The Effects of Principal Reduction on HAMP Early Redefault Rates

July 9, 2012

I. Executive Summary

This paper summarizes the econometric analysis performed to evaluate the effect of principal reduction on the performance of loan modifications made under the Home Affordable Modification Program (HAMP). It is based on data related to modifications with principal reduction entered into the HAMP system of record by HAMP participating servicers. In early 2010, servicers began reporting that they were reducing principal on some standard HAMP modifications. Following Treasury's introduction of the HAMP Principal Reduction Alternative (HAMP PRA) in June 2010 – pursuant to which Treasury began paying investor incentives for non-GSE loans with principal reduction - servicer reporting of modifications with principal reduction increased. With over eighteen months of data on this type of modification, it is now possible to compare the performance of borrowers who have received principal reductions with those who have not.

The data set for this analysis is a population of 621K[1] loans that had received HAMP modifications through January of 2012, of which 20K reported some amount of principal reduction offered under HAMP PRA, and another 18K reported some amount of principal reduction under standard HAMP. The analysis looks at the factors that influence whether the borrower had redefaulted[2] under HAMP (became 90 days or more delinquent) within the first six months after modification, which should provide an early indication of lifetime redefault rates.

Table 1. Rates of 6 month redefault under HAMP

	All modifications			All modifications with principal reduction			Modifications with principal reduction under HAMP PRA		
	Total	90+ after 6 months		Total	90+ after 6 months		Total	90+ after 6 months	
		Count	%		Count	%		Count	%
Filtered population of HAMP permanent modifications	620,673	35,330	5.7%	37,861	1,816	4.8%	19,776	1,213	6.1%

Data through January 31, 2012 from IR2 (HAMP system of record)

Table 1 shows that the rates of early borrower redefault varied between the loans receiving principal reduction and the overall HAMP population. The six month redefault rate on the total population was 5.7%, while the redefault rate for all modifications with any kind of principal reduction was 4.8%. The table also shows that the redefault rate on HAMP PRA modifications was 6.1%, higher than the average redefault rate for all modifications with principal reduction. Based on

[1] The population contains primarily non-GSE loans. As of June 2012, the GSEs were not participating in principal reduction under HAMP. As of January 2012, there have been approximately 200 GSE loans modified under a pilot principal reduction program conducted by Fannie Mae.

[2] For the purpose of this paper, a loan is considered to have redefaulted when it is 90 days or more delinquent. Under HAMP, a loan is considered disqualified from the program when it is 90 days or more delinquent, regardless of whether the loan cures subsequently.

these figures, one might conclude that while principal reduction appears to improve the performance of HAMP modifications, HAMP PRA does not.

However, the risk of redefault for a given loan will vary depending on characteristics of the borrower and of the loan prior to modification. To better understand the specific effect of principal reduction, a multivariate statistical analysis was performed to try to control for the effects of these varying characteristics. For example, HAMP experience shows that modification redefault rates are particularly sensitive to the amount of payment reduction. It is possible that a loan with reduced principal may perform well simply because the payments have been made more affordable. HAMP experience also shows that modification redefault rates are sensitive to pre-modification delinquency and credit score. It is possible that HAMP PRA modifications perform worse because they are generally performed on loans with higher delinquency and lower credit score. A series of logistic regressions on the loan population was performed to control for these factors and try to isolate the effect of principal reduction.

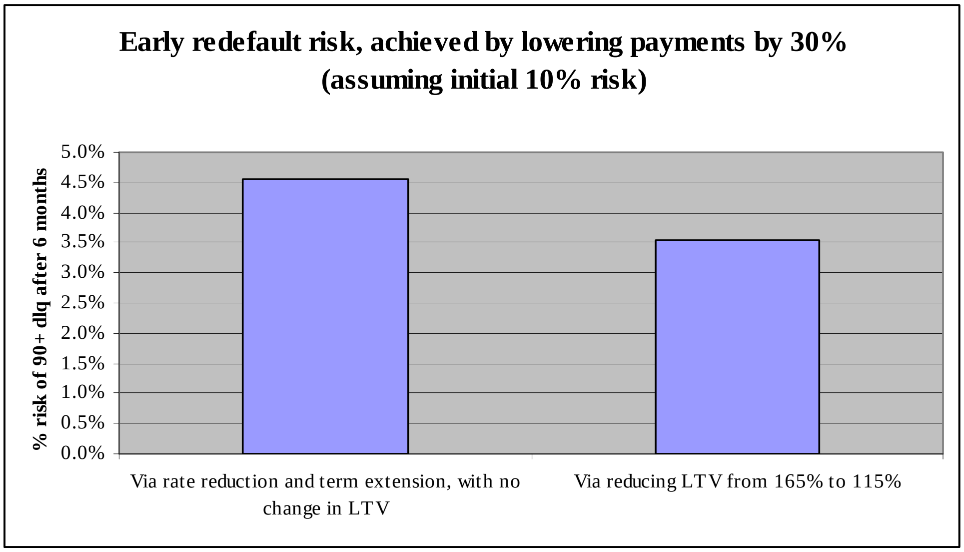
The regression results show a modest but meaningful decline in early redefault rates, related solely to reducing the borrower's negative equity, above and beyond all other effects. Principal reduction improves the borrower's performance under HAMP, not just because it makes their loans more affordable, but because it appears to influence their willingness to pay. The analysis in this paper shows that the behavior of borrowers who get principal reductions under HAMP is much more closely related to their new, reduced loan-to-value (LTV) ratio, than to their before modification (higher) LTV.

For example, suppose that a borrower receives a modification that reduces their principal and thereby lowers their LTV ratio from 165% to 115% but does not change any other loan terms (i.e., rate, term, forbearance). The borrower's payments have consequently been reduced by 30% through principal reduction. The regression results show that this borrower is less likely to redefault than one who had received the same payment reduction without any principal reduction. Furthermore, this borrower will perform at least as well as someone who originally had an LTV ratio of 115% and received a 30% payment reduction without any change in principal balance.

In this example, which is illustrated in Figure 1, a 30% payment reduction achieved without reducing principal has the effect of reducing a borrower's six-month redefault risk from 10% to 4.6%. The same payment change accomplished via principal reduction is expected to lower the redefault rate to about 3.5%.[3]

[3] These percentages should be higher if we were examining cumulative default rates over longer periods of time. From program experience, while the total 90+ day delinquency rate rises steadily across months 3 through 9, it increases at a slower rate beginning in month 12.

Figure 1. Comparison of effect of principal reduction vs. no principal reduction on redefault risk for a loan with the same payment change.



