borrower inattention and

[4]Contemporaneous borrowers with Federal Housing Administration (FHA) backed loans were eligible for a streamlined refinance program with FHA(Caplin et al., 2015).

[5] See `www.fhfa.gov/AboutUs/Reports/ReportDocuments/Refi_1Q2017.pdf`

inertia can help explain why borrowers refinance less often or more slowly than is optimal (Keys et al., 2016)). Additionally, mortgage payment decisions are not made in isolation from other household financial decisions. A "double-trigger" theory of default, that is default is often the result of both a price decline as well as a negative personal shock, such as job loss, is often used to explain default choices (Foote et al., 2008) and evidence on consumer debt payments shows that some groups of homeowners changed the prioritization of repayment of their debts (i.e. mortgage vs. credit card) during the financial crisis (Chomsisengphet et al., 2013).

4.2 Prepayment

Borrowers who are current on their mortgage may prepay for one of two reasons: selling their home and moving or the refinance the mortgage of their existing property. Although virtually all mortgages have a due on sale clause that triggers prepayment when a borrower moves, the decision to refinance is driven largely by changes in mortgage interest rates.[6] Other factors including refinance costs, remaining term on the mortgage, expected housing tenure, and personal income tax rates are important components of optimizing the refinance choice(Agarwal et al., 2013).

Households frequently make sub-optimal financial decisions. Particularly in the case of the choice to refinance residential mortgages, borrowers have shown to choose a course of inaction despite active reminders that refinancing to lower interest rates would provide immediate savings that would translate to substantial financial gain over the life of the

[6]Equity extraction through a cash-out refinance is another motivation for refinance.

loan (Keys et al., 2016). However, the decision to refinance can be complex and difficult to understand for households. Previous research suggests that borrowers do not optimally refinance (e.g. Stanton (1995); Campbell (2006); Deng and Quigley (2012); Agarwal et al. (2013); Johnson et al. (2015); Agarwal et al. (2015a,b)). Andersen et al. (2015) provide evidence from Danish markets that socio-demographic variables are important in explaining inertia and inattention in the decision to refinance. The purchase of a home is one of the largest and most complicated financial decisions a household faces (Campbell and Cocco, 2003), but the decision to refinance is some ways more difficult in that refinancing choice is a complex optimization problem.

4.3 Impact of HARP

Several studies have explored the effect HARP has had on eligible borrowers that chose to refinance under the program. Agarwal et al. (2015a) find that over three million borrowers refinanced under HARP, receiving an average reduction of 1.4 percent in interest rate which amounts to an average o f $3,500 in annual savings. They point out that "by facilitating eligible borrowers to refinance their loans to lower their payments regardless of their housing equity, the program implied a transfer from investors in the mortgage securities backed by eligible loans to indebted borrowers". The total implied effect was that borrowers who refinanced their loans under HARP increased their consumption by a total of approximately $20 billion during the first three years after refinancing.

Abel and Fuster (2018) find that using HARP to refinance with a lower interest rate mortgage enabled borrowers to cut their default rates on mortgages by forty percent and their rates of delinquency by twenty five percent. With these previously documented motivations for borrower prepayment and default in mind, our study examines how eligibility for HARP impacted borrower prepayment and default decisions.

5 Data, Variables, and Summary Statistics

In Section 5.1 we discuss the data sources used in this study. In Section 5.2 we define our criteria for forming a matched sample. Finally, in Section 5.3 we present summary statistics for our matched sample.

5.1 Data

We use residential loan-level payment data for both government agency held (eligible for HARP) and privately held mortgages (ineligible for HARP). In 2014, both Freddie Mac and Fannie Mae made their mortgage records publicly available. Freddie Mac and Fannie Mae now provide mortgage origination files and performance files that could be merged to obtain a full history of mortgages on the loan-level. The origination files report loan characteristics at mortgage closing such as loan to value ratio, borrower credit score, the purpose of the mortgage (acquisition vs refinancing), initial interest rate and others. The performance files report whether or not a loan was still outstanding and what payments were made, if any. Fannie Mae and Freddie Mac hold about 47 percent of all mortgages outstanding in US as of

September 2015, according to the Federal Board of Governors report. The combined total of the files is estimated to have records on approximately 50 million mortgages. The mortgages in turn have monthly payment records from the first quarter of 1999 to the third quarter of 2014, thus there are approximately several hundred million records available. In this paper, we focus on using a sample of the Freddie Mac data for 30 year fixed rate mortgages.

Additionally, we use loan level information on mortgages from private-label (PLS) securitizations from Blackbox Logic, LLC (BBx). BBx covers over 90% of non-agency residential securitized mortgages including prime, Alt-A, and subprime loans. The database has detailed information on the mortgage contract at loan origination and monthly records of mortgage payment information. BBx contains information on approximately 23 million loans and over 900 million remittance records as of December 2014.

