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The Determinants of Subprime Mortgage Performance Following a Loan Modification

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Abstract

We examine the evolution of mortgage modification terms obtained by distressed subprime borrowers during the recent housing crisis, and the effect of the various types of modifications on the subsequent loan performance. Using the CoreLogic LoanPerformance dataset that contains detailed loan level information on mortgages, modification terms, second liens, and home values, we estimate a discrete time proportional hazard model with competing risks to examine the determinants of post-modification mortgage outcomes. We find that principal reductions are particularly effective at improving loan outcomes, as high loan-to-value ratios are the single greatest contributor to re-default and foreclosure. However, any modification that reduces total payment and interest (P&I) reduces the likelihood of subsequent re-default and foreclosure. Modifications that involve increasing the loan principal—primarily through capitalized interest and fees—are more likely to fail, even controlling for changes in P&I.

Keywords: Mortgage Modification, Subprime, Mortgage Default, Foreclosure, HAMP
JEL Classification: D12, G21, R20, R28

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Introduction

Following the exuberant housing market of the mid-2000s, a national housing price collapse that began in 2007 resulted in many borrowers owing more on their mortgage than their home was worth. This inability to pay-off a mortgage with the proceeds from a home's sale, combined with widespread unemployment and declines in income, made many mortgages unsustainable for borrowers (Mayer et al. 2009). In response to the resulting millions of homeowners who defaulted on their mortgages and faced foreclosure, mortgage modifications were actively pursued by policymakers, consumer advocates, and, to a lesser extent, investors and mortgage servicers as a means of keeping borrowers in their homes.

Mortgage modifications, whereby the terms of the loan are altered in order to promote repayment by a distressed borrower, were relatively rare prior to the recent housing crisis. The vast majority of defaults self-cured, and foreclosure proceedings offered the lender or servicer a high recovery rate for the remaining loans (B. Ambrose and Capone 1996; Capone 1996; Adelino et al. 2009). This dynamic was altered during the housing crisis when mortgage default rates rose dramatically and the share of delinquent mortgages self-curing plummeted, particularly among subprime mortgages (Agarwal et al. 2011; Sherlund 2008). This, combined with plunging home values, changed the relative costs and benefits of providing alternatives to foreclosure, including mortgage modifications (Cutts and Merrill 2008).

Early in the housing crisis, the parameters of mortgage modifications, when they were even offered, varied widely depending on the mortgage servicer (Agarwal et al. 2011). Moreover, the mortgage modifications made in 2008 often failed to lower monthly payments for the borrower, with approximately half of all modifications in the subprime and alt-a market yielding payment increases (White 2009). Similarly, data from the Office of the Comptroller of

the Currency's (OCC) mortgage metrics report, which includes prime loans and covers approximately two-thirds of all first-lien mortgages outstanding in the US, shows that in 2008, 32 percent of modified loans resulted in an increase in monthly payments and 42 percent in a decrease in the monthly payment (Office of the Comptroller of the Currency 2009). As these early mortgage modifications rarely improved the affordability of the mortgage payment, the loans were highly likely to re-default following the modification: Over 60 percent of mortgages modified in 2008 had re-defaulted within 12 months (Goodman et al. 2011).

As part of the policy response to the financial crisis, the federal government allocated billions of dollars to programs aimed at assisting homeowners in distress. This included the Home Affordable Modification Program (HAMP), introduced in March 2009, which provided incentive payments to mortgage lenders, servicers, borrowers, and investor for modifying loans to conform to the HAMP guidelines. The primary requirement was that the first lien mortgage payment be reduced to 31 percent of the borrower's income; however, the terms of the loan that are modified in order to achieve the reduction in payment varied from borrower to borrower. The intent of the HAMP payment reduction requirement was to improve the affordability of the mortgage for distressed borrowers, and thus improve their chances of remaining in their homes.

Following the introduction of HAMP, an increasing share of modified loans received payment decreases, regardless of whether or not they qualified as HAMP modifications. In the first quarter of 2009, 53 percent of modifications involved a payment reduction; by the second quarter of 2009, 78 percent of modifications involved a payment reduction. Thereafter, the percent of modifications involving a reduction in the monthly payment continued to increase, reaching approximately 93 percent by the fourth quarter of 2012 (Office of the Comptroller of the Currency 2013). While many mortgage modifications since the implementation of HAMP

are not classified as resulting directly from the program, the standard terms offered on these proprietary modifications changed following its implementation (Goodman et al. 2011).

The number of mortgage modifications occurring increased substantially beginning in 2009 and peaked at over 250,000 in the second quarter of 2010 (Goodman et al. 2012; Office of the Comptroller of the Currency 2011). While the number of modifications done each quarter has generally decreased since mid-2010, as of the second quarter of 2014, 2.49 percent of residential mortgages were still at some stage of the foreclosure process and 6.04 percent were at least one payment past due but not in foreclosure (Mortgage Bankers' Association 2014). Thus mortgage modifications continue to play an important role in the recovery of the housing market, and it is therefore important to understand what aspects of modifications are most successful at allowing the borrower to avoid default and foreclosure.

Despite the important role that mortgage modifications have played in the response to the housing crisis, relatively little research exists examining which types of mortgage modifications are the most successful at avoiding subsequent re-default and foreclosure. While a handful of studies have examined post-modification loan performance, this research has either tended to focus on narrow geographic areas (Voicu et al. 2012a), or only pre-HAMP loan modifications (Quercia and Ding 2009; Haughwout et al. 2009; Agarwal et al. 2011). This study augments the existing literature by examining post-modification loan performance for a national sample of subprime loans using a rich dataset that includes information on junior liens, current property valuations, and detailed information on the parameters of loan modifications. Specifically, we examine whether principal reductions, reductions in interest rate, or reductions in payment and interest, are most effective at reducing subsequent re-default and foreclosure. Using loan-level data from CoreLogic's LoanPerformance Asset Backed Securities (ABS) Data on privately

securitized subprime mortgages originated from 2000 through 2007, we find that principal reductions are the most effective type of modification, as they generally lower the borrower's monthly payment and reduce the loan to value ratio, in addition to having an independent effect on re-default. However, any modification that improves the affordability of the mortgage, such as a reduction in the monthly payment and interest, reduces the probability of subsequent re-default and foreclosure. Our results provide insights to loan servicers, mortgage investors, and policymakers as to the relative effectiveness of the various types of loan modifications, allowing them to more accurately assess the cost of a modification relative to the cost of a foreclosure.

Previous Literature

A large body of literature exists on the determinants of mortgage default for prime mortgages (Deng et al. 2000; Phillips and VanderHoff 2004; Quercia and Stegman 1992; B. W. Ambrose et al. 1997) and subprime mortgages (Kau et al. 2011; deRitis et al. 2010; Danis and Pennington-Cross 2008) prior to the housing crisis. However, from the 1990s through the mid-2000s, mortgage underwriting standards declined substantially, resulting in an unprecedented national wave of default and foreclosure when house prices subsequently fell and economic conditions deteriorated (Demyanyk and Van Hemert 2011; Haughwout et al. 2008; Mian and Sufi 2009).

With this wave of mortgage defaults, researchers turned their attention to analyzing mortgage outcomes for borrowers in default, with an emphasis on whether the loan terminated in foreclosure or received a modification. These studies identified a wide range of factors that affect mortgage outcomes, with state laws governing foreclosure, the amount of home equity, credit scores at origination, and presence of junior liens among the most significant (Voicu et al. 2012b; Chan et al. 2013; Gerardi et al. 2013). Interventions, such as mortgage default

counseling, were also shown to substantially increase the probability that a borrower receives a loan modification and reduce the probability of foreclosure (Collins and Schmeiser 2013; Collins et al. 2013).

While the literature on outcomes for loans in default following the housing crisis has provided significant insight into the determinants of receiving a loan modification, a much smaller body of literature has examined the parameters of mortgage modifications and how they affect subsequent loan performance. Among the earliest studies of post-modification loan performance was Quercia and Ding (2009), who used a national sample of subprime and alt-a securitized mortgages drawn from the Columbia Collateral File that were modified in 2008. They found that the greater the reduction in the monthly payment, the lower the likelihood that the mortgage re-defaults by December 2008. Payment reductions achieved through a combination of rate and principle reductions were most effective at reducing re-default, followed by rate reductions alone.

Many of the subsequent studies focused on analyzing the performance of pre-HAMP loan modifications. For example, Haughwout et al. (2009) used the CoreLogic LoanPerformance data on subprime and alt-a securitized loans, to analyze the determinants of post-mortgage modification re-default prior to the implementation of HAMP. Using a proportional hazard framework, they find that the greater the reduction in monthly payment, the lower the likelihood that the mortgage re-defaults. They further find that having a negative equity position substantially increases the probability of re-default.

Agarwal et al. (2011) also focused on mortgage modifications that occurred prior to the introduction of HAMP. Using the OCC Mortgage-Metrics database, they estimate the probability that a loan re-defaults (60+ days delinquent) within six months of a modification, and

find that the probability of re-default declines the more monthly payments are reduced, and that re-default rates increase as LTV increases. They further find that the servicer of the mortgage has a significant effect on the ultimate success of the modifications, even after controlling for the terms of the modification.