It is also possible to contrast the effect of principal reduction with that of principal forbearance. The graph in Figure 2 shows the expected redefault probabilities for a set of representative loans receiving HAMP modifications with either principal reduction or forbearance. The pre-modification LTV ratios for these loans range between 125% and 215%. Ordinarily, the loans with the higher LTV ratios would have a higher redefault risk, but other risk characteristics have been adjusted so that each loan's risk of early redefault would be exactly 10% under a baseline "modification" with no payment change, principal reduction, or forbearance[4].

Each loan's expected redefault risk can be calculated under the assumption that the modification will either:

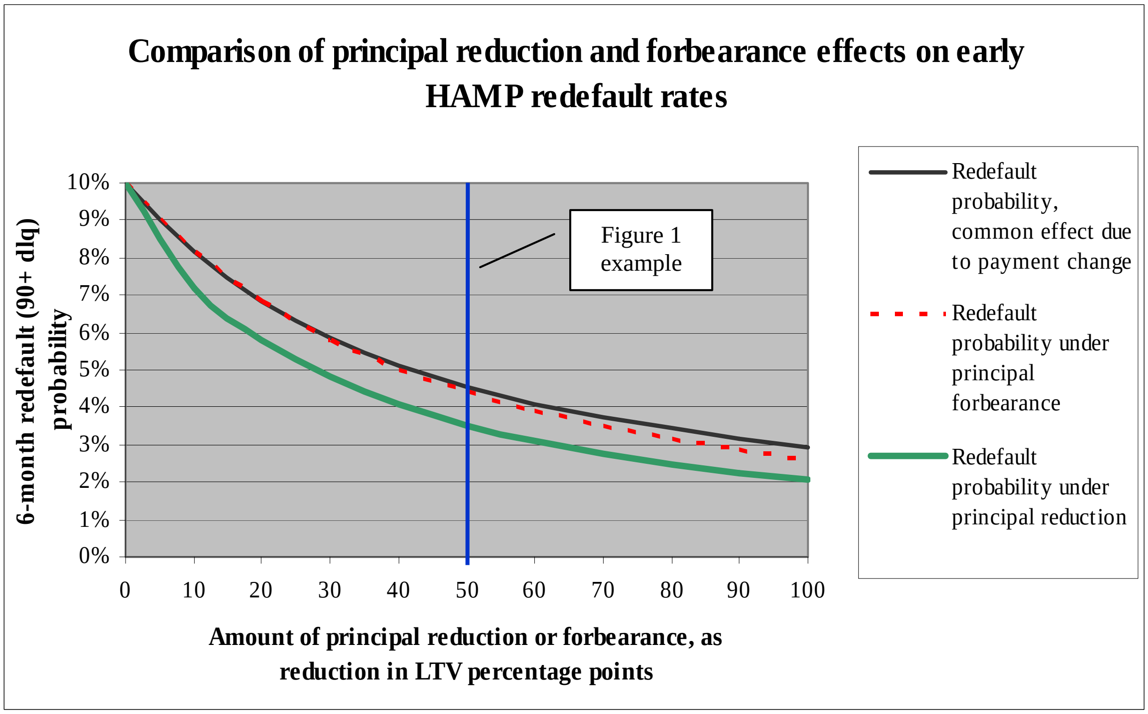
- reduce the borrower's principal exactly down to an LTV level of 115%, or
- give the borrower an equivalent amount in forbearance.

No changes are made to the interest rate or term of the loan. Because the loans with higher initial LTV receive a larger amount of principal reduction or forbearance, the resulting risk reductions from the baseline level of 10% will be greater as initial LTV increases. The bottom curve in the diagram shows the redefault risk using principal reduction. The middle curve shows the effect of comparable forbearance. The topmost curve represents the amount of risk reduction attributable to the reduction in the borrower's payment that is common to both the principal reduction and principal forbearance modifications. This curve can also be interpreted as the effect of a HAMP modification consisting of rate and term changes that reduces the borrower's payments in the same amount as the corresponding principal reduction and principal forbearance modifications.

Taking again the example borrower who starts at 165% LTV, if they received forbearance equivalent to 50% of their home value, which also results in a 30% payment reduction, the borrower's expected redefault rate is 4.4%, as compared with 3.5% if the same payment reduction is achieved through principal reduction and 4.6% if it is achieved through rate and term changes.

[4] This type of modification is known as capitalization modification (cap mod). According to OCC Mortgage Metrics Report Q4-2008, prior to HAMP (pre-2009), 58% of modifications were cap mods where late fees and delinquent interest were capitalized into the UPB of the loan. The modification simply reset the payment status of the loan. There is no payment reduction and there may be a payment increase.

Figure 2. Comparing principal reduction and forbearance effects.



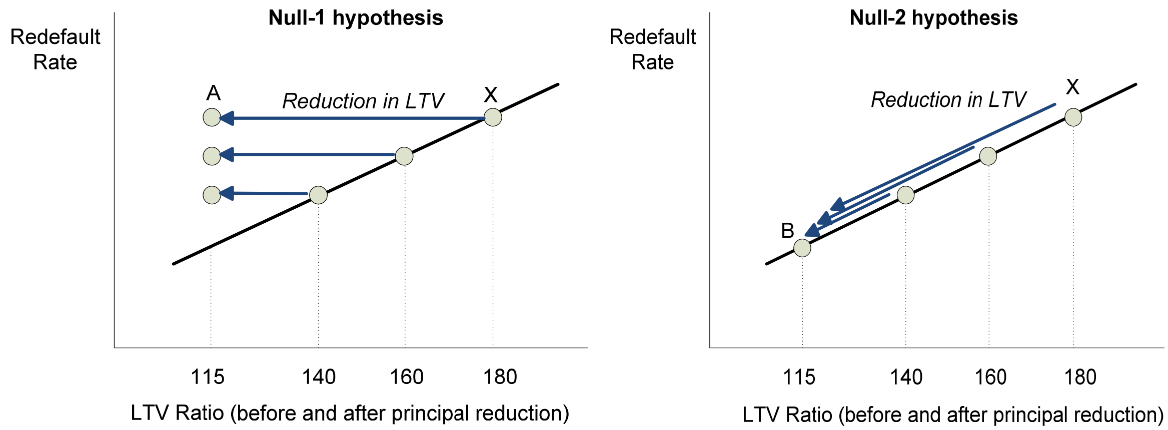
II. Modeling Approach

The analysis was centered on the testing of two alternative hypotheses:

- **Null-1** states that when controlling for affordability related factors (i.e., payment reduction), the level of principal reduction (change in LTV ratio) has *no additional effect* on redefault rates. If null-1 is accepted, then one expects a borrower receiving a principal reduction to behave as if they received a standard HAMP modification with the same payment change, but maintained their old (post-capitalization) LTV ratio.
- **Null-2** states that redefault depends on the borrower's *post*-modification LTV ratio. One assumes that the borrower's willingness to pay is affected by their current level of negative equity, but not by the history of how they got there (e.g., through changes in home prices, through their own pay down, or through principal reduction).