Finally, we use quarterly housing price indices for 3 digit zip codes from the Federal Housing Finance Agency (FHFA).[7]

5.2 Propensity Score Matching

We restrict our data sets to attain comparable sets of borrowers and mortgages. We restrict both our Freddie Mac and PLS samples to first-lien fixed-rate mortgages with a 30 year term that are classified as single-family primary residences. Additionally, we exclude PLS loans that have negative amortization features, interest only periods, teaser rates, or prepayment penalties, as these type of loans would have been ineligible for purchase by

[7]Loans from the PLS sample are identified by a 5-digit zip code; however, the Freddie Mac sample is only identified at the 3-digit zip code. Therefore, we construct our estimate of current housing values using the 3-digit zip indices.

Freddie Mac. To examine the impact of HARP eligibility on prepayment and default, we further restrict the sample of PLS loans to loans below the conforming loan limit, removing all jumbo loans from the data set. Additionally, we restrict the PLS sample to prime loans with full documentation.

We perform propensity score matching on the restricted PLS sample and the pool of Freddie Mac mortgages based on origination characteristics. We match the loans based on origination characteristics such as appraised home value at loan origination, FICO credit scores of borrowers, origination LTV ratios, origination interest rates, origination year, three digit zip code and initial loan amounts.

5.3 Summary Statistics

Figure 2 provides a visual depiction of the prepayment rates in two subsamples of highly comparable borrowers. Table 1 reports our matched sample summary statistics. *Current LTV* is current LTV based on three digit zip code house appreciation. *FICO* is the credit score and *OriginationLTV* the Loan to Value at loan origination. The Origination Characteristics are very similar across the two subsamples. FICO score is 719 for the private sample and 718 for the Freddie Mac sample, and LTV at Origination is 73 percent and 72 percent respectively. The matched data set consists of 350,249 mortgages in each sample. Monthly performance, labeled Time Variant Characteristics is observed over 23 million and 19 million observations for the private and Freddie Mac samples, respectively. We see that

PLS loans had nearly half the refinancing/prepayment rate of Freddie Mac loans (0.0073 vs 0.0132). Delinquency is 60 percent higher in the PLS pool, where borrowers were not eligible to refinance at higher rates. The outstanding current LTV ratios are comparable between the two samples. Loan Age is higher for the PLS sample, where borrowers could not refinance. Subsequently we examine pairwise correlations among our variables of interest. The correlation coefficients are reported in Table 2. We see that PLS loans have a positive correlation with loan age and delinquency and a negative correlation with prepayment.

6 Hypothesis and Findings

It appears that our sample of highly comparable borrowers, as presented in Table 1, had very different loan performance characteristics. Given that PLS borrowers were excluded from HARP, we propose that this exclusion was at least one of the drivers of the difference in delinquency and refinancing rates. We formulate our first hypothesis:

Hypothesis 1: HARP ineligible borrowers were less likely to refinance than HARP eligible borrowers due to their low property values.

To test our first Hypothesis, we use logistic regression with standard errors clustered by zip code to estimate the following equation.

$$Pr(Refi_{i,t}) = \alpha + \beta_1 PrivateLoan + \beta_2 Treatment + \beta_3 Underwater_{i,t} + ControlVariablesi + \epsilon_i \quad (1)$$

The marginal effects are presented in Table 3. The dependent variable is a binary indicator for prepayment. Our *Treatment* variable is defined as a private loan, post introduction of HARP in April 2009. *Underwater* is defined as greater than 100 percent loan to value ratio, calculated monthly based on three digit zip code house appreciation. Column 1 reports our baseline specification, with loan performance observed from 2005 to 2013. Our estimated baseline treatment effect of can be interpreted as borrowers with a private loan post-HARP announcement are 0.768% less likely to prepay their mortgages each month than borrowers in the Freddie Mac pool who are potentially eligible for HARP. This translates into a 9.216% reduction in the annual probability of private borrower prepayment (0.768*12). Column 2 uses and alternate, expanded time frame, from 2001 to 2014. Column 3 includes current LTV in lieu of origination LTV. Column 4 includes an interaction term of FICO score and LTV. We find that regardless of time window or the LTV metric used, ineligible borrowers were significantly less likely to refinance, especially if their mortgages were in a negative equity position.