One of the only studies to examine mortgage modifications both pre- and post-HAMP was done by Voicu et al. (2012a). Focusing only on the New York City area, they find that modifications where the interest rate or principal are reduced are less likely to re-default. Further, they find that HAMP modifications perform better than proprietary modifications, although they are unable to determine what aspects of HAMP yield better loan performance.

Our research expands on this existing literature in several ways. First, we use a sample of subprime and alt-a mortgages drawn from across the United States rather than one specific geographic area. Second, we examine both HAMP and proprietary mortgage modifications done from 2008 through 2013, and follow their performance through the fourth quarter of 2013. Finally, using a discrete time proportional hazard framework, we control for the full range of information CoreLogic collects on the loans, including the presence and amount of any junior liens, a current property value generated using an automated valuation model, and detailed terms for the mortgage modifications.

Data

The data for this study come from CoreLogic's Loan Performance Asset Backed Securities (ABS) data on privately securitized mortgages. The CoreLogic ABS data include information on subprime and alt-a loans, but do not include information on agency backed securities or loans

held in portfolio.[1] As of 2010, these data contained monthly performance history for about 20 million individual loans. The CoreLogic data used in this paper are only representative of privately securitized subprime and alt-a loans, not the entire US mortgage market. While the coverage of these data may limit the generalizability of our findings, the loans here are of particular interest to investors and policymakers given the high incidence of default, foreclosure, and modification in this population.

The CoreLogic data contain detailed static and dynamic information on the loans and their performance. The static data include information from origination such as date of origination, the zip code where the property is located, the borrower's FICO score, origination balance, interest rate, payment and interest amount, and servicer. The dynamic data are updated monthly and include information on the current interest rate, mortgage balance, payment amount, and loan performance.

CoreLogic also provides two supplemental files that are used in our analysis. The first contains detailed information on whether a borrower received a loan modification, as well as the parameters of the modification (e.g. reduction in principal, reduction in interest rate, or change in amortization term). While CoreLogic does not explicitly identify a loan as being a HAMP modification, we infer whether or not the loan was modified under HAMP by whether the characteristics of the modification follow the HAMP program waterfall for reducing the monthly payment, such as reducing the interest rate to 2 percent and then extending the term of the loan once the 2 percent floor is reached. The second file is the CoreLogic TrueLTV Data, which matches the loans in the CoreLogic Loan Performance data to public records to obtain information on subsequent liens taken out on the property. These data also contain a monthly

[1] CoreLogic also has a separate database on privately securitized prime and/or jumbo loans; however we restrict our analysis sample to the subprime and alt-a loan data.

estimate of the property's value from their automated valuation model (AVM). The combination of monthly data on the value of all liens on the property with the monthly estimate of the property's value from the AVM allow for the computation of a current combined loan to value (CLTV) ratio.

The ability to include a current estimate of CLTV based on the inclusion of junior liens in the loan amount and a value estimated specifically for that property represents a major improvement over previous studies. Past research has largely excluded junior liens from the loan amount, and been limited to the inclusion of MSA level price indices or adjusting the appraised value at origination by some price index to capture current property value.

Given the number of loans in the CoreLogic ABS data, we select a five percent random sample from the universe of first-lien mortgages. Our data on modifications and loan performance cover the period January 2008 through December 2013. We restrict our data to loans originated no earlier than January 2000 and modifications occurring after January 2008. To provide economic context for the loan performance, we merge in monthly state level unemployment rates obtained from the Bureau of Labor Statistics.

After we merge our five percent random sample of the CoreLogic ABS data with the supplemental loan modification file, we have approximately 2.3 million loan month observations from approximately 64,000 individual loans. Because we are interested only in loans that have been modified, we drop all observations for loan ID numbers that have no modifications over the course of our study period, leaving us with the 64,000 matched loans. After dropping observations with missing data, we are left with 46,734 unique loans that experience approximately 50,000 unique modifications. Thus, a couple thousand mortgages in our sample received more than one modification during their time in our sample. Figure 1 plots the number

of mortgage modifications occurring each month in our sample over the period January, 2008 to December, 2013. The number of monthly modifications peaks in early 2009, just prior to the enactment of HAMP, before plummeting.[2] The number of modifications increased sharply again in early 2010, and since then has largely declined.

Figure 2 plots the terminal outcomes for all of the modified loans in our data over time. The graph shows that REO is the most likely terminal outcome for a modified loan in our sample, except for two short periods in 2012 and 2013. The peak of foreclosure occurred at the end of 2011, and has fluctuated below that peak in the time since. Short sales and foreclosure sales increased to a peak at the end of 2012 and appear to have declined in the months after, while pay offs have remained relatively flat over the sample period.

Figure 3 shows a survival graph for the share of loans that remain current or 30 days delinquent in the months following a modification. The survival rates to 60+ days delinquent are plotted separately by the year in which the mortgage received its first modification to illustrate the substantial variation in subsequent loan performance. The rate at which loans become 60+ days delinquent following a modification declines substantial in each successive year from 2008 to 2012. For loans first modified in 2008, over 60 percent had re-defaulted within 12 months of the modification. In contrast, for loans first modified in 2012, the 12 month re-default rate had declined to only 20 percent.

The top panel of Figure 4 shows the percentage of modified loans receiving either a principal increase or decrease over the sample period. From 2008 until 2012 a loan modification was far more likely to result in an increase in the mortgage principal balance than to result in a decrease in mortgage principal, as fees and accrued interest were often rolled in to the modified

[2] This drop in modifications may be partially attributable to mortgages qualifying for HAMP modification and entering their three month trial period, as HAMP modifications are not counted until they are made permanent.

principal amount. From 2009 through 2010, approximately 80 percent of modifications resulted in the mortgage principal increasing, thereafter declining until reaching less than 40 percent in late 2012. The share of modifications resulting in principal decreases rises steadily throughout the sample period, and by mid-2012 actually exceeds the share of loans with principal increases. Since mid-2012 the share of modified loans in our sample involving a principal reduction has consistently exceeded 40 percent.

The bottom panel of Figure 4 shows the percentage of modified loans that yield either an increase or decrease in the monthly payment amount. Throughout the study period, the majority of modifications have resulted in borrowers having their monthly payment reduced; however, the share of borrowers whose monthly payment was lowered has increased over time, going from around 50 percent in January of 2008, to just below 80 percent in October, 2013.

Table 1 presents descriptive statistics for the first modification experienced by each mortgage in our analysis sample. The subprime nature of our sample is apparent from the average characteristics at the time of origination: 48 percent had low or no documentation and the average FICO score was 635. Nearly three-quarters of the mortgages were originated in either 2005 or 2006, and 63 percent were refinancings. The majority of first modifications were done from 2008 to 2010, with only 29 percent occurring in 2011 through 2013. Almost 23 percent of the first modifications in our sample appear to be HAMP modifications. On average, 15 percent of first modifications resulted in an increase in P&I. For those loans where the P&I was reduced, the average decrease was $534. The reduction in P&I was largely driven by a reduction in the interest rate on the loan, with an average rate reduction of 3.4 percentage points when an interest rate reduction occurred. Nearly three-quarters of the first modifications in our sample result in an increase in principal balance, consistent with Figure 4 and the OCC Mortgage

Metrics reports. However, when a principal reduction did occur, the average amount was $48,249. The average principal balance post-modification was $254,000, and 43 percent of the sample had a junior lien at the time of modification. Overall, the average CLTV at modification was 113 percent, meaning even after a modification the average homeowner was underwater on their mortgage.

Empirical Model

We begin our analysis of how the various types of loan modifications affect subsequent loan performance by using a simple probit model to estimate the probability that a loan reaches 60 plus days delinquent within twelve months following a loan modification. Our probit model takes the form:

$$\Pr(Y_{is} = 1) = \mathrm{f}\,(\alpha + \beta X_i + \gamma Mod_i + \delta CLTV_i + \theta State_s + \varepsilon_{is}) \qquad (1)$$

where Y is an indicator for whether or not the loan becomes 60 plus days delinquent within twelve months, X is a vector of loan characteristics from origination, including an indicator for whether the loan was used for a home purchase, categories for the borrower's FICO score, whether the home was owner occupied, whether the loan had low or no documentation, and indicators for the origination year. Mod is a vector of loan characteristics at the time of modification, including loan servicer fixed-effects, an indicator for whether the property has a junior lien, and modification year indicators. Mod further includes the key characteristics of the mortgage modification of interest for our analysis: being a HAMP modification, the percent reduction in principal, an indicator for having an increase in principal, the percent reduction in P&I, an indicator for an increase in P&I, and the percent reduction in the interest rate. We further include the CLTV ratio at the time of modification in categories, with less than 80 percent used

as the omitted category. Finally, State is a vector of indicators for whether the property is in a judicial foreclosure, redemption law, or non-recourse state. The probit model is run as a cross-sectional analysis using only the covariate values from the time of the modification. Moreover, state fixed-effects are omitted, so as to allow the inclusion of the various state-specific mortgage laws.