Below is a graph of the redefault sensitivity of borrowers to their LTV (Figure 3). For example, if a borrower is initially at 180% LTV and they receive a principal reduction down to 115% LTV, null-1 says that their expected redefault rate would be at point A – i.e., the same as it would be at point X (if they had had a similar payment reduction but no change in LTV). Null-2 says that their redefault rate will be at point B – as if they had received a modification without principal reduction and had been at 115% LTV in the first place.

Figure 3. Comparing principal reduction and forbearance effects.



Estimating the relative contribution of payment reduction and LTV changes in a population of modified loans can be difficult due to multicollinearity issues. For example, the level of principal reduction offered will be correlated with the amount of payment reduction.

Analysis shows that using just the sub-population of loans with principal reduction makes it difficult to arrive at conclusive results. Thus, the analysis pooled the effects of principal reduction over the larger population of HAMP modifications and then broke out separate effect magnitudes on the mods-with-principal reduction and mods-without-principal reduction sub-populations (by interacting effect variables with a principal reduction flag). When no significant difference in effects was seen between the populations, the pooled effect was kept in the model. For example, the impact of the borrower's credit score on redefault does not depend on whether principal was reduced or not.

III. Model Setup and Population Analysis

The sample used was the entire population of HAMP official (permanent) modifications through January 31, 2012. Modifications that were seasoned less than 6 months and those with missing or outlier data were filtered out. Filters are summarized in Table A1 in the Appendix. The numbers of modifications with principal reduction after the filters are applied can be seen on line [3] of Table A2. Line [3] represents the population used in most of the tests and involves some data imputation. Of this filtered population, there were 620,673 loans, including 37,861 with some kind of principal reduction. (A description of this data imputation process can be found in section VII(a)). Of these, about half (19,776) were loans modified under the HAMP PRA program. The other 18,085 received principal reduction under standard HAMP.

Of this line [3] overall HAMP population, 35,330 loans (5.7%) redefaulted within 6 months. The overall redefault rate for the modifications with principal reduction was 4.8%. Of those modifications that received principal reduction, the redefault rate under HAMP PRA was 6.1% and under standard HAMP was 3.3%. The analysis suggests that the differences can be explained by servicer selection of loan population between these two subgroups, and possibly due to other program implementation differences. In general, raw redefault rates may be higher under HAMP PRA, because it allows the selection of riskier, high LTV loans that may not have been NPV positive under standard HAMP modifications.

The main hypothesis tests are all based on the evaluation of different LTV-related effects. Prior experience in HAMP has shown that modification redefault sensitivity to LTV will be nonlinear. The HAMP NPV model treats this nonlinear effect using a spline: a series of linear segments with kinks at various knot points. This analysis uses a parametric approach, in which three continuous variables were included: LTV, LTV squared, and LTV cubed. This allows the fitting of a cubic (third-order) polynomial curve to describe the estimated sensitivity. This approach makes hypothesis testing somewhat easier since it does not require estimating the position of knot points and only uses three degrees of freedom to describe any LTV-related effects.

The "before principal reduction LTV" variables used in evaluating null-1 always incorporate capitalization. They describe the LTV that the borrower would have arrived at with a standard HAMP modification. The "after principal reduction LTV" variables used in evaluating null-2 are based on subtracting the reduced principal, but not any forbearance amounts, from the loan balance.

In all of the tests, dummy variables corresponding to whether the loan was modified by one of the top servicers by program volume were included. In initial rounds of testing, data shows that two large servicers, which we will designate as Servicers A and B, had lower redefault rates on their loans with principal reduction than on their other HAMP modifications. This difference was not seen in the results for other servicers with large principal reduction volumes. Therefore, in some of the tests, controls were included for the interaction of these two servicer types with the principal reduction flag. The analysis also included additional tests on the subpopulations of loans belonging to these two servicers.

The expectation in accounting for servicer effects and program type is that this helps to control for possible variations in sample selection based on direct differences in screening algorithms or on more indirect factors such as borrower outreach and contact histories. To the extent that program selection for principal reduction does not correlate with existing control variables, it may potentially contaminate the measurement of the program treatment effect from principal reduction.

In all regressions, a set of additional controls were applied that have been found to affect redefault in other tests, including credit score at modification, servicer, property state, home price forecast, months past due at NPV evaluation, date of modification, and most significantly, payment change. Because of the covariance between the percentage reduction in monthly payment and the borrower's before-mod front-end debt-to-income ratio (DTI)[5], a separate control for the DTI ratio was not included.

Analysis was also performed to check for interactions between the principal reduction flag and the remaining controls (besides servicer and type of principal reduction, as already mentioned). Data showed significant interaction between principal reduction and investor type. Loans without principal reduction tend to redefault at a lower rate when they are GSE loans or loans in a bank's portfolio than loans held in private label MBS. The differences in effects for loans in portfolio versus private label MBS were found to be amplified for loans with principal reduction.

There were also two significant but relatively weaker control interactions for which sensitivity tests were performed. Principal reduction appears to be somewhat more effective in reducing redefault for loans in certain states (Florida, Georgia, and Arizona), and somewhat less effective in reducing redefault for loans that were between 1 and 6 months delinquent at the time of modification. Including or excluding these controls does not significantly affect the other results.

IV. Null-1 Test Results

After testing the null-1 hypothesis in a number of different ways using a variety of controls and sub-populations, the results always indicate a strong rejection of the null-1 hypothesis – the model in which principal reduction does not influence post-modification performance is not supported.

If null-1 were a valid specification, then the estimated sensitivity to the before modification LTV[6], modeled here as a cubic polynomial fit, will not be significantly different between the HAMP modifications with and without principal reduction. Also in this case, borrowers would be found to behave as if they had received a standard HAMP modification with an equivalent payment reduction but with no principal reduction. This can be tested by first modeling the LTV response curve over the pooled population, and then using a likelihood ratio test to see if an unrestricted model, in which loans with principal reduction have a different LTV response curve, is preferred to the baseline.

[5] Under HAMP, proposed modification payments are varied to achieve a fixed post-modification target DTI ratio of 31%.
[6] Before modification LTV includes capitalization.

Table A4 shows the sequence of models that were analyzed in order to evaluate the null-1 hypothesis and the resulting likelihood ratio test results. Model (1a) is a "pure" null-1, in which there are no principal reduction associated effects at all. Model (1a) is then tested against three alternatives (1b-1d) where the effect of principal reduction is expressed as either a pure intercept shift (1b), a collection of shifts based on servicer and investor type (1c), or as a change in the LTV response curve (1d). Statistically, the null-1 hypothesis (represented by the restricted model (1a)) is strongly rejected in all three likelihood ratio tests against these alternatives (pr << 0.01).