The next consideration is whether or not refinancing was the optimal course of action. We rely on methodology put forth by Agarwal et al. (2013) to pinpoint which of the outstanding loans in our sample would profit from refinancing in the form of future interest cost savings. Agarwal et al. (2013) derived a theoretical closed form solution for the value of interest rate differential between the current interest rate and the interest rate on the mortgage that

would indicate that it is profitable to refinance. Following their approach, we estimate "In The Money Refinance" as follows.

$$x^* \approx -\sqrt{(\frac{\sigma k}{M(1-\tau)})\sqrt{2(\rho+\lambda)}} \tag{2}$$

Where τ is the marginal tax rate, σ is annualized standard deviation of the mortgage interest rate, K is the cost of refinancing and $K = 0.01M + 2000$, ρ is discount rate, M the outstanding loan amount. Where λ, the expected real repayment rate of the mortgage, is defined as follows:

$$\lambda = \mu + \frac{i_0}{e^{(i_0\Gamma)} - 1} + \pi \tag{3}$$

Where μ is hazard of relocation, i_0 the original nominal interest rate, π is inflation, Γ is the remaining life (in years) of the mortgage. Consistent with the work ofAgarwal et al. (2013) and Keys et al. (2016), we assume that the discount rate is 5 percent, the income tax rate is 28 percent, the probability of moving any given year is 10 percent and that the standard deviation of mortgages is 1.09 percent. We let the cost of refinancing equal 2000 thousand dollars plus 1 percent of the unpaid loan amount. Upon computing the interest rate differential that meets the condition to refinance, we are able to identify which borrowers would benefit from refinancing by comparing the minimum interest rate differential to the actual difference between the interest rate on the loan and the 30 year mortgage interest rate as provided by St. Louis Federal Reserve.

We segment our sample into mortgages where refinancing would be profitable by this metric (Refi ITM) and those where refinancing would not be worth the cost (Refi NITM) and re-estimate Equation (1). The results are reported in Table 4. The results present reflect the average marginal effects estimated subsequent to a logit regression where the dependent variable was a binary indicator for prepayment. The model includes observation month, observation year, and origination year fixed effects. Columns 1 and 2 report High and Low LTV loans, defined as greater and less than 80 percent current LTV, respectively. We observe that High LTV borrowers were much less likely to refinance without access to HARP. Columns 3 and 4 report results for High LTV loans where refinancing would be profitable, or where the savings would exceed x* from Equation 2. Columns 5 and 6 report the same for Low LTV loans. The *Treatment* coefficient for In The Money refinances is significant for High LTVs loans yet insignificant for Low LTV loans. That is, when it is profitable to refinance and the borrowers are able to do so because their LTVs are low enough to meet the refinancing requirements (80%), then being eligible for HARP has no impact (Column 6). However, when refinancing would be profitable, some borrowers were unable to take advantage of the savings since they didn't qualify refinance due to their high LTVs, in absence of HARP eligibility (Column 4).

Given that borrowers were locked in to high loan payments, all else equal these borrowers could have more difficulty in keeping their loans current. We formulate our second hypothesis.

Hypothesis 2: HARP ineligible borrowers were more likely to default on their mortgages due to their inability to refinance at lower interest rates.

We define delinquency as being over 30 days behind on mortgage payments. We estimate a multinomial logistic regression where Delinquency and Prepayment (refinancing) are potential outcomes. The base case is loan is current. Average marginal effects are reported in Table 5. PLS loans are more likely to be in default, as indicated by the positive and significant *Treatment* coefficient in Column 1, in addition to not being able to refinance, indicated by the negative and significant coefficient in Column 2. Our findings suggest that Loan to Value is a significant determinant of refinancing and default. It would follow that our results would vary with property values. Mian et al. (2013) show that the effect of housing net worth shocks on consumption is a reduction in spending of 5-7 cents for every $1 of housing wealth loss. Thus, home values have important consumption implications. This leads to our third and fourth hypotheses:

Hypothesis 3: HARP ineligible borrowers in geographic areas with highest (lowest) property appreciation rates were most (least) likely to refinance.
Hypothesis 4: HARP ineligible borrowers in geographic areas with highest (lowest) property appreciation rates were least (most) likely to default.

To test both hypotheses, we examine the areas which fall into the top and bottom deciles of

home price appreciation. Table 7 reports our tests of Hypothesis 3. While ineligibility for HARP was a factor in all areas, it was much greater in the lowest home price appreciation markets. The *Treatment* coefficient in Column 1, Bottom 10% of Price Growth, is nearly three times in magnitude of the coefficient in Column 2, Top 10% of Price Growth. Next we test Hypothesis 4, and the results are reported in Table 8. We find that HARP ineligible loans in the low price appreciation markets, the Bottom 10% of Price Growth, are more than twice as likely to be in default as loan in the high price appreciation markets.

7 Robustness

To examine potential misspecification or spurious findings we consider two robustness tests. First, we employ alternative specifications of our *Treatment* variable and second, we perform placebo tests.

To examine alternative specifications of the *Treatment* variable we consider different phases of HARP. The second phase of HARP, which had a treatment date of July 2009 when HARP was extended to include borrowers with LTVs up to 125%. The third phase of HARP had a treatment date of October 2011 when HARP was extended to include borrowers with no LTV cap. The results are reported in Table 8. We further include a restricted sample, which uses the HARP 1 sample, but excludes delinquent loans and loans with LTVs greater than 105 and less than 80; that is, loans ineligible for the initial HARP program. The results show

that all phases of HARP had a significant negative impact on the likelihood of refinancing, and that the most restricted eligible sample had the highest effect.