We supplement this probit analysis with a discrete time proportional hazard framework with competing risks analysis of how the various modification parameters affect mortgage performance and mortgage outcomes over the entire post-modification period. This strategy also allows us to take advantage of time variation in variables such as the CLTV and state unemployment rate.

Once a borrower receives a modification, they should be current on their payments in the month following the modification, creating a good origination point to compare the outcomes of modified loans. Since we focus only on modified loans, we drop all mortgages that do not receive modifications over the course of our sample period. The status of a mortgage in our sample in a given month can take on one of a number of different discrete states. We categorize the set of possible states into six options: current or 30 days delinquent, 60+ days delinquent, foreclosure filing (*lis pendens)*, REO/sale out of foreclosure, short pay off, or re-modification. REO and sale out of foreclosure are combined into one outcome since they are equivalent from the borrower's perspective, as they both result in the loss of the home. While it is possible for borrowers who receive a modification to prepay their mortgage in full, so few people in our sample actually did so that we simply dropped them from the sample.

We structure our data in event history format so as to estimate our proportional hazard model using a standard multinomial logit. Months since modification is then included as a

covariate to allow for time dependence of the hazard rate. We include as covariates the same loan characteristics from origination used in the probit analysis: an indicator for whether the loan was used for a home purchase, categories for the borrower's FICO score, whether the home was owner occupied, whether the loan had low or no documentation, and indicators for the origination year. The loan-level covariates from the time of modification again include loan servicer fixed-effects, an indicator for whether the property has a junior lien, modification year indicators, and indicators for whether the property is in a judicial foreclosure, redemption law, or non-recourse state. We then include the characteristics of the mortgage modifications: being a HAMP modification, the percent reduction in principal, an indicator for having an increase in principal, the percent reduction in P&I, an indicator for an increase in P&I, and the percent reduction in the interest rate. However, in the proportional hazard framework we allow the CLTV ratio to vary over time as the house price and loan balances change. We further include the monthly state unemployment rate to capture changes in the economic conditions faced by the borrower.

In order to evaluate whether or not the performance of HAMP modifications differs from that of proprietary modifications, we re-estimate our proportional hazard model on the sample limited to non-HAMP and then HAMP modifications. When the sample is limited to non-HAMP modifications, the covariates included in the analysis remain identical to those for the full sample, with the exception of the HAMP indicator being removed. When the sample is limited to HAMP modifications, we also drop the indicator for first modification occurring in 2009 and use that as the reference category, and drop the indicator for P&I increasing, as none of the HAMP modifications resulted in a higher P&I for the borrower. Moreover, the sample period now begins in April 2009, as no HAMP modifications occurred prior to that date.

Results

Table 2 presents the results of our probit analysis of the effect of the various modification parameters on the twelve month probability of re-default. Of the key mortgage modification parameters of interest, the coefficients on reduction in the P&I and the interest rate appear to have the greatest magnitude and be statistically significant. A one percent reduction in P&I is estimated to reduce the probability of re-default by 0.22 percentage point, while a one percent reduction in the interest rate reduces the probability of re-default by 0.11 percentage point. From Table 1, the average P&I reduction was 31 percent and the average interest rate reduction was 43 percent, conditional on receiving either a P&I reduction or an interest rate reduction. Overall, 41 percent of the loans in our estimation sample become 60 days or more delinquent within only twelve months of receiving a loan modification, suggesting that the average reduction in P&I reduced re-default by 17 percent, and the average interest rate reduction reduce re-default by 12 percent. In this specification, principal reductions appear to have little effect on the probability of twelve month re-default independent of their effect on P&I and the CLTV. While HAMP mods appear to be somewhat less likely to re-default, the coefficient is only marginally significant.

The probit results also suggest what types of modifications are particularly prone to failure. In particular, a modification that increases the mortgage principal increases the probability of re-default within twelve months by 4.7 percentage points, or 11 percent, while one that increases the P&I increases the probability of re-default within twelve months by 7.6 percentage points, or 19 percent.

Other characteristics that appear to contribute to determining the probability of re-default within twelve months of a modification include the FICO score at loan origination, the year of origination and the year of modification, and the CLTV. FICO scores from origination, which may have been years in the past, do a remarkable job of predicting loan performance, as those with FICO scores above 720 at origination are 24 percentage points, or 59 percent, less likely to re-default within twelve months of a modification. CLTV is also strongly predictive of re-default, with those having a CLTV in excess of 150 percent being 6.9 percentage points, or 17 percent more likely to re-default than those with a CLTV below 80 percent.

Turning now to our proportional hazard model, we examine a wider range of post-modification loan outcomes. We begin our analysis of post-modification performance with the full sample of modified loans. Table 3 presents the results of the multinomial logit model, where the coefficients are reported as relative risk ratios with the reference outcome being current or 30 days delinquent. In the first column, we report estimates for the outcome being 60+ days delinquent, followed by the loan being re-modified, entering foreclosure, ending in a foreclosure sale or REO, and short pay-off in the final column.

Having a junior lien on the property at the time of modification is among the largest contributors to the mortgage experiencing an adverse outcome. Loans with junior liens have approximately a 25 percent higher relative risk of being 60+ days delinquent, entering foreclosure, or ending in a foreclosure sale or REO. They are also 11 percent more likely to require a re-modification.

Even after a loan modification, the borrower's FICO score measured at the time that the mortgage was originated continues to be a strong predictor of subsequent mortgage outcomes. Borrowers with FICO scores below 580 at origination are used as the reference category in the

model. The higher the origination FICO score, the less likely the loan is to re-default, enter foreclosure, require re-modification, or enter one of the terminal outcomes. For example, borrowers with FICO scores between 580 and 649 have a 23 percent lower relative risk of being 60+ days delinquent, followed by those with a FICO between 650 and 719 who have a 47 percent lower relative risk, and then those with a FICO over 720 who have a nearly 70 percent lower relative risk of being delinquent. The effect is similarly pronounced for the outcomes foreclosure filing or foreclosure sale/REO, with those borrowers who had FICO scores of 720 or above at origination having a 61 percent lower relatively risk of foreclosure filing and a 45 percent lower relative risk of foreclosure sale/REO.

State level mortgage laws also play a role in determining re-default following a modification, as loans in states with judicial foreclosure have a 5 percent higher relative risk of being 60+ days delinquent than states without judicial foreclosure. Judicial foreclosure states also have a 17 percent higher risk of foreclosure filing, and a 163 percent higher risk of foreclosure sale/REO. Conversely, mortgages made in states with redemption laws, or where mortgages are non-recourse loans have a 6 and 17 percent lower relative risk of being 60+ days delinquent. Borrowers in non-recourse states are substantially less likely to experience a foreclosure sale/REO, with a 29 percent lower relative risk.

The modification terms affect the post modification chances of re-default in ways that are consistent with our expectations. Reductions in principal balance, interest rate, and payment and interest all lower the risk of being 60+ days delinquent, with a one percent reduction in any of these terms reducing the risk of being delinquent by approximately 0.7 percent. Conditional on receiving a principal reduction, the average percent of the mortgage balance reduced was 26 percent (Table 1), suggesting that a typical loan that received a principal reduction was 17

percent less likely to be 60+ days delinquent. As our model controls for any changes in the CLTV resulting from the principal reduction, this estimate captures only part of the total effect of a principal reduction on subsequent loan performance. For those who received an interest rate reduction the average change was 43 percent, while for those receiving a P&I reduction the average was 31 percent, thus our coefficient estimates imply typical reductions in the relative risk of being 60+ days delinquent of 30 percent and 21 percent, respectively.

Turning to the effect of mortgage modification terms on the subsequent risk of entering foreclosure or terminating in a foreclosure sale/REO, the effect of principal reductions and P&I reductions becomes even more pronounced. A one percent reduction in principal is estimated to reduce the likelihood of receiving a foreclosure filing or terminating in a foreclosure sale/REO by approximately one percent. A one percent reduction in P&I yields a 1.3 percent reduction in the likelihood of receiving a foreclosure filing, a 1.7 percent reduction in the likelihood of terminating in a foreclosure sale/REO, and a 1.1 percent reduction in the likelihood of a short sale.

As previously mentioned, many of the early mortgage modifications actually resulted in increases in principal balances and the monthly P&I, as accumulated interest and fees were capitalized. The ineffectiveness of this approach is clearly demonstrated in our results, as modifications that resulted in any principal balance increase were 29 percent more likely to be 60+ days delinquent, 36 percent more likely to result in a foreclosure filing, and 27 percent more likely to terminate in a foreclosure sale/REO. Modifications that included an increase in P&I were 41 percent more likely to be 60+ days delinquent, 32 percent more likely to result in a foreclosure filing, and 19 percent more likely to terminate in a foreclosure sale/REO. They were

also far more likely to end up requiring a subsequent re-modification, with a 25 percent higher relative risk.

Even conditional on the actual modification terms, those modifications done through the HAMP program appear to be particularly effective. HAMP modifications have a 16 percent lower relative risk of being 60+ days delinquent, a 20 percent lower relative risk of experiencing a foreclosure filing, a 27 percent lower relative risk of terminating in a foreclosure sale/REO, and a 32 percent lower relative risk of ending in a short sale.