Specifications (1e) and (1f) are combined alternatives: (1e) is a change in the LTV polynomial that includes a constant term (i.e., the principal reduction flag itself), and (1f) is equivalent to (1e) but also includes the servicer and investor interactions with the principal reduction flag. In all cases, likelihood ratio tests indicate rejection of the more restricted models, so that the most unrestricted model, (1f), is preferred to the others.

Null-1 was also tested under a number of other specifications, not shown here. The rejection of the null-1 hypothesis is always strong and is robust to many changes in specification - whether the principal reduction is expressed in terms of a linear or polynomial change in LTV, whether an intercept shift is included, and whether the principal reduction flag is interacted with other effects or not. Both when the test is performed on the whole HAMP population and subsets of specific servicers, the absence of a principal reduction effect on redefault, beyond the associated payment reduction, cannot be supported.

Table A5 shows a subset of the model parameter estimates for each of the six specifications (1a) through (1f). The coefficients on the interaction between principal reduction and the LTV cubic polynomial, seen in models (1d) through (1f), are always highly significant. The principal reduction flag itself is significant in all models except (1f). This indicates that borrower sensitivity to LTV after principal reduction does not look at all like it would if no principal reduction had occurred. Furthermore, the significance of the interacted coefficients shows that principal reduction has affected the shape of the LTV response curve.

Notice that the coefficients for the interacted LTV variables are generally nearly opposite to the corresponding pooled LTV variables, effectively cancelling them out. This means that the responsiveness of loans with principal reduction to the before-modification LTV is nearly a flat line. The question of whether this sensitivity is statistically different from zero can be evaluated using Wald tests of the form X-Y= 0, where X is one of the three pooled LTV coefficients, and Y is the corresponding interacted LTV coefficient. In each case, the Wald test fails to reject the restriction. In other words, borrower behavior does not seem to be affected by their LTV *prior* to the modification.

V. Null-2 Test Results

The null-2 hypothesis aligns with the assumptions underlying the present HAMP NPV default model. This model presumes that the borrower's sensitivity to negative equity (LTV) will be aligned with their new, post-principal reduction LTV ratio. Any forbearance that may be offered as part of the modification is *not* taken into account, since this would not affect the borrower's equity position if they paid off the loan. The borrower is also considered to be indifferent to their previous LTV history: someone who is reduced from 180% LTV to 115% is expected to behave similarly to someone whose LTV is reduced from 140% to 115%.

The tests for null-2 follow the same structure as for null-1, except that post-principal reduction LTV is used in the specification rather than pre-modification LTV. Note that these two LTV ratios will be identical for any loan that did not receive principal reduction as part of the modification. The structure of the alternative models (2a) through (2f) exactly parallels the specifications (1a) through (1f) from the null-1 tests, except for the change in the LTV variable. Table A6 shows a subset of the estimated parameters from a logitic regression on these models. As with the null-1 tests, the raw logit coefficients (betas) are shown rather than the marginal effects. Table A4 also shows the results of the likelihood ratio tests on pairs of these models.

Whereas the likelihood ratio tests led to the firm rejection of the null-1 hypothesis in all of its variations, represented by models (1a) through (1c), the results fail to reject one form of the null-2 hypothesis that is represented by model (2c). This model allows for a general change in redefault probabilities due to any kind of principal reduction being offered with the modification, as represented by a significant coefficient on the principal reduction flag itself. The model also allows for variation in the general effect of principal reduction depending on the servicer and on whether the loan is held in the servicer's portfolio or is part of an investor-owned security. This variation can be due to unobserved differences in loan characteristics between servicers and between their loans held in or out of portfolio. Selection effects may also occur due to servicers' implementation of the HAMP PRA program.

Model (2c) can be thought of as a variant on the null-2 hypothesis in that any change in the curvature of redefault sensitivity to after-modification LTV between borrowers who received principal reduction and those who did not is not allowed. In technical terms, the likelihood ratio test comparing models (2c) and (2f) evaluates whether pooling the model's cubic polynomial in LTV between borrowers who received principal reduction and those who did not is preferable to allowing those polynomials to differ between the populations. Results fail to reject the pooling restriction even at a 10% confidence interval.

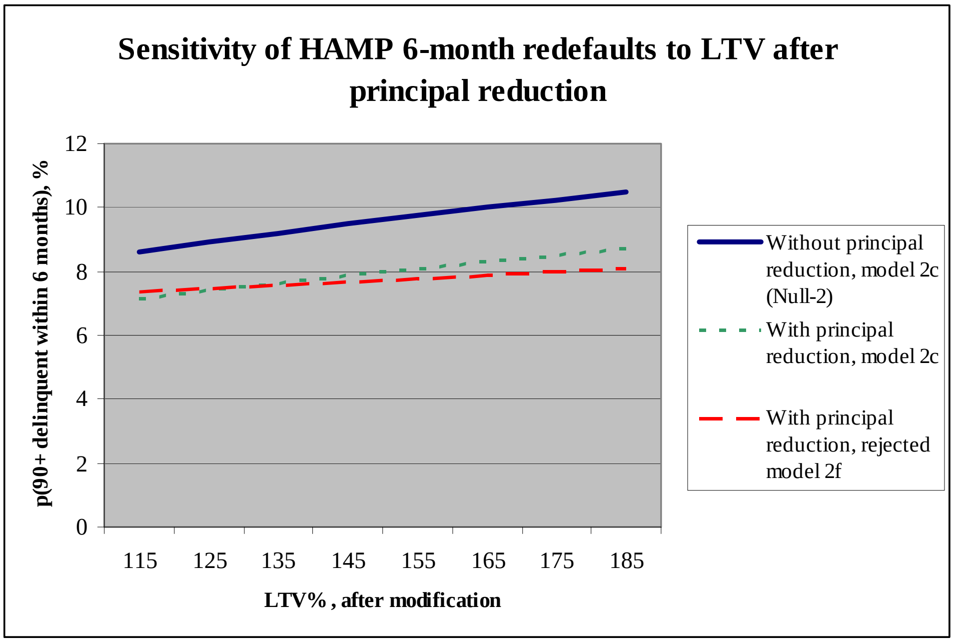
Model (2c) then becomes the preferred specification of the effect of principal reduction on redefault. It shows that borrowers whose LTV is reduced via principal reduction perform similarly to those borrowers with the same post-modification LTV who did not receive principal reduction. In fact, because of the significant negative coefficient on the principal reduction flag in this model, it can be concluded that, after controlling for post-modification LTV, borrowers who received a modification with principal reduction performed better than borrowers who received a modification without principal reduction.