To further test the validity of our findings, we perform placebo tests. Table 9 reports the results. Placebo group 1 contains all private loans randomly assigned to treatment. Placebo group 2 contains all Freddie Mac loans randomly assigned to treatment. The effect of treatment in either placebo group is not significant and all coefficient estimates are close to zero.

8 Conclusion

Prior studies have shown that borrowers who refinanced under HARP received a 140 basis point reduction in mortgage interest rate and that regions of the U.S. that had higher exposure rates to HARP enjoyed benefits such as increases in consumer spending, decreases in foreclosure rates, and faster house price recovery relative to area with lower HARP exposure Agarwal et al. (2015a).

Using parameters suggested in the closed form solution by Agarwal et al. (2013) to denote when the option to refinance becomes financially attractive to borrowers we provide evidence that PLS borrowers were unable to refinance when it was profitable to do so, and when similar borrowers with government agency held mortgages were taking advantage of HARP. Further we document significantly higher default rates for PLS borrowers that

had identical credit worthiness characteristics to borrowers whose loans qualified for HARP. Lastly, we show that areas with the lowest home price appreciation were the most impacted by ineligibility for HARP both in terms of default and inability to refinance.

Extending HARP eligibility to PLS and portfolio mortgages would have dramatically expanded the pool of borrowers with access to HARP, given that by the end of 2012, there were still over a million borrowers with loans in PLS or on bank portfolios who otherwise would have been HARP-eligible (Goodman et al., 2013) our results are economically significant.

References

J. Abel and A. Fuster. How do mortgage refinances affect debt, default, and spending? evidence from harp. *FRB of New York Staff Report No. 841*, 2018. URL `https://ssrn.com/abstract=3132012orhttp://dx.doi.org/10.2139/ssrn.3132012`.

S. Agarwal, J. C. Driscoll, and D. I. Laibson. Optimal mortgage refinancing: A closed-form solution. *Journal of Money, Credit and Banking*, pages 591–622, 2013.

S. Agarwal, G. Amromin, S. Chomsisengphet, T. Piskorski, A. Seru, and V. Yao. Mortgage refinancing, consumer spending, and competition: Evidence from the home affordable refinancing program. *NBER Working Paper 21512*, 2015a.

S. Agarwal, R. J. Rosen, and V. Yao. Systematic mistakes of borrowers in the mortgage markets. *Management Science*, 62:3494–3509, 2015b.

S. Andersen, J. Y. Campbell, K. M. Nielsen, and T. Ramadorai. Inattention and inertia in household finance: Evidence from the danish mortgage market. *NBER Working Paper 21386*, July 2015.

J. Y. Campbell. Household finance. *Journal of Finance*, 61(4):1553–1604, 2006.

J. Y. Campbell and J. F. Cocco. Household risk management and optimal mortgage choice. *Quarterly Journal of Economics*, 118(4):1449–1494, 2003.

A. Caplin, A. Cororaton, and J. Tracy. Is the fha creating sustainable homeownership? *Real Estate Economics*, 43(4):957–992, 2015.

S. Chomsisengphet, D. Glennon, and F. Li. The changing pecking order of consumer defaults. *Journal of Money, Credit and Banking*, 45(2–3):251–275, 2013.

Y. Deng and J. M. Quigley. Woodhead behavior and the pricing of residential mortgages. Unpublished working paper, 2012.

Y. Deng, J. Quigley, and R. Van Order. Mortgage termination, heterogeneity and the exercise of mortgage options. *Econometrica*, 68(2):275–307, March 2000.

C. Foote, K. Geraldi, and W. Paul. Negative equity and foreclosure: Theory and evidence. *Journal of Urban Economics*, 64(2):234–245, September 2008.

W. S. Frame. Introduction to special issue: Government involvement in residential mortgage markets. *Real Estate Economics*, 43(4):807–819, 2015. doi: 10.1111/1540-6229.12122. URL `https://onlinelibrary.wiley.com/doi/abs/10.1111/1540-6229.12122`.

L. Goodman. The rebirth of securitization. *Urban Institute.*, 2015. URL `http://www.urban.org/sites/default/files/alfresco/publication-pdfs/2000375-The-Rebirth-of-Securitization.pdf`.

L. S. Goodman, L. Yang, R. Ashworth, and B. Landy. Government programs to refinance (or modify) performing borrowers in private label securitizations: Implications for investors. *Journal of Structured Finance*, 19(1):39–55, 2013.

L. Guiso, P. Sapienza, and L. Zingales. The determinants of attitudes toward strategic default on mortgages. *The Journal of Finance*, 68(4):1473–1515, 2013.