The CLTV following a modification is by far the largest determinant of subsequent mortgage outcomes, with the likelihood of default, foreclosure, and REO increasing substantially as the CLTV increases. The CLTV is constructed by dividing the current total value of the first lien mortgage and any junior liens by CoreLogic's AVM estimate for the property value. Relative to the reference category of a CLTV below 80 percent, a borrower with a CLTV ratio between 80 and 89 percent has a 12 percent higher relative risk of being 60+ days delinquent, a 20 percent higher risk of requiring a re-modification, and a 23 percent higher relative risk of entering foreclosure. However, for borrowers with a CLTV between 80 and 89 percent there is no significant difference in the likelihood of the mortgage terminating in a foreclosure sale/REO or short sale compared to those borrowers with a CLTV below 80 percent.

The likelihood of an adverse outcome consistently increases with each higher category of CLTV included in the model and there is a notable jump in coefficient magnitude for the categories of CLTV in excess of 100 percent. Borrowers with a CLTV of between 100 and 124 percent are 35 percent more likely to be 60+ days delinquent, 76 percent more likely to enter foreclosure, 142 percent more likely to terminate in a foreclosure sale/REO, and 26 percent more likely to terminate in a short sale. They are also 39 percent more likely to require a re-

modification of their mortgage. Finally, at the extreme, borrowers with a CLTV of 150 percent or more are 83 percent more likely to be 60+ days delinquent, 233 percent more likely to enter foreclosure, 740 percent more likely to terminate in a foreclosure sale/REO, and 420 percent more likely to terminate in a short sale. While these values may appear extreme, they are consistent with Bhutta et al. (2010) who find that borrowers with a CLTV of 150 percent or more are over 10 times more likely to default than borrowers with a CLTV of around 100. This is driven in part by their finding that when home equity falls below -62 percent (CLTV greater than 162 percent) borrowers are far more likely to strategically default on their loans (stop paying the mortgage even if they are able to make the monthly payment). Guiso et al. (2013) also find that borrowers are substantially more likely to report a willingness to strategically default when the absolute value of negative equity is $100,000 or greater.

As mentioned above, the aggregate effect of a principal reduction on subsequent loan performance is a combination of the share of principal reduced and the change in the CLTV. It also mechanically reduces the P&I, assuming the loan amortization period isn't shortened. Given the large magnitude of the coefficients found for CLTV, as well as the magnitude of the coefficients on both the principal reduction and P&I variables, principal reductions would appear to be an extremely effective modification strategy, particular for those borrowers with CLTVs in excess of 100 percent.

As we find that modifications done under the HAMP are significantly more effective than proprietary mortgage modifications, we split our sample into non-HAMP and HAMP modifications and re-run our analysis. The results for the non-HAMP loans are presented in Table 4, while those for the HAMP loans are presented in Table 5. For the non-HAMP loans, we see little change in any of the coefficient magnitudes or levels of statistical significance from the

full sample, which is relatively unsurprising given that the HAMP loans make up only 22 percent of the full sample.

In contrast, the results for the HAMP loans reported in Table 5 are notably different than those for the full sample. Here, reductions in principal and interest rate are estimated to modestly *increase* the relative risk of being 60+ days delinquent, entering foreclosure, or terminating with a foreclosure sale/REO. This is likely driven by the waterfall nature of HAMP modifications, where larger reductions in the interest rate or principal balance are indicative of a particularly distressed borrower. However, the coefficient on the percent reduction in P&I remains consistent with what we would expect, as a one percent reduction in P&I is estimated to reduce the relative risk of being 60+ days delinquent by 1.5 percent, entering foreclosure by 1.6 percent, terminating in a foreclosure sale/REO by 2.4 percent, and terminating in a short sale by 1.8 percent.

For the sample of HAMP loans, the magnitude of the coefficients on the CLTV categories actually increases substantially relative to the non-HAMP loans. At every level of CLTV in excess of 80 percent we see substantial increases in the relative risk of the adverse outcomes. Again, there is a particularly pronounced jump in the effect at CLTVs in excess of 100 percent: Those with a CLTV of 100 to 124 percent are now 35 percent more likely to be 60+ days delinquent, 76 percent more likely to enter foreclosure, 142 percent more likely to terminate in a foreclosure sale/REO, and 26 percent more likely to terminate in a short sale. At a CLTV of 150 percent or more, the mortgage is 83 percent more likely to be 60+ days delinquent, 233 percent more likely to enter foreclosure, 242 percent more likely to terminate in a foreclosure sale/REO, and 740 percent more likely to terminate in a short sale. Overall, these

results suggest that HAMP modifications that reduce principal would be most effective at reducing subsequent default and foreclosure.

Conclusions

We use both a probit model and a discrete time proportional hazard framework with competing risks to analyze how the parameters of mortgage modifications affect the post-modification loan performance. Using a rich dataset that provides information on modification parameters, second liens, and current property values our estimates suggest the completely intuitive conclusion that modifications that improve the terms of the loan for the borrower—reduce the interest rate, reduce the monthly P&I, or reduce the loan's principal balance—reduce the likelihood that the borrower re-defaults and enters foreclosure. Conversely, modifications that capitalize accrued interest and fees, resulting in an increase in the mortgage balance, or that increase the monthly P&I are particularly prone to re-default and ending in foreclosure. Principal reductions are particularly effective, as they appear to independently affect subsequent mortgage performance, as well as affect subsequent performance through a reduction in the loan to value ratio and the P&I. HAMP modifications also appear to perform substantially better than non-HAMP modifications, independent of the terms of the actual modification.

Mortgages with CLTV ratios in excess of 100 percent following a modification, and especially those with CLTV ratios above 150 percent, are far more likely to re-default than those with some equity. Thus when implementing a principal reduction, it would appear reasonable for servicers to target reducing the total of outstanding loan balances on the property below one of these key CLTV thresholds. However, a broad based policy of principle reduction may introduce moral hazard into the mortgage market, resulting in borrowers strategically defaulting

in order to obtain a modification and reduce their principle balance (Foote et al. 2008). Applying the learnings from the previous literature on negative equity and strategic default to target only borrowers experiencing both high negative equity and an income shock may reduce moral hazard and yield more cost effective principle reductions (Bhutta et al. 2010; Foote et al. 2008).

While principal reductions are clearly the most effective type of mortgage modification as measured by subsequent loan performance, they may not necessarily be the most cost-effective for the investor on a net present value basis. Further analysis of the costs to investors of the various types of modifications relative to their effect on loan performance is necessary to make the final determination. However, our results provide an important input into the calculation of modification costs versus benefits.

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Table 1 Descriptive statistics

	Mean	SD
Junior Lien	0.4275	0.4947
Loan Used for Purchase	0.371	0.4831
Not Owner Occupied	0.0477	0.2132
Low or No Documentation	0.4824	0.4997
Judicial Foreclosure State	0.3977	0.4894
State with Redemption Law	0.4583	0.4983
Non-Recourse State	0.55	0.4975
Originated 2004	0.0856	0.2798
Originated 2005	0.2802	0.4491
Originated 2006	0.4558	0.4981
Originated 2007	0.1396	0.3466
First Modified in 2008	0.2532	0.4348
First Modified in 2009	0.2163	0.4117
First Modified in 2010	0.2393	0.4267
First Modified in 2011	0.1332	0.3398
First Modified in 2012	0.0935	0.2911
First Modified in 2013	0.0644	0.2455
FICO at Origination	635.1031	64.9563
HAMP Modification Indicator	0.2263	0.4184
Monthly P&I Pre-Modification ($)	1,625.26	1,570.14
Reduction in P&I ($)	-534.87	566.83
P&I Increase Indicator	0.1463	0.3534
Percent Reduction in P&I	25.7766	21.4640
Interest Rate Pre-Modification	7.4283	2.0848
Reduction in Interest Rate	-3.4301	1.8894
Percent Reduction in Interest Rate	37.977	25.2398
Principal Balance Pre-Modification ($)	253,398.80	175,253.10
Principal Balance Post-Modification ($)	254,067.40	183,766.30
Reduction in Principal ($)	-48,249.34	66,651.33
Principal Increase Indicator	0.7294	0.4443
Percent Reduction in Principal	4.0581	11.6167
Loan to Value Ratio Pre-Modification	113.5151	38.5677
Loan to Value Ratio Post-Modification	113.7906	65.1255
Unemployment Rate at Modification	8.7457	2.417
Number of Loans	46734	

Note: The average reductions in P&I, interest rate, and principal balance exclude zero values. The percent reductions include zero values.