There is some ambiguity in this result because the null-2 hypothesis is rejected in its simpler forms (models 2a and 2b) that do not include the controls for servicer and investor interactions. As a result, one cannot completely rule out the possibility that principal reduction also flattens the borrower's LTV response. The reason for this ambiguity becomes clearer when the predicted redefault rates for borrowers with different post-modification LTV ratios under the alternative models are graphed below (Figure 4).

The graph below shows the expected performance of a hypothetical group of borrowers who are identical in all their characteristics except for LTV. The topmost (solid) curve shows expected redefault rates when these borrowers do not receive any principal reduction according to model (2c). The next two curves show the expected redefault rates when these borrowers do receive principal reduction, according to models (2c) and (2f). The predicted redefault rates for LTVs between 115% and 135% under these two models are quite similar, but the model (2f) redefault rates are somewhat lower for borrowers with very high LTVs. This is because model (2f) allows for a change in the LTV response curve rather than just a downward shift.

Because most borrowers in the HAMP PRA program have their principal reduced to a level of 135% LTV or lower, the population at the highest LTV levels is fairly thin, and redefault predictions at this level are more ambiguous. It is possible that additional data points could support an LTV response curve that is closer to that of model (2f).

Figure 4. LTV redefault sensitivity, with and without principal reduction.



Given the current set of models evaluated, model (2c) represents the preferred specification. One way in which the model can be interpreted is to consider the effect of principal reduction on a particular loan as being composed of three parts:

(1) The effect (on ability to pay) solely due to the payment reduction when principal is reduced;

(2) The effect (on willingness to pay) due to the reduction in LTV itself, so that the redefault response moves down the response curve (solid line in the above graph);

(3) An additional effect associated with any amount of principal reduction whatsoever (shift from solid line to green dotted in the above graph). This effect is associated with the model's principal reduction flag coefficient.

Of these three effects, the third effect (an intercept shift of about -0.2) is the most difficult to interpret. Effect (1) is already well known and has been documented in prior studies of the HAMP program. Effect (2) is established by the rejection of null-1 and the failure to reject null-2. However, the possibility that effect (3) could be due at least in part to a selection effect into HAMP PRA, as opposed to a standard HAMP modification without principal reduction that is common to all servicers, cannot be ruled out. Because the model controlled for a number of loan and borrower characteristics, such a selection effect would have to be due to unobserved characteristics associated with selection into HAMP PRA. It is not desirable to include this selection effect in evaluating the effectiveness of principal reduction, because it does not reflect how principal reduction will change the performance of a given borrower.

It is also possible that some of effect (3) is in fact a program treatment effect that does not stem from a purely rational economic calculation on the part of borrowers, but is instead some kind of psychological, reciprocity based response to principal reduction, such as those described in the behavioral economics literature. Because the evaluation is only focused on borrower behavior at six months following modification, it is possible that such a response may diminish over time.

Another possibility is that the performance of borrowers receiving principal reduction, as shown in effect (3) and also in the alternate model (2f), is partly due to a borrower selection effect. Perhaps a number of high LTV borrowers may have decided to strategically redefault and did not respond to the HAMP PRA modification offer, leaving those borrowers who have shown a willingness to continue making payments at high LTV levels (at least for a brief time prior to becoming delinquent), as the ones who participate in HAMP PRA. In this case, even though a selection process is involved, effect (3) would still be considered a valid program treatment effect, because it accurately predicts how a given high LTV HAMP borrower will perform under principal reduction.

Because of the difficulty in interpreting the source of effect (3), the analysis makes an adjustment – it halves the principal-principal reduction coefficient. With this adjustment, the analysis compares the relative contribution of effects (1) through (3) to the expected performance of a given borrower.

Take a hypothetical set of borrowers with similar characteristics and vary the levels of *pre*-modification LTV. One can imagine that these borrowers have DTI levels such that under the HAMP PRA guidelines they all receive principal reduction exactly down to 115% LTV, and this reduction also brings their DTI down to the target of 31%, so that no additional waterfall steps, such as rate and term changes or forbearance, are performed. Table 2 shows the absolute value of logit score reductions associated with each of the component effects of a HAMP PRA modification. Higher logit score figures indicate greater reductions in redefault.

Table 2. Breakdown of principal reduction effects into components. *(Note: column sums may not be exact due to rounding.)*

Reduction in LTV percentage points (to 115)	% payment change due to LTV reduction	Effect (reduction in logit score) due to payment change (1)	Effect due to reduction in LTV (2)	Additional effect of principal reduction (3)	Total effect of principal reduction (1+2+3)	% payment change needed for equivalent total effect
10	8	0.22	0.04	0.1	0.36	13
20	15	0.41	0.07	0.1	0.59	21
30	21	0.58	0.11	0.1	0.78	28
40	26	0.72	0.14	0.1	0.96	34
50	30	0.84	0.17	0.1	1.11	40
60	34	0.95	0.19	0.1	1.25	45
70	38	1.05	0.22	0.1	1.37	49
80	41	1.14	0.24	0.1	1.48	53
90	44	1.22	0.26	0.1	1.58	57

For example, if a loan is reduced from LTV 165% to LTV 115%, this will also represent about a 30% payment reduction (ignoring other modification effects). The logit score reduction associated with this change in payment (that is, with effect 1 above) is 0.84, while the score associated with the reduction in the borrower's LTV (effect 2) is 0.17, or about one-fifth of the strength of the payment change effect. With the reduction of effect (3), expressed as a logit score, from 0.20 to 0.10, one can expect that the total logit score reduction for this amount of principal reduction is 1.11. The actual reduction in redefault probability will depend on the other characteristics of the loan.

The principal reduction effects can be calibrated to compare non-principal reducing modifications under standard HAMP in which the borrower's payments are reduced but their LTV remains the same. To achieve the same reduction in redefault for a borrower at 165% LTV, using interest rate reduction or term extension, the monthly payment must be reduced by 40% rather than 30%.

VI. Comparison to Forbearance

As an additional experiment, analysis was performed to measure the comparable redefault effect stemming from principal forbearance, above and beyond the associated payment change. When using simple category variables for forbearance ranges, data showed no significant effect except for forbearance in excess of 40% of UPB. Analysis was performed to estimate a cubic polynomial with forbearance measured in terms of LTV points so that forbearance and principal reduction effects could be assessed head-to-head and in relation to payment change. The resulting effects, as shown in Table 3, are fairly small but convex. Large forbearance amounts will have a better than linear impact on redefault.