E. Johnson, S. Meier, and O. Toubia. Money left on the kitchen table: Exploring sluggish mortgage refinancing using administrative data, surveys, and field experiments. Unpublished working paper, July 2015.

K. Karamon, D. McManus, and J. Zhu. Refinance and mortgage default: A regression discontinuity analysis of harp's impact on default rates. *The Journal of Real Estate Finance and Economics*, pages 1–19, 2016.

J. B. Kau and D. C. Keenan. An overview of the option-theoretic pricing of mortgages. *Journal of Housing Research*, 6:217–235, 1995.

B. J. Keys, D. G. Pope, and J. C. Pope. Failure to refinance. *Journal of Financial Economics*, 122:482–499, 2016.

A. Mian, K. Rao, and A. Sufi. Household Balance Sheets, Consumption, and the Economic Slump*. *The Quarterly Journal of Economics*, 128(4):1687–1726, 09 2013. ISSN 0033-5533. doi: 10.1093/qje/qjt020. URL `https://dx.doi.org/10.1093/qje/qjt020`.

K. Mitman. Macroeconomic effects of bankruptcy and foreclosure policies. *American Economic Review*, 106(8):2219–2255, 2016.

W. Passmore and S. M. Sherlund. Fha, fannie mae, freddie mac and the great recession. *Real Estate Economics*, Forthcoming. doi: 10.1111/1540-6229.12296. URL `https://onlinelibrary.wiley.com/doi/abs/10.1111/1540-6229.12296`.

M. J. Seiler. The role of informational uncertainty in the decision to strategically default. *Journal of Housing Economics*, 27:49 – 59, 2015. ISSN 1051-1377. doi: https://doi.org/10.

1016/j.jhe.2015.02.006. URL http://www.sciencedirect.com/science/article/pii/S1051137715000091. Special Issue on Housing Finance.

R. Stanton. Rational prepayment and the valuation of mortgage-backed securities. *Review of Financial Studies*, 8:667–708, 1995.

J. E. Stiglitz and M. Zandi. The one housing solution left: Mass mortgage refinancing. *The New York Times op-ed*, August 2012.

J. Zhu, J. Janowiak, L. Ji, K. Karamon, and D. McManus. The effect of mortgage payment reduction on default: evidence from the home affordable refinance program. *Real Estate Economics*, 43(4):1035–1054, 2015.

9 Tables & Figures

Table 1: Propensity Score Matched Sample: Origination and Performance
This table presents a matched sample of origination characteristics. A restriction is imposed to limit the data set to single family, owner occupied mortgages. Subsequent to restriction, the loans were matched based on origination characteristics such as appraised home value at loan origination, FICO credit scores of borrowers, origination LTV ratios, origination interest rates, origination year, three digit zip code and initial loan amounts. All loans are 30 year fixed rate mortgages.

	(1) PLS Average	(2) Std. Dev.	(3) Freddie Mac Average	(4) Std. Dev
Origination Characteristics				
FICO Score	719.28	39.62	717.55	55.70
LTV at Origination	73.29	15.68	72.17	16.33
Original Loan Balance	148795	75529	165505	77522
Interest Rate	6.08	0.66	6.27	0.61
N	350,249		350,249	
Time Variant Characteristics				
Prepayment	0.0073	0.08516	0.0132	0.1143
Delinquent	0.0876	0.2827	0.05289	0.2238
Current LTV	69.20	20.04	69.94	21.51
Loan Age	50.46	32.99	41.83	32.77
N	23,537,489		19,006,454	

Table 2: Correlation Coefficients

This table provides the correlation matrix for selected variables utilized in the analysis for the full propensity score matched sample. All pairwise correlations are statistically significant at the 5 percent level.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) PLS Loan	1.00									
(2) Log Original Balance	-0.0804	1.00								
(3) Log Original LTV	-0.0208	0.0575	1.00							
(4) Log Current LTV	-0.0181	0.1148	0.8354	1.00						
(5) Log FICO	0.0342	-0.0237	-0.1447	-0.1578	1.00					
(6) Loan Age	0.1293	-0.0675	0.0112	-0.0834	-0.0169	1.00				
(7) Interest Rate	-0.0565	-0.3029	0.0761	0.0533	-0.1370	-0.0791	1.00			
(8) Underwater	-0.2532	0.0812	0.0651	0.3736	-0.0513	0.0275	-0.0236	1.00		
(9) Prepaid	-0.0405	0.0169	-0.0048	-0.0100	0.0090	0.0011	0.0225	0.0053	1.00	
(10) Delinquent	0.0813	0.0259	0.0604	0.1049	-0.1548	0.1518	-0.0179	0.0654	-0.0289	1.00

Table 3: Reluctance to Refinance: Baseline Results

Model estimated using logistic regression with standard errors clustered by zip code. Average marginal effects presented in table. The dependent variable was a binary indicator for prepayment. All loans are originated 2001-2007. Loans are observed monthly 2005-2013, except in Column 2, where observations from 2001-2014 are used. Model includes observation month, obervation year, and origination year fixed effects. Variable definitions are provided in the Appendix.