Table 2 Determinants of Mortgage Default Post Modification

All Modifications	60+ Days Delinquent within 12 Months
Junior Lien	0.0286***
	(6.0378)
Loan Used for Purchase	0.0471***
	(10.0540)
FICO at Origination 580 to 649	-0.0531***
	(-9.2766)
FICO at Origination 650 to 719	-0.1422***
	(-21.2141)
FICO at Origination 720 and Above	-0.2443***
	(-26.8636)
Not Owner Occupied	0.0353***
	(3.5979)
Low or No Documentation	0.0098**
	(2.1498)
Judicial Foreclosure State	0.0271***
	(5.7321)
State with Redemption Law	0.0139***
	(2.8297)
Non-Recourse State	-0.0002
	(-0.0343)
HAMP Modification Indicator	-0.0121*
	(-1.6652)
Percent Reduction in Principal	-0.0005*
	(-1.9160)
Principal Increase Indicator	0.0469***
	(7.9918)
Percent Reduction in Interest Rate	-0.0011***
	(-7.9042)
Percent Reduction in P&I	-0.0022***
	(-12.6197)
P&I Increase Indicator	0.0759***
	(11.1224)
Originated 2004	0.0264**
	(2.0817)
Originated 2005	0.0323***
	(2.8147)
Originated 2006	0.0499***
	(4.3978)
Originated 2007	0.0622***
	(5.0482)

Table 2 (continued)

First Modified in 2009	-0.0828***
	(-11.1447)
First Modified in 2010	-0.1517***
	(-18.4959)
First Modified in 2011	-0.2001***
	(-23.5565)
First Modified in 2012	-0.2345***
	(-25.4473)
First Modified in 2013	-0.4084***
	(-36.0970)
CLTV 80 to 89 Percent	0.0137*
	(1.7336)
CLTV 90 to 94 Percent	0.0090
	(0.9367)
CLTV 95 to 99 Percent	0.0179*
	(1.8459)
CLTV 100 to 124 Percent	0.0376***
	(5.4218)
CLTV 125 to 149 Percent	0.0583***
	(7.1490)
CLTV 150 Percent and Above	0.0692***
	(7.8559)
Unemployment Rate	-0.0109***
	(-7.5098)
Log-Likelihood	26835.184
Chi-Sq	8820.71
Borrowers	46734

Probit model for 12 month re-default. Coefficients are average marginal effects. Z-statistics in parentheses. Sample is CoreLogic LoanPerformance data on subprime and alt-a mortgages originated from January 1, 2000 to January 1, 2008 and modified after January 1, 2008. Mortgage servicer fixed-effects are included in the model, but coefficients are omitted due to data license agreement.

* p<0.10, ** p<0.05, *** p<0.01

Table 3 Determinants of Mortgage Default Post Modification

All Modifications	60+ Delinquent	Modification	Foreclosure Filing	REO/Foreclosure Sale	Short Pay Off
Junior Lien	1.2480***	1.1123***	1.2457***	1.2791***	1.0880
	(46.3881)	(10.4737)	(35.5376)	(5.6313)	(1.4391)
Loan Used for Purchase	1.2518***	1.0546***	1.3402***	1.4856***	1.4843***
	(47.7276)	(5.2566)	(48.3838)	(9.2583)	(6.8520)
FICO at Origination 580 to 649	0.7662***	0.8868***	0.8016***	0.8420***	0.8007***
	(-48.1322)	(-9.6838)	(-30.4207)	(-3.2568)	(-3.1090)
FICO at Origination 650 to 719	0.5288***	0.7812***	0.6240***	0.7601***	0.7273***
	(-92.6418)	(-16.8809)	(-53.2499)	(-4.3285)	(-3.7474)
FICO at Origination 720 and Above	0.3121***	0.7043***	0.3942***	0.5471***	0.7149***
	(-111.6696)	(-18.0723)	(-70.6535)	(-6.6306)	(-3.0557)
Not Owner Occupied	0.9885	0.9435***	1.2879***	1.9786***	1.9441***
	(-1.0492)	(-2.6125)	(19.7084)	(9.0775)	(6.7710)
Low or No Documentation	1.0212***	1.0324***	1.2416***	1.0149	0.8674**
	(4.5075)	(3.2412)	(36.5280)	(0.3450)	(-2.4344)
Judicial Foreclosure State	1.0457***	1.0674***	2.6332***	1.1681***	0.8783**
	(9.4013)	(6.3191)	(154.4326)	(3.5554)	(-2.1059)
State with Redemption Law	0.9351***	1.0815***	0.9261***	1.0100	1.2837***
	(-13.8361)	(7.4519)	(-11.7117)	(0.2229)	(4.1708)
Non-Recourse State	0.8319***	0.9852	1.0001	0.7079***	0.6845***
	(-40.3872)	(-1.5044)	(0.0085)	(-8.2488)	(-6.6731)
HAMP Modification Indicator	0.8415***	0.9645**	0.7971***	0.7281***	0.6823***
	(-21.9959)	(-2.4244)	(-21.6727)	(-3.9381)	(-3.7396)
Percent Reduction in Principal	0.9935***	1.0115***	0.9889***	0.9896***	0.9963
	(-20.9647)	(23.1124)	(-23.9359)	(-2.6390)	(-0.9895)
Principal Increase Indicator	1.2941***	0.7467***	1.3561***	1.2669***	0.9361
	(44.0926)	(-24.8871)	(39.6223)	(4.3249)	(-1.0021)
Percent Reduction in Interest Rate	0.9930***	0.9953***	0.9947***	0.9959***	0.9921***
	(-51.3003)	(-15.5730)	(-30.4386)	(-3.3667)	(-4.9684)
Percent Reduction in P&I	0.9933***	0.9996	0.9868***	0.9830***	0.9886***
	(-37.7233)	(-1.1892)	(-57.2727)	(-10.2266)	(-5.2156)
P&I Increase Indicator	1.4092***	1.2547***	1.3167***	1.1864***	1.2655***
	(53.0150)	(15.3767)	(33.5192)	(3.0284)	(3.1676)
Originated 2004	1.1259***	1.0265	1.0006	0.7231***	0.7705
	(8.8353)	(0.9331)	(0.0319)	(-2.5816)	(-1.5332)
Originated 2005	1.1086***	0.9655	1.0248	0.8080*	0.8524
	(8.4423)	(-1.3871)	(1.5164)	(-1.9547)	(-1.0547)
Originated 2006	1.1839***	0.9804	1.0983***	0.7880**	0.8367
	(13.9726)	(-0.7899)	(5.8593)	(-2.2019)	(-1.1853)
Originated 2007	1.3621***	1.0283	1.1825***	0.6819***	0.9207
	(23.5845)	(1.0347)	(9.6724)	(-3.1546)	(-0.5077)

Table 3 (continued)

First Modified in 2009	0.7024***	0.9384***	0.7263***	0.7246***	0.7238***
	(-67.5695)	(-4.6888)	(-47.7431)	(-6.8031)	(-4.8949)
First Modified in 2010	0.5560***	0.7524***	0.6282***	0.6601***	0.8056***
	(-94.7380)	(-20.0441)	(-56.6466)	(-6.9187)	(-2.7388)
First Modified in 2011	0.4773***	0.5792***	0.6123***	0.6422***	0.9525
	(-79.9624)	(-33.1771)	(-38.5844)	(-4.5490)	(-0.4228)
First Modified in 2012	0.4166***	0.4748***	0.4480***	0.4145***	0.7361
	(-58.2728)	(-37.5654)	(-33.0348)	(-4.2005)	(-1.4507)
First Modified in 2013	0.2716***	0.6645***	0.1175***		0.6594
	(-40.5129)	(-17.4669)	(-24.5348)		(-0.9910)
CLTV 80 to 89 Percent	1.1177***	1.2019***	1.2256***	1.0402	0.8991
	(12.1729)	(10.1912)	(15.0005)	(0.3293)	(-0.7987)
CLTV 90 to 94 Percent	1.1580***	1.2155***	1.3984***	1.5100***	0.9362
	(13.7785)	(9.0555)	(21.9215)	(3.2489)	(-0.4170)
CLTV 95 to 99 Percent	1.1823***	1.2400***	1.4902***	1.6583***	0.7642
	(15.8562)	(9.9113)	(26.7089)	(4.0953)	(-1.5854)
CLTV 100 to 124 Percent	1.3518***	1.3860***	1.7589***	2.4238***	1.2598**
	(38.8037)	(20.6579)	(50.0875)	(9.5355)	(2.1464)
CLTV 125 to 149 Percent	1.5410***	1.5817***	2.2407***	3.6131***	2.1753***
	(50.0018)	(25.3909)	(66.5060)	(13.1328)	(6.8797)
CLTV 150 Percent and Above	1.8317***	1.8608***	3.3344***	8.4005***	5.2049***
	(67.4602)	(32.6756)	(97.4776)	(21.9868)	(14.9371)
Unemployment Rate	1.0434***	0.9188***	1.0814***	0.9812	0.9838
	(32.1175)	(-31.2779)	(41.0791)	(-1.4619)	(-0.9384)
Log-Likelihood	-1444985.7				
Chi-Sq	371126.63				
Observations	1,699,217				
Borrowers	46,734				

Competing risk models with relative risk ratios reported. t-statistics in parentheses. Sample is CoreLogic LoanPerformance data on subprime and alt-a mortgages originated from January 1, 2000 to January 1, 2008 and modified after January 1, 2008. Mortgage servicer fixed-effects are included in the model, but coefficients are omitted due to data license agreement.
* p<0.10, ** p<0.05, *** p<0.01