For example, a forbearance of 30% of principal balance when the LTV is 165% can be translated into an equivalent LTV change of 50 percentage points. The resulting logit score attributable to the forbearance, above and beyond the 30% payment reduction, is 0.04, which is at least five times smaller in magnitude than the effects seen for principal reduction. For comparison, Table 3 also shows the magnitude of the payment change effect at each level of LTV reduction, which is equivalent to effect (1) shown in Table 2, and of the principal reduction effects, which are equivalent to the sum of effects (2) and (3) in that table.

Table 3. Comparison of principal reduction and forbearance effects (logit scores).

Reduction in LTV percentage points due to principal reduction or forbearance	Reduction in logit score due to payment reduction	Reduction in logit score due to principal forbearance	Reduction in logit score due to principal reduction
10	0.22	0.00	0.14
20	0.41	0.01	0.18
30	0.58	0.01	0.21
40	0.72	0.02	0.24
50	0.84	0.04	0.27
60	0.95	0.05	0.29
70	1.05	0.07	0.32
80	1.14	0.09	0.34
90	1.22	0.11	0.36
100	1.30	0.13	0.38

Another way to compare relative impacts of different modifications is to calculate the estimated redefault probability for a typical loan – a loan with a 5% redefault rate if it received a 30% payment reduction without any principal reduction or forbearance. This translates into a 10% redefault rate under a baseline payment reduction of zero.

Table 4 shows the predicted redefault probabilities for both forbearance and principal reduction, as well as the redefault rate that would occur if borrower payments were reduced by an equivalent amount without principal reduction or forbearance. This baseline redefault rate can also be thought of as the common effect of both principal reduction and forbearance attributable to payment reduction. The information in this table is also represented as figure 2.

Table 4. Predicted redefault probabilities, principal reduction vs forbearance.

Reduction in LTV percentage points due to principal reduction or forbearance	Redefault probability, common effect due to payment change	Redefault probability under principal forbearance	Redefault probability under principal reduction
10	8.2%	8.2%	7.2%
20	6.9%	6.8%	5.8%
30	5.9%	5.8%	4.8%
40	5.1%	5.0%	4.1%
50	4.6%	4.4%	3.5%
60	4.1%	3.9%	3.1%
70	3.7%	3.5%	2.7%
80	3.4%	3.1%	2.5%
90	3.2%	2.9%	2.2%
100	3.0%	2.6%	2.0%

Data shows that while principal forbearance does have an effect on borrower performance beyond that of its associated payment reduction, an equivalent amount of principal reduction has a larger effect in reducing the redefault rate.

VII. Sensitivity Tests

a. Data Imputation

In order to calculate our dependent variable, the 90 day delinquency (redefault) condition at 6 months from modification, the analysis includes some basic imputations in the case where the servicer's report on borrower performance (known as the Official Monthly Report (OMR), that serves as the monthly servicer submission of borrower payment activity on a permanent modification) at month 6 was missing. This was true for 49K loans, out of our total population of 621K. If all of these loans were simply filtered out, the redefault rate would have been overestimated, as shown on line 5 of Table A2. In imputation step 1 (shown on line 3 of Table A2), any disqualified loan with a servicer OMR arriving after month 6 (indicating that the borrower's most recent payment (LPI date) was at month 3 or earlier) was marked as 'redefaulted'. In step 2, any loans for which no OMRs at all had been received after month 6, were excluded from the population (see line 4). There were only 79 loans of this type, where the redefault status was truly unknown. Conversely, if any report on the loan had arrived after month 6, showing that the borrower had not defaulted, or had defaulted but was seen to be less than 90 days delinquent as of month 6, we could safely impute a 'non redefault' status for that loan.

The line 3 and line 4 populations, which are very similar, therefore represent the boundaries of what we can safely impute about the state of the modified loan after six months. The line 4 population, which simply excludes the 79 loans with unknown status, may slightly overestimate the rate of redefault, while the line 3 population will slightly underestimate it. We used the line 3 population for most of our estimates, and also re-ran some regressions using the line 4 population, and found no significant difference in outcomes.

b. Servicer Effects

Principal reduction within HAMP can be thought of as a cluster of similar experiments being conducted by the various participating servicers over the same time period. Each servicer may use different selection criteria for deciding when a given borrower will receive a HAMP PRA modification or a standard HAMP modification. They may restrict the population receiving principal reduction to certain portions of their book of business, such as loans acquired under a merger, or loans with specific product types or other characteristics. They may also apply different rules for the maximum amount of principal reduction a given loan may receive. In order to better examine the influence of these servicer-specific effects, the null-1 and null-2 hypothesis tests were re-run against three subpopulations of loans: the loans modified by Servicers A and B (as discussed in section III), and the loans modified by all other servicers.

The null-1 test results for these three groups of loans were all very similar to the outcomes described in Section IV. However, there were some differences in the null-2 test results. For the Servicer A and remainder populations, the outcome was the same as described in Section V: the tests failed to reject the null-2 hypothesis, and Model 2c was the preferred specification. However, for Servicer B, the tests did reject null-2, and instead Model 2f became the preferred specification. As shown in Figure 2 of Section V, the main difference between these models is that, under Model 2f, there is a slight additional reduction in redefault rate for loans with very high LTV (over 150%).

c. Program Effects

The next set of sensitivity tests compared modifications under the HAMP PRA program with standard HAMP modifications that also reduced principal balances. Table A3 shows how the volume of HAMP modifications with principal reduction has evolved over time. Before the introduction of HAMP PRA, some servicers were already offering principal reduction on standard HAMP modifications, with the largest volumes being reached in late 2010. After the launch of the HAMP PRA program (where Treasury provides incentives for principal reduction), the volume of HAMP loans with principal reduction shifted from standard HAMP into HAMP PRA.

The null-1 and null-2 tests were run against these subpopulations of HAMP PRA and standard HAMP modifications. The outcomes were similar to those for the entire population. In each case, the null-1 hypothesis was rejected, and the null-2 (Model 2c) was not rejected. Additionally, the intercept shift effect in Model (2c) that is associated with principal reduction was larger for the HAMP PRA modifications. That is, the presence of the HAMP PRA program incentives seems to have resulted in an overall lower redefault rate. However, because there is essentially no program treatment difference between HAMP PRA and standard HAMP principal reduction, this difference in the intercept shift can be attributed to program or servicer selection effects.

d. Others

Follow-up tests were also performed in response to inter-agency reviewer comments. An updated snapshot of the loan population was obtained (data as of February 29, 2012) that allowed the behavior of borrowers in the sample population to be tracked over a longer time period. The null-1 and null-2 tests were then re-run, using a 90 day borrower delinquency within nine months after modification (rather than just six months), as the dependent variable. The test results once again rejected the null-1 hypothesis while failing to reject null-2.