	(1) All	(2) All	(3) All	(4) All
PLS loan	-0.00208***	-0.00352***	-0.00152***	-0.00209***
	(0.000169)	(0.000186)	(0.000161)	(0.000169)
Treatment	-0.00768***	-0.00653***	-0.00826***	-0.00768***
	(0.000289)	(0.000320)	(0.000278)	(0.000289)
Log Original Balance	0.00388***	0.00575***	0.00394***	0.00387***
	(0.0000901)	(0.000127)	(0.0000927)	(0.0000899)
Log Original LTV	-0.00280***	-0.00314***		-0.0379***
	(0.000115)	(0.000125)		(0.00732)
Log Current LTV			-.004623***	
			(.0001355)	
underwater	-0.00287***	-0.00243***		-0.00286***
	(0.000126)	(0.000115)		(0.000127)
Log Fico	0.0215***	0.0228***	0.0201***	-0.00103
	(0.000427)	(0.000472)	(0.000453)	(0.00465)
Fico X LTV				0.0053156***
				(0.0011101)
Loan Age	0.0000113**	0.0000800***	-0.00000351	0.0000116**
	(0.00000558)	(0.00000648)	(0.00000562)	(0.00000558)
Interest Rate	0.00299***	0.00473***	0.00310***	0.00299***
	(0.0000805)	(0.000114)	(0.0000804)	(0.0000803)
Observations	35459025	42429065	33561720	35459025

Table 4: Reluctance to Refinance: CLTV Results

The results below reflect the elasticities estimated subsequent to a logit regression where the dependent variable was a binary indicator for prepayment. All loans are originated 2001-2007. Loans are observed monthly 2005-2013. Model includes observation month, obervation year, and origination year fixed effects. Standard errors clustered by zip code. Variable definitions are provided in the Appendix.

	(1) High CLTV	(2) Low CLTV	(3) HCLTV Refi NITM	(4) HCLTV Refi ITM	(5) LCLTV Refi NITM	(6) LCLTV Refi ITM
PLS loan	-0.00367***	-0.00204***	-0.00278***	-0.0183***	-0.00179***	-0.0121***
	(0.000271)	(0.000159)	(0.000220)	(0.00202)	(0.000155)	(0.000580)
Treatment	-0.0104***	-0.00739***	-0.00571***	-0.00519***	-0.00526***	-0.000463
	(0.000437)	(0.000279)	(0.000371)	(0.00199)	(0.000267)	(0.000563)
Log Original Balance	0.00395***	0.00383***	0.00295***	0.00546***	0.00377***	0.00372***
	(0.000149)	(0.0000952)	(0.000141)	(0.000297)	(0.0000991)	(0.000177)
Log Original LTV	-0.00182***	-0.00212***	-0.00153***	-0.00214***	-0.00188***	-0.00264***
	(0.000217)	(0.000140)	(0.000210)	(0.000492)	(0.000143)	(0.000247)
underwater	-0.00207***		-0.00126***	-0.00355***		
	(0.000121)		(0.000128)	(0.000218)		
Log Fico	0.0312***	0.0173***	0.0146***	0.0642***	0.00719***	0.0461***
	(0.000577)	(0.000530)	(0.000595)	(0.00137)	(0.000535)	(0.00102)
Loan Age	0.0000307***	-0.00000618	0.0000460***	-0.0000161	-0.0000110	-0.00000110
	(0.0000105)	(0.00000633)	(0.0000109)	(0.0000242)	(0.00000736)	(0.0000131)
Interest Rate	0.00347***	0.00281***	0.00453***	-0.00283***	0.00420***	-0.00294***
	(0.000109)	(0.0000990)	(0.000118)	(0.000236)	(0.000120)	(0.000168)
Observations	8694664	26764361	6183295	2511369	20731837	6032524

Table 5: Impact of HARP on Default and Prepayment

Mortgage delinquency is defined as 30+ days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, and origination year fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-HARP. Treatment time period post April 2009. The treatment effect is the interaction of PLS (private) loans post-HARP. Control Freddie Mac mortgages chosen using propensity score match from national samples. Parameters estimated with multinomial logistic regression; base case is loan is current. Average marginal effects shown in table.