Table 4 Determinants of Mortgage Default Post Modification

Non-HAMP Modifications	60+ Delinquent	Modification	Foreclosure Filing	REO/Foreclosure Sale	Short Pay Off
Junior Lien	1.2434***	1.1127***	1.2362***	1.2466***	1.0824
	(42.7592)	(9.3128)	(32.4010)	(4.8279)	(1.2851)
Loan Used for Purchase	1.2388***	1.0405***	1.3286***	1.4906***	1.4550***
	(42.8459)	(3.5150)	(44.4788)	(8.9686)	(6.2106)
FICO at Origination 580 to 649	0.7690***	0.8999***	0.8096***	0.8417***	0.8035***
	(-45.3626)	(-7.8759)	(-27.9103)	(-3.1734)	(-2.9746)
FICO at Origination 650 to 719	0.5369***	0.7978***	0.6265***	0.7693***	0.7151***
	(-85.1812)	(-13.9270)	(-50.0589)	(-3.9991)	(-3.7758)
FICO at Origination 720 and Above	0.3243***	0.7047***	0.4036***	0.5547***	0.7710**
	(-99.1868)	(-15.4300)	(-63.9669)	(-6.1150)	(-2.2621)
Not Owner Occupied	0.9749**	0.9220***	1.2717***	1.9325***	1.9227***
	(-2.2200)	(-3.3641)	(18.1346)	(8.4986)	(6.4557)
Low or No Documentation	1.0394***	1.0381***	1.2858***	1.0393	0.8732**
	(7.8330)	(3.4119)	(40.3002)	(0.8646)	(-2.2109)
Judicial Foreclosure State	1.0443***	1.0850***	2.6495***	1.2065***	0.8965*
	(8.6211)	(7.1161)	(148.2588)	(4.1521)	(-1.7078)
State with Redemption Law	0.9349***	1.1389***	0.9247***	0.9986	1.2670***
	(-13.1281)	(11.2071)	(-11.3846)	(-0.0310)	(3.8017)
Non-Recourse State	0.8445***	1.0243**	1.0127**	0.7081***	0.6900***
	(-35.0221)	(2.1754)	(1.9708)	(-7.9324)	(-6.2639)
Percent Reduction in Principal	0.9913***	1.0172***	0.9851***	0.9849***	0.9959
	(-24.8832)	(28.3862)	(-28.2380)	(-3.3919)	(-1.0377)
Principal Increase Indicator	1.2964***	0.7438***	1.3600***	1.2646***	0.9338
	(41.7167)	(-22.5187)	(37.8041)	(4.1251)	(-0.9959)
Percent Reduction in Interest Rate	0.9912***	0.9996	0.9925***	0.9938***	0.9895***
	(-59.4716)	(-1.3336)	(-40.2180)	(-4.7809)	(-6.1356)
Percent Reduction in P&I	0.9938***	0.9995	0.9865***	0.9832***	0.9891***
	(-31.2714)	(-1.2417)	(-53.4678)	(-9.3661)	(-4.6197)
P&I Increase Indicator	1.3832***	1.3418***	1.2597***	1.1570**	1.2074**
	(48.3069)	(18.7235)	(27.1626)	(2.5144)	(2.4522)
Originated 2004	1.1372***	1.0497	0.9965	0.7599**	0.7736
	(9.1943)	(1.5874)	(-0.1887)	(-2.1017)	(-1.4783)
Originated 2005	1.1244***	1.0145	1.0490***	0.8632	0.8449
	(9.2105)	(0.5234)	(2.8473)	(-1.2910)	(-1.0881)
Originated 2006	1.2124***	1.0274	1.1300***	0.8364	0.8603
	(15.2761)	(0.9905)	(7.3389)	(-1.5779)	(-0.9786)
Originated 2007	1.4238***	1.0907***	1.2272***	0.7239**	0.9602
	(25.6317)	(2.9136)	(11.2631)	(-2.5283)	(-0.2424)

Table 4 (continued)

First Modified in 2009	0.7087***	0.9579***	0.7371***	0.7266***	0.7185***
	(-64.6857)	(-3.1153)	(-44.8240)	(-6.6402)	(-4.9152)
First Modified in 2010	0.5415***	0.7681***	0.6116***	0.6405***	0.7886***
	(-93.5850)	(-17.5073)	(-56.7896)	(-7.0589)	(-2.8931)
First Modified in 2011	0.4810***	0.5515***	0.6328***	0.7378***	0.9917
	(-70.1583)	(-31.4064)	(-32.2738)	(-2.9509)	(-0.0684)
First Modified in 2012	0.4040***	0.4123***	0.4014***	0.3981***	0.7453
	(-51.0328)	(-35.9072)	(-30.9253)	(-3.7823)	(-1.2803)
First Modified in 2013	0.2527***	0.6152***	0.1065***	0.0000	0.6321
	(-36.2497)	(-17.0020)	(-21.7673)	(.)	(-1.0016)
CLTV 80 to 89 Percent	1.1134***	1.1110***	1.2312***	1.0228	0.8958
	(11.1770)	(5.3668)	(14.6458)	(0.1809)	(-0.8032)
CLTV 90 to 94 Percent	1.1418***	1.0782***	1.3860***	1.5242***	0.9796
	(11.8383)	(3.1891)	(20.3684)	(3.2198)	(-0.1291)
CLTV 95 to 99 Percent	1.1707***	1.1008***	1.4844***	1.5917***	0.7498
	(14.1960)	(4.0520)	(25.2725)	(3.5983)	(-1.6437)
CLTV 100 to 124 Percent	1.3376***	1.2132***	1.7575***	2.4435***	1.2278*
	(35.4954)	(11.1799)	(47.6207)	(9.2649)	(1.8443)
CLTV 125 to 149 Percent	1.5080***	1.3798***	2.2000***	3.4866***	2.1736***
	(44.8612)	(16.1260)	(61.7320)	(12.2494)	(6.6616)
CLTV 150 Percent and Above	1.7770***	1.6090***	3.2401***	8.1970***	4.8951***
	(60.2538)	(22.2905)	(90.1455)	(20.8714)	(13.8472)
Unemployment Rate	1.0543***	0.8929***	1.0943***	0.9998	0.9945
	(38.3719)	(-39.0759)	(45.6391)	(-0.0186)	(-0.3086)
Log-Likelihood	-1256731.9				
Chi-Sq	277739.38				
Observations	1,383,936				
Borrowers	36,158				

Competing risk models with relative risk ratios reported. t-statistics in parentheses. Sample is CoreLogic LoanPerformance data on subprime and alt-a mortgages originated from January 1, 2000 to January 1, 2008 and receiving a proprietary modification after January 1, 2008. Mortgage servicer fixed-effects are included in the model, but coefficients are omitted due to data license agreement.

* p<0.10, ** p<0.05, *** p<0.01

Table 5 Determinants of Mortgage Default Post Modification

HAMP Modifications	60+ Delinquent	Modification	Foreclosure Filing	REO/Foreclosure Sale	Short Pay Off
Junior Lien	1.2795***	1.0012	1.3913***	1.8830***	1.1347
	(16.6088)	(0.0468)	(15.9535)	(3.9259)	(0.6041)
Loan Used for Purchase	1.3200***	1.1650***	1.3760***	1.3196*	1.7030**
	(18.4624)	(5.7703)	(15.2810)	(1.6706)	(2.4948)
FICO at Origination 580 to 649	0.7439***	0.7763***	0.6926***	0.8352	0.7864
	(-14.7316)	(-6.6319)	(-13.1284)	(-0.7415)	(-0.7081)
FICO at Origination 650 to 719	0.4951***	0.5954***	0.6087***	0.7629	1.0043
	(-31.3774)	(-12.5370)	(-16.2211)	(-1.0266)	(0.0124)
FICO at Origination 720 and Above	0.2687***	0.5288***	0.3581***	0.5439*	0.5914
	(-43.8278)	(-13.2017)	(-25.1215)	(-1.8710)	(-1.2362)
Not Owner Occupied	1.0642	1.0843	1.2567***	2.6511***	1.7538
	(1.3187)	(1.1686)	(3.6603)	(2.7988)	(1.0887)
Low or No Documentation	0.9523***	0.8947***	1.0078	0.8921	0.8413
	(-3.3488)	(-4.2818)	(0.3807)	(-0.6891)	(-0.8136)
Judicial Foreclosure State	1.0520***	1.0497*	2.3372***	0.8748	0.7689
	(3.2765)	(1.7395)	(37.3932)	(-0.7318)	(-1.0500)
State with Redemption Law	0.9533***	0.9779	1.0204	1.4790**	1.1398
	(-2.9200)	(-0.7652)	(0.8465)	(2.0410)	(0.5376)
Non-Recourse State	0.7358***	0.8884***	0.8504***	0.7147**	0.7311
	(-20.6323)	(-4.3680)	(-7.7769)	(-1.9762)	(-1.4001)
Percent Reduction in Principal	1.0065***	1.0065***	1.0072***	1.0143	1.0135
	(8.4758)	(6.2203)	(6.3922)	(1.4232)	(1.0690)
Principal Increase Indicator	1.1947***	0.9495	1.1430***	1.1225	1.0794
	(9.1060)	(-1.6437)	(4.9112)	(0.5089)	(0.2632)
Percent Reduction in Interest Rate	1.0087***	0.9591***	1.0128***	1.0138***	1.0231***
	(18.8703)	(-44.7605)	(19.7128)	(2.9604)	(3.0712)
Percent Reduction in P&I	0.9850***	1.0011	0.9840***	0.9760***	0.9820***
	(-30.8323)	(1.2504)	(-23.7958)	(-4.6676)	(-2.6501)
Originated 2004	0.9686	0.7793***	1.2522***	0.3954*	0.7798
	(-0.6427)	(-3.1030)	(3.2465)	(-1.7596)	(-0.2835)
Originated 2005	0.9473	0.6869***	0.8510***	0.3493**	1.0291
	(-1.2289)	(-5.2033)	(-2.5806)	(-2.5754)	(0.0382)
Originated 2006	0.9612	0.7700***	0.9426	0.4463**	0.6316
	(-0.9125)	(-3.6799)	(-0.9598)	(-2.0461)	(-0.6122)
Originated 2007	0.9748	0.8448**	1.0144	0.3580**	0.6371
	(-0.5661)	(-2.2780)	(0.2251)	(-2.4341)	(-0.5839)