All of the test results support the approach used in the HAMP NPV model, to use the borrower's post modification LTV to estimate expected redefault rates. However, one should not expect the NPV model coefficients to be directly comparable to those in the test runs, because of the significant differences between the model specifications.

VIII. Conclusion

The logistic regression analysis presented in this paper is intended to isolate and measure the effects of principal reduction on a given loan that receives a HAMP modification. This is necessary because participating HAMP servicers have selected loans with riskier credit characteristics to receive the principal reduction feature under HAMP PRA – loans that are more seriously delinquent at modification and loans with lower overall credit scores than all HAMP modifications. The analysis shows that for loans with similar characteristics, there is a small but measurable reduction in redefaults when the HAMP modification includes principal reduction.

Principal reduction under HAMP is shown to influence borrower redefaults through multiple channels. The strongest effect is associated with the reduction in the borrower's monthly mortgage payment. But there is also an additional reduction in redefaults, separate from the payment reduction effect, that stems from the reduction of the borrower's negative equity, or equivalently, their LTV ratio.

A final effect of HAMP principal reductions is not related to the magnitude of the reduction in the borrower's LTV or in their payments, and may be, at least in part, an artifact of program selection biases. We have therefore discounted for this effect in our examples.

The pattern of borrower behavior seen in this analysis confirms the expectations that underlie the HAMP NPV model used to evaluate borrower eligibility for a modification. The NPV model calculates its estimate of the expected risk of eventual borrower redefault after a modification, based in part on the reduction in the borrower's payments (affecting ability to pay), and, in part, on what their LTV ratio will be after the modification (affecting willingness to pay).[7] The borrower's LTV ratio before the modification does not enter into the NPV model specification.

All of these NPV model assumptions are consistent with the results of this paper. In the case where a borrower receives principal reduction under HAMP, their redefault risk is related, in part, to their post-modification LTV ratio, but not to their pre-modification LTV ratio. This implies that the use of post-modification LTV within the NPV model is appropriate.

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[7] One important area for future research is to understand how borrowers are selected, either by servicer outreach or by their own initiative, into a loan modification program offering principal reduction, in comparison to a program without such an option. On the one hand, some borrowers who are considering strategic default (those who are wavering in their willingness to continue making mortgage payments despite the ability to do so) may opt into and comply with a HAMP PRA modification, who otherwise would have not cooperated with another type of modification and may have eventually defaulted. But the moral hazard issue must also be considered where some borrowers who are current and have no intention of strategic default will feign a hardship condition and become delinquent in order to receive principal reduction. The first group of borrowers may enhance the benefits of a principal reduction program, while the second group (which is referred to as "strategic modifiers") may dilute or even nullify those benefits.

Data Appendix

Table A1. Filters applied to the HAMP loan population.

Starting population is all ever-permanent first lien HAMP modifications through Jan 2012 (951,320 loans before filtering).

Filter	Count	Percent	Cumulative Count	Cumulative %
Modification is less than 6 months old	121,061	36.61%	121,061	36.6%
Paid Off by Month 6	696	0.21%	121,757	36.8%
Delinquency Data Missing - Trial Start Before 12/1/2009	50,672	15.33%	172,429	52.2%
Delinquency Data Missing - Trial Start On or After 12/1/2009	54,126	16.37%	226,555	68.5%
Delinquency Data Missing - Wrong Model Type Code	25,592	7.74%	252,147	76.3%
Origination LTV Data Missing	2,307	0.70%	254,454	77.0%
Months Dlq at NPV > 40 or < 0	778	0.24%	255,232	77.2%
After Mod LTV Missing	10	0.00%	255,242	77.2%
After Mod UPB > 1,000,000 or <= 0	33	0.01%	255,275	77.2%
After Mod LTV > 1,000 or <= 0	591	0.18%	255,866	77.4%
Before Mod FE DTI Missing	7	0.00%	255,873	77.4%
Before Mod FE DTI > 200 or < 31	21,844	6.61%	277,717	84.0%
Home Price Forecast Data Missing	1,451	0.44%	279,168	84.4%
Credit Score Missing (Current)	51,151	15.47%	330,319	99.9%
Credit Score > 850 or < 300	105	0.03%	330,424	99.9%
GSE Loans with Principal Reduction[8]	223	0.07%	330,647	100.0%

[8] As of June 2012, the GSEs were not participating in principal reduction under HAMP. To date, there have been approximately 200 GSE loans modified under a pilot principal reduction program conducted by Fannie Mae.

Table A2. Raw redefault rates on HAMP loan populations.

	All Modifications			Mods w/ Principal Reduction (all)			Mods w/ Principal Reduction under HAMP PRA			Mods w/ Principal Reduction, non PRA		
		90+			90+			90+			90+	
	Total	Count	%	Total	Count	%	Total	Count	%	Total	Count	%
[1] No Filters, but excluding Missing OMRs	747,991	43,668	5.84%	39,307	2,062	5.25%	21,249	1,394	6.56%	18,058	668	3.70%
[2] Filtered, including missing OMRs	620,673	32,903	5.30%	37,861	1,664	4.40%	19,776	1,078	5.45%	18,085	586	3.24%
[3] Filtered, including Missing OMRs, w/imputed logic [final population]	620,673	35,330	5.69%	37,861	1,816	4.80%	19,776	1,213	6.13%	18,085	603	3.33%
[4] Filtered, including Missing OMRs. w/imputed logic 2	620,594	35,330	5.69%	37,838	1,816	4.80%	19,753	1,213	6.14%	18,085	603	3.33%
[5] Filtered, excluding Missing OMRs	571,760	32,903	5.75%	35,189	1,664	4.73%	17,523	1,078	6.15%	17,666	586	3.32%

Table A3. Differences between HAMP PRA and standard HAMP with principal reduction – timelines.

	Type of Principal reduction				All	
	a.HAMP PRA Principal reduction		b.Non-PRA Principal reduction			
	N	RowPctN	N	RowPctN	N	ColPctN
Mod Effective Date						
2009Q4			9	100	9	0.02
2010Q1			214	100	214	0.57
2010Q2			1,943	100	1,943	5.13
2010Q3			5,796	100	5,796	15.31
2010Q4	199	4.07	4,689	95.93	4,888	12.91
2011Q1	3,146	53.81	2,700	46.19	5,846	15.44
2011Q2	8,021	76.10	2519	23.90	10,540	27.84
2011Q3	8,410	97.51	215	2.49	8,625	22.78
All	19,776	52.23	18,085	47.77	37,861	100

Table A4. Likelihood Ratio Tests of Null-1 and Null-2 Hypotheses.