	(1)	(2)
	Delinquent	Prepayment
PLS Loan	0.0348***	-0.0015***
	(0.0015)	(0.0015)
Treatment Effect	0.03056***	-0.0098***
	(0.0014)	(0.0003)
Log Original Balance	0.04917***	0.0040***
	(0.0010)	(0.0001)
Log Original LTV	-0.0326***	0.0060***
	(0.0027)	(0.0060)
Log Current LTV	0.1056***	-0.0096***
	(0.01476)	(0.0002)
Log FICO	-0.6034***	0.02048***
	(0.0060)	(0.0004)
Loan Age	-0.0003***	-0.0000***
	(0.0000)	(0.0000)
Interest Rate	-0.00637***	0.0031***
	(0.0006)	(0.0001)
Observations	33561720	
Pseudo R^2	0.1353	

Table 6: Geographic Variation in Loan Prepayment

Bottom 10% of Price Growth refers to loans that in a given year of observation are in the bottom (top) decile of area price appreciation (decline) since origination. Top 10% of Price Growth refers to loans in a given year of observation are in the top decile of appreciation since origination. Model estimated using logistic regression with standard errors clustered by zip code. Average marginal effects presented in table. All loans are originated 2001-2007. Loans are observed monthly 2005-2013. Model includes observation month, observation year, and origination year fixed effects.

	Bottom 10% of Price Growth	Top 10% of Price Growth
PLS loan	0.000352***	-0.00520***
	(0.000133)	(0.000316)
Treatment	-0.00977***	-0.00311***
	(0.000307)	(0.000463)
Log Original Balance	0.00213***	0.00522***
	(0.000153)	(0.000237)
Log Original LTV	-0.00402***	0.0000368
	(0.000168)	(0.000350)
underwater	-0.00196***	-0.000915***
	(0.000167)	(0.000211)
Log Fico	0.00850***	0.0143***
	(0.00104)	(0.00183)
Loan Age	0.000156***	0.0000304
	(0.0000222)	(0.0000197)
Interest Rate	0.00256***	0.00210***
	(0.000159)	(0.000177)
Observations	4300286	3533724

Table 7: Geographic Variation in Loan Delinquency

Bottom 10% of Price Growth refers to loans that in a given year of observation are in the bottom (top) decile of area price appreciation (decline) since origination. Top 10% of Price Growth refers to loans in a given year of observation are in the top decile of appreciation since origination. Model estimated using logistic regression with standard errors clustered by zip code. Delinquency is defined at 30+ days delinquent in payment. Average marginal effects presented in table. All loans are originated 2001-2007. Loans are observed monthly 2005-2013. Model includes observation month, observation year, and origination year fixed effects.

	Bottom 10% of Price Growth	Top 10% of Price Growth
PLS loan	0.0556***	0.0234***
	(0.00236)	(0.00158)
Treatment	0.0229***	0.00943***
	(0.00192)	(0.00169)
Log Original Balance	0.00395	0.00541***
	(0.00313)	(0.00128)
Log Original LTV	0.0966***	0.0574***
	(0.00585)	(0.00387)
underwater	0.0554***	0.00960***
	(0.00244)	(0.00206)
Log Fico	-0.538***	-0.421***
	(0.0126)	(0.0106)
Loan Age	-0.00145***	0.000142*
	(0.0000866)	(0.0000834)
Interest Rate	-0.0000346	-0.00323**
	(0.00103)	(0.00141)
Observations	4300286	3533724

Table 8: Robustness: Alternative HARP Date Specification

HARP 2 refers to the second phase of HARP and the treatment date is July 2009 when HARP was extended to include borrowers with LTVs up to 125%. HARP 3 refers to the third phase of HARP and the treatment date is October 2011 when HARP was extended to include borrowers with no LTV cap. Restricted sample uses the HARP 1 sample, but excludes delinquent loans and loans with LTVs greater than 105 and less than 80; that is, loans ineligible for the initial HARP program. Model estimated using logistic regression with standard errors clustered by zip code. Average marginal effects presented in table. All loans are originated 2001-2007. Loans are observed monthly 2005-2013. Model includes observation month, obervation year, and origination year fixed effects.