Table 5 (continued)

First Modified in 2010	1.0198	0.8392***	1.2139***	0.9440	1.2867
	(0.9749)	(-4.0559)	(6.8719)	(-0.2840)	(0.8856)
First Modified in 2011	0.8952***	0.6773***	1.1943***	0.5893*	1.8143
	(-4.3877)	(-8.2792)	(4.8477)	(-1.7356)	(1.5762)
First Modified in 2012	0.8270***	0.6035***	1.1171**	0.6690	1.2437
	(-5.3892)	(-9.6399)	(2.0092)	(-0.8437)	(0.3047)
First Modified in 2013	0.6733***	0.5634***	0.3976***		3.1135
	(-5.9980)	(-9.3646)	(-5.4518)		(1.0074)
CLTV 80 to 89 Percent	1.2046***	1.5117***	1.1811***	1.6545	0.6717
	(5.9239)	(8.1310)	(3.3721)	(1.1217)	(-0.5761)
CLTV 90 to 94 Percent	1.3918***	1.8426***	1.6139***	1.1824	
	(9.1559)	(10.4086)	(8.8323)	(0.2811)	
CLTV 95 to 99 Percent	1.3740***	1.7450***	1.5852***	3.2378***	1.1614
	(8.7382)	(9.1804)	(8.4397)	(2.6474)	(0.2144)
CLTV 100 to 124 Percent	1.5517***	2.0939***	1.8376***	2.1356**	1.5500
	(16.7398)	(17.2978)	(15.3598)	(1.9940)	(0.9311)
CLTV 125 to 149 Percent	1.9046***	2.3529***	2.8424***	5.7266***	2.4813*
	(22.6000)	(18.0218)	(25.0656)	(4.6187)	(1.8521)
CLTV 150 Percent and Above	2.5268***	2.4721***	4.9265***	12.0475***	10.3187***
	(31.8753)	(18.6978)	(37.9455)	(6.6025)	(5.0510)
Unemployment Rate	0.9617***	0.9228***	0.9780***	0.7639***	0.9559
	(-7.2410)	(-8.9074)	(-2.6476)	(-4.4365)	(-0.5254)
Log-Likelihood	-158680.6				
Chi-Sq	63595.51				
Observations	295,651				
Borrowers	10,576				

Competing risk models with relative risk ratios reported. t-statistics in parentheses. Sample is CoreLogic LoanPerformance data on subprime and alt-a mortgages originated from January 1, 2000 to January 1, 2008 and receiving a HAMP modification after March 2009. Mortgage servicer fixed-effects are included in the model, but coefficients are omitted due to data license agreement.

* p<0.10, ** p<0.05, *** p<0.01

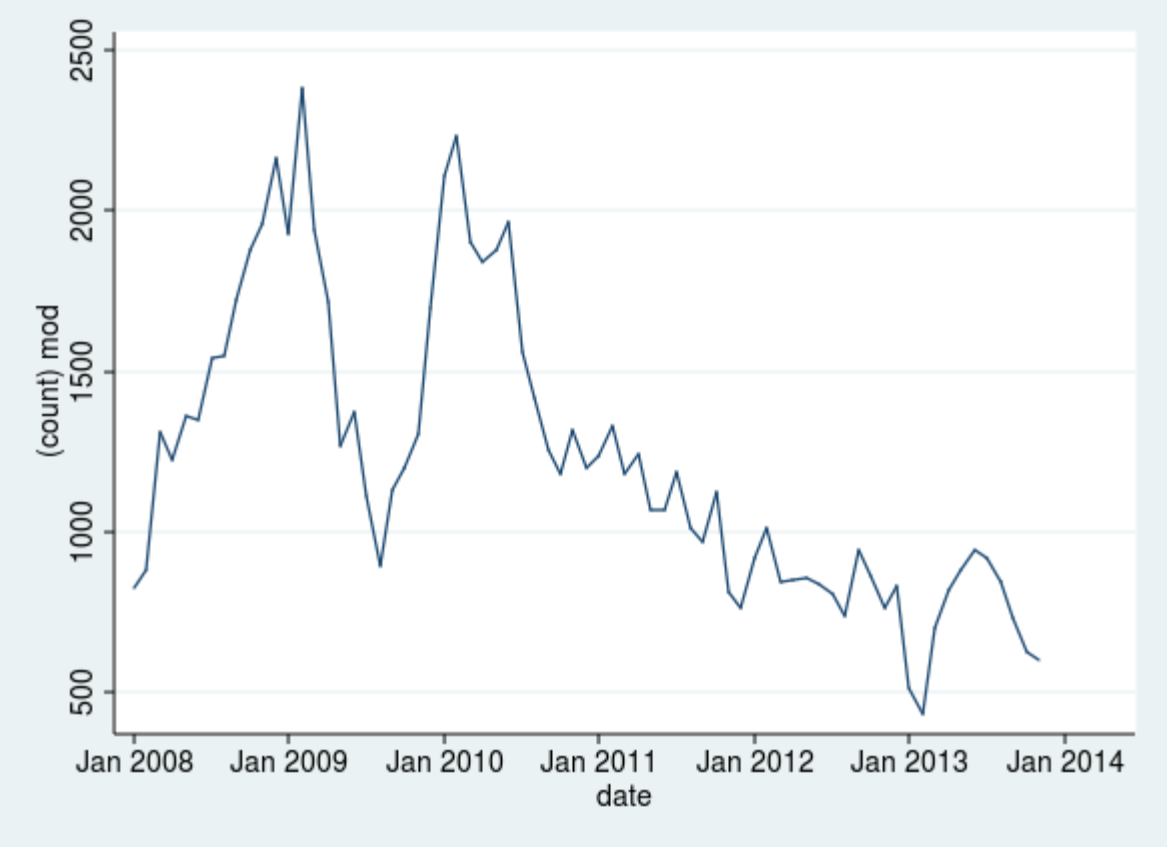

Fig. 1 Number of mortgage modifications per month for the sample.

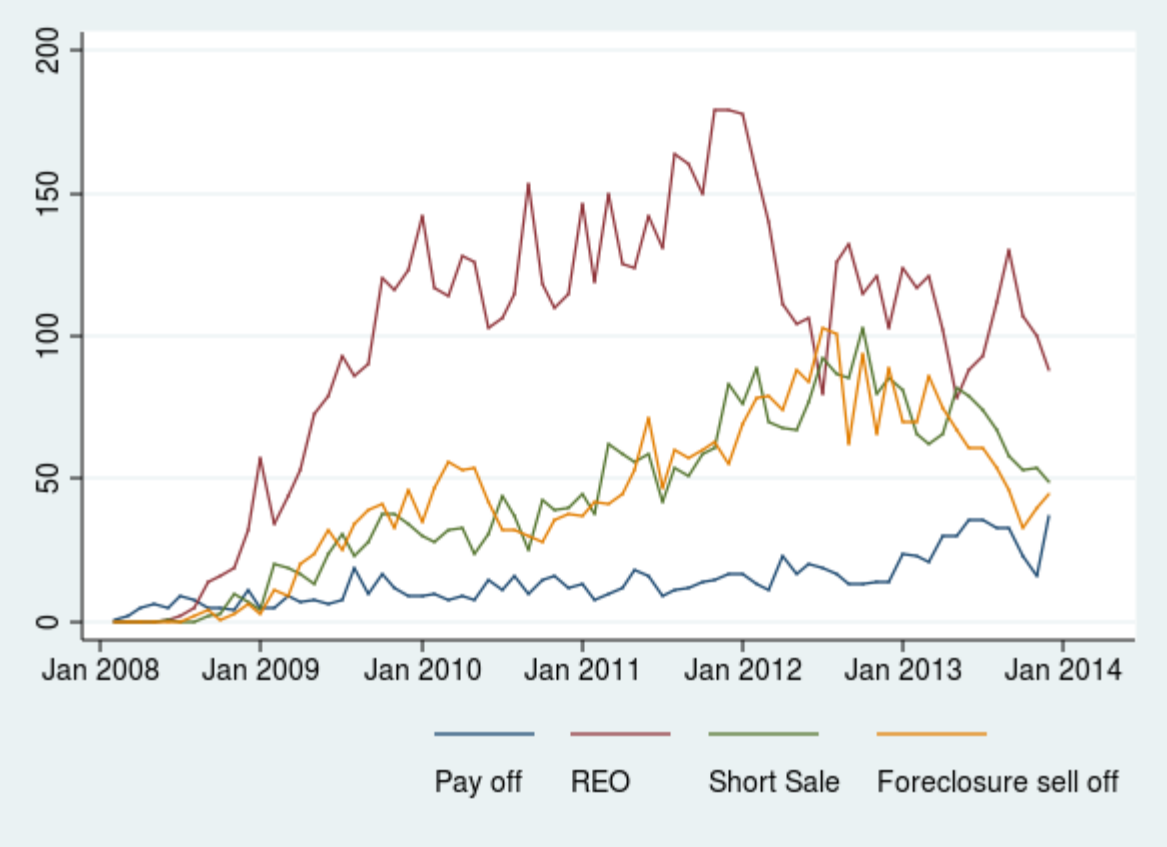

Fig. 2 Number of mortgage terminations per month by termination type, for the sample.

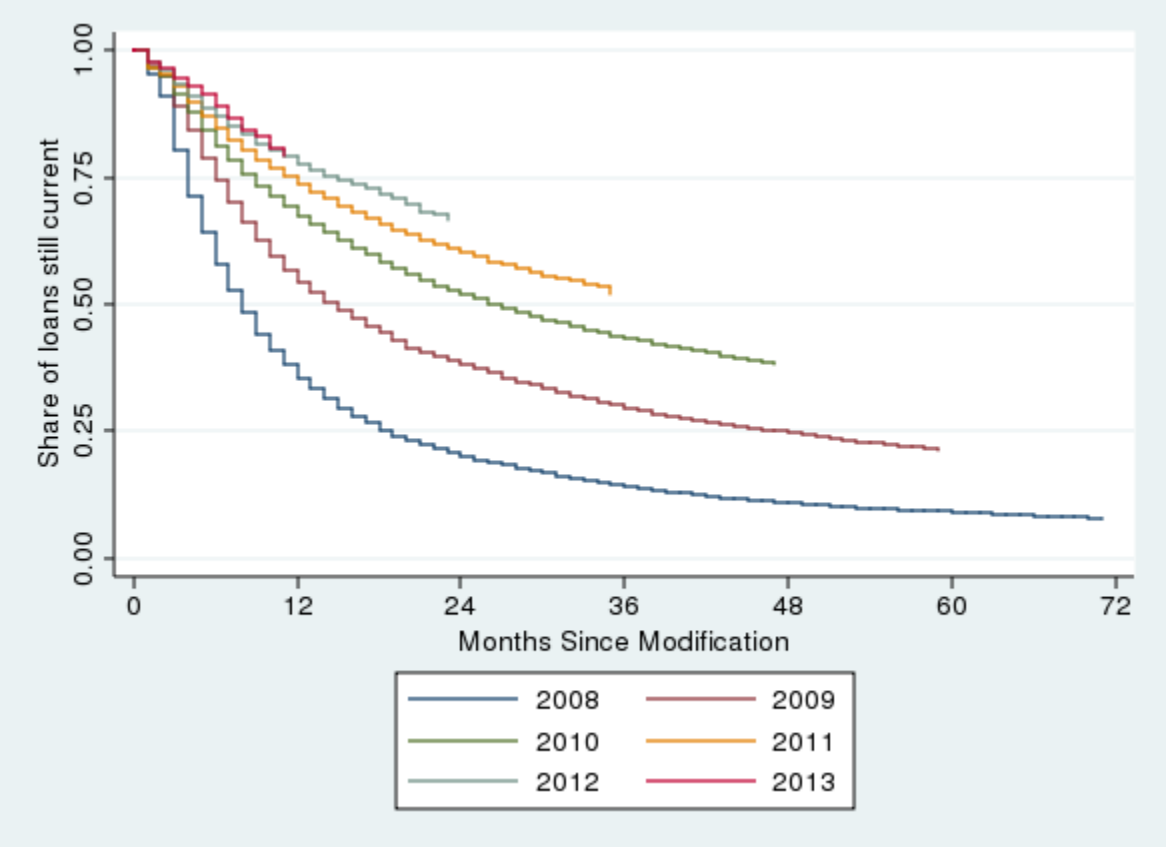

Fig. 3 Kaplan-Meier survival graph for mortgage performance, by year of modification. Notes: Failure is defined as the mortgage reaching 60+ days delinquent post-modification. Analysis time begins at the month of modification.

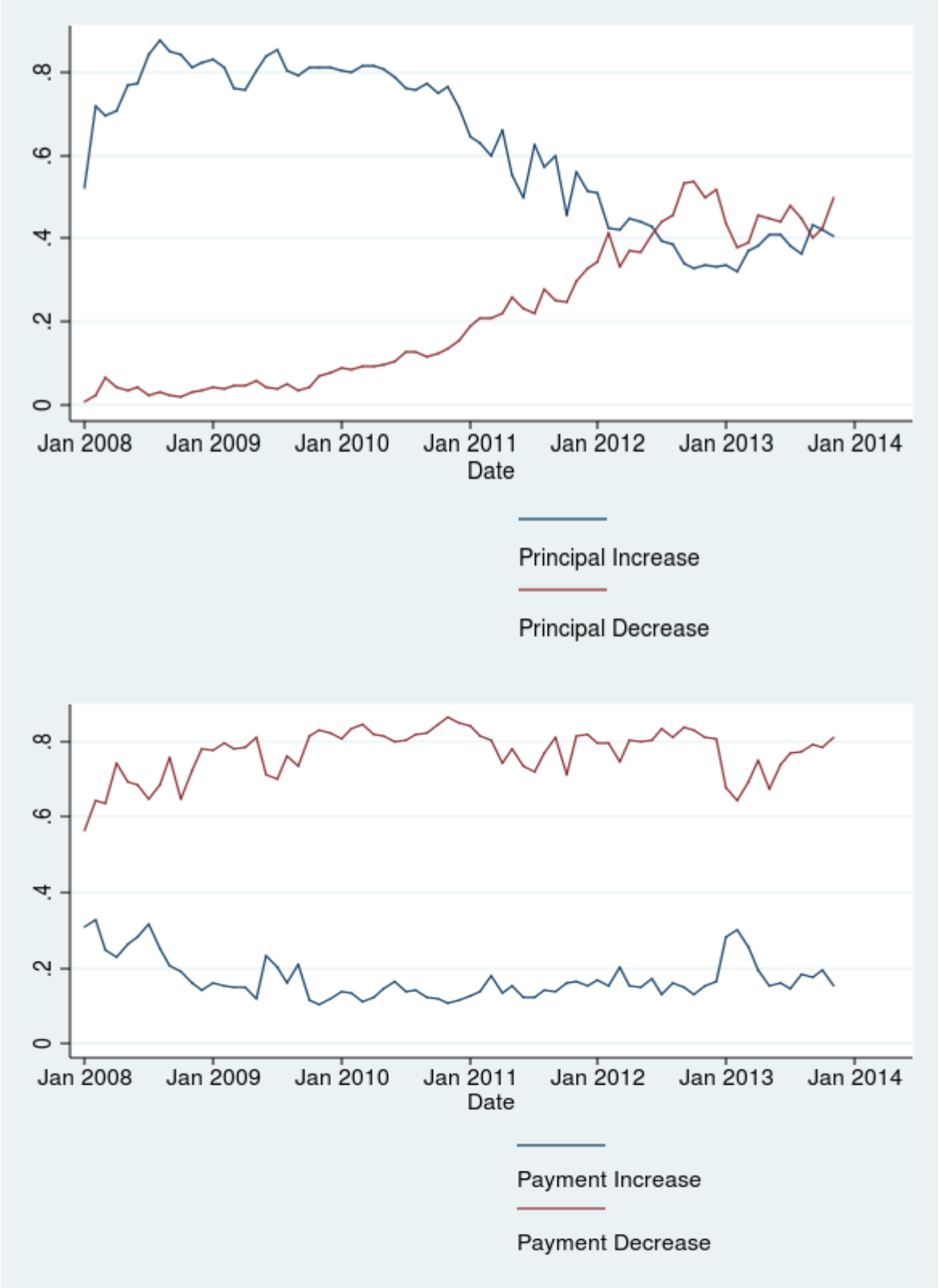

Fig. 4 Share of sample loan modifications where borrower has their principal increased/decreased and payment increased/decreased, by date of modification.