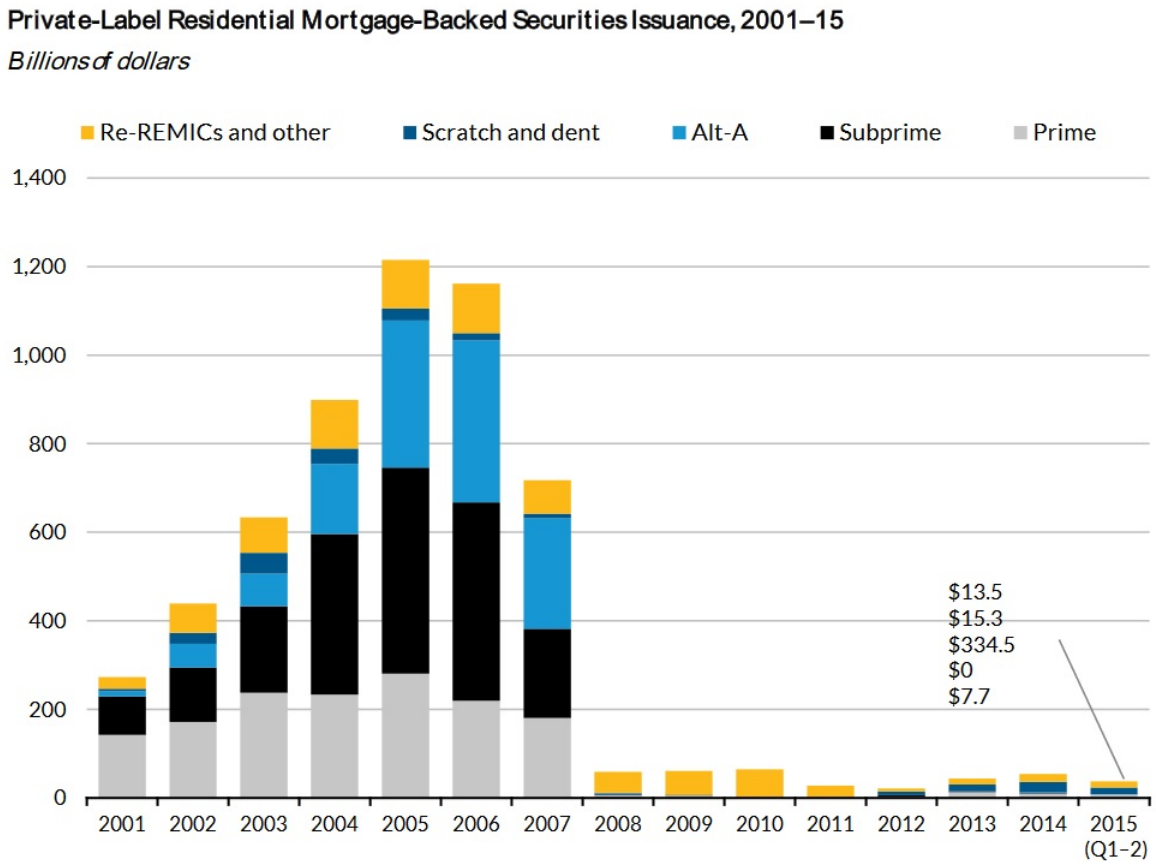
	HARP Phase 2	HARP Phase 3	HARP 1- Restricted
PLS loan	-0.00270***	-0.00442***	-0.000817***
	(0.000171)	(0.000157)	(0.000288)
HARP 2	-0.00709***		
	(0.000281)		
HARP 3		-0.00784***	
		(0.000265)	
Restricted Eligibility			-0.0117***
(HARP 1)			(0.000421)
Log Original Balance	0.00388***	0.00388***	0.00533***
	(0.0000902)	(0.0000903)	(0.000155)
Log Original LTV	-0.00279***	-0.00279***	0.00566***
	(0.000115)	(0.000116)	(0.000527)
underwater	-0.00282***	-0.00262***	-0.00301***
	(0.000123)	(0.000117)	(0.000237)
Log Fico	0.0215***	0.0217***	0.0263***
	(0.000426)	(0.000427)	(0.000815)
Loan Age	0.00000919	0.00000761	-0.00000303
	(0.00000560)	(0.00000560)	(0.0000135)
Interest Rate	0.00300***	0.00298***	0.00418***
	(0.0000807)	(0.0000808)	(0.000129)
Observations	35459025	35459025	5100395

Table 9: Robustness: The Impact of Harp: Placebo Tests

Model estimated using logistic regression with standard errors clustered by zip code. Placebo group 1 contains all private loans randomly assigned to treatment. Placebo group 2 contains all Freddie Mac loans randomly assigned to treatment. Average marginal effects presented in table. All loans are originated 2001-2007. Loans are observed monthly 2005-2013. Model includes observation month, observation year, and origination year fixed effects.

	Placebo Test-Freddie Mac Loans	Placebo Test-Private Label Loans
Placebo PLS Loan	0.0000766	0.0000416
	(0.0000930)	(0.0000448)
Placebo Treatment 1	-0.000114	
	(0.000120)	
Placebo Treatment 2		-0.0000897
		(0.0000679)
Log Original Balance	0.00553***	0.00282***
	(0.000157)	(0.000107)
Log Original LTV	-0.00265***	-0.00271***
	(0.000181)	(0.000124)
underwater	-0.00318***	-0.0207***
	(0.000188)	(0.000641)
Log Fico	0.0269***	0.0200***
	(0.000596)	(0.000702)
Loan Age	0.0000241**	-0.000000898
	(0.00000958)	(0.00000638)
Interest Rate	0.00430***	0.00199***
	(0.000126)	(0.0000849)
Observations	14374224	21084801

Figure 1: Private RMBS Composition



Sources: Inside Mortgage Finance and Urban Institute.
Note: REMIC = real estate mortgage investment conduit.

Figure 2: Prepayment Rates
The vertical line indicates April 2009, the initial introduction of HARP.