Null-1 Tests

	A: Null-1 Baseline	B: Add Principal Reduction Intercept Shift	C: Add Principal Reduction Servicer, Investor Interactions	D: Add Principal Reduction LTV Curve Change	E: Add Principal Reduction Shift & Curve Change	F: Add Principal Reduction Servicer, Investor Interactions & Curve Change
Log Likelihood	-122,823.66	-122,755.33	-122,728.05	-122,737.83	-122,731.35	-122,705.78
Parameter df	67	68	71	70	71	74

LR Test	**A to B**	**B to C**	**D to E**	**E to F**	**A to D**	**B to E**	**C to F**
Chi Square	136.65	54.55	12.96	51.15	171.65	47.96	44.55
pr	< 0.0001	< 0.0001	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Null-2 Tests

	A: Null-2 Baseline	B: Add Principal Reduction Intercept Shift	C: Add Principal Reduction Servicer, Investor Interactions	D: Add Principal Reduction LTV Curve Change	E: Add Principal Reduction Shift & Curve Change	F: Add Principal Reduction Servicer, Investor Interactions & Curve Change
Log Likelihood	-122772.49	-122740.95	-122707.88	-122735.97	-122732.70	-122704.84
Parameter df	67	68	71	70	71	74

LR Test	**A to B**	**B to C**	**D to E**	**E to F**	**A to D**	**B to E**	**C to F**
Chi Square	63.09	66.13	6.54	55.73	73.04	16.49	6.09
pr	< 0.0001	< 0.0001	0.0105	< 0.0001	< 0.0001	0.0009	**0.1072**

Note: In all tests, dependent variable is 90+ delinquency within six months of trial period start.

Additional controls used for all tests, and not shown in tables A5 & A6: loan modification effective date (year & quarter); 12 month home price forecast at mod (< 100; 100-102.5; 102.5-105; >105; age at mod (0-50 mos; 50-75 mos; 75+); property units (1, 2, 3-4); UPB before principal reduction (< 150k, 150-200k, 200-300k, 300k+); delinquency at modification (< 1m, 1-6m, 6-12m, 12-24m, 24m+); trial month length (<=3, >3); property state = (AZ, CA, FL, GA, IL, MA, MD, MI, NJ, NV, NY, TX, other); servicer = (7 other specific servicers).

Table A5. Null-1 hypothesis and alternatives, parameter estimates (models 1A-1F).

Logit Model Parameters	1A: Null-1 Baseline		1B: Add Principal Reduction Intercept Shift		1C: Add Principal Reduction Servicer, Investor interactions		1D: Add Principal Reduction LTV Curve Change		1E: Add Principal Reduction Shift & Curve Change		1F: Add Principal Reduction Servicer & Investor interactions & Curve Change	
	est β	stderr	est β	stderr	est β	stderr	est β	stderr	est β	stderr	est β	stderr
Intercept	-4.1231	(.0816)****	-4.0238	(.0819)****	-4.0575	(.0821)****	-4.1187	(.0845)****	-4.1615	(.0853)****	-4.1930	(.0855)****
Principal Reduction Flag			-.3292	(.0288)****	-.3012	(.0894)***			.5524	(.1584)***	.5258	(.1796)***
LTV Before PR	.5281	(.0367)****	.5538	(.0367)****	.5531	(.0367)****	.6935	(.0480)****	.7362	(.0494)****	.7334	(.0494)****
[LTV Before PR]^2	-.0973	(.0097)****	-.1024	(.0097)****	-.1020	(.0098)****	-.1526	(.0152)****	-.1652	(.0155)****	-.1646	(.0155)****
[LTV Before PR]^3	.0050	(.0007)****	.0053	(.0007)****	.0052	(.0007)****	.0099	(.0013)****	.0109	(.0013)****	.0109	(.0013)****
[LTV Before PR] & PR Flag							-.3661	(.0388)****	-.8593	(.1508)****	-.8157	(.1515)****
[LTV Before PR]^2 & PR Flag							.1031	(.0172)****	.2140	(.0388)****	.2040	(.0386)****
[LTV Before PR]^3 & PR Flag							-.0079	(.0015)****	-.0142	(.0027)****	-.0137	(.0026)****
GSE	.0950	(.0182)****	.0593	(.0183)***	.0435	(.0186)**	.0603	(.0183)***	.0651	(.0184)***	.0472	(.0186)**
Private MBS	.2594	(.0192)****	.2419	(.0192)****	.2231	(.0198)****	.2422	(.0192)****	.2450	(.0192)****	.2233	(.0198)****
Portfolio												
Private MBS & PR Flag					.2651	(.0904)***					.2653	(.0909)***
Portfolio & PR Flag												
Servicer A	.7817	(.0244)****	.8361	(.0249)****	.8596	(.0254)****	.8393	(.0248)****	.8348	(.0249)****	.8616	(.0254)****
Servicer B	.2251	(.0207)****	.2378	(.0208)****	.2506	(.0210)****	.2399	(.0208)****	.2417	(.0208)****	.2512	(.0210)****
Servicer C	-.0333	(.0220)	-.0392	(.0220)*	-.0408	(.0220)*	-.0383	(.0220)*	-.0382	(.0220)*	-.0396	(.0220)*
Servicer D	.4870	(.0283)****	.5206	(.0284)****	.4823	(.0289)****	.5205	(.0284)****	.5163	(.0284)****	.4794	(.0290)****
Servicer A & PR Flag					-.1762	(.0917)*					-.1869	(.0922)**
Servicer B & PR Flag					-.4223	(.0710)****					-.3670	(.0722)****
<= 10% Pmt Chg	1.8291	(.0282)****	1.8173	(.0282)****	1.8112	(.0282)****	1.8150	(.0282)****	1.8136	(.0282)****	1.8076	(.0282)****
10 - 20% Pmt Chg	1.5900	(.0268)****	1.5788	(.0269)****	1.5737	(.0269)****	1.5766	(.0269)****	1.5750	(.0269)****	1.5700	(.0269)****
20 - 30% Pmt Chg	1.3117	(.0266)****	1.3027	(.0266)****	1.2995	(.0266)****	1.3004	(.0266)****	1.2988	(.0266)****	1.2956	(.0266)****
30 - 40% Pmt Chg	1.0240	(.0268)****	1.0143	(.0268)****	1.0117	(.0268)****	1.0117	(.0268)****	1.0099	(.0268)****	1.0074	(.0268)****
40 - 50% Pmt Chg	.7204	(.0274)****	.7118	(.0275)****	.7099	(.0275)****	.7091	(.0275)****	.7072	(.0275)****	.7055	(.0275)****
50 - 60% Pmt Chg	.4234	(.0293)****	.4171	(.0293)****	.4164	(.0293)****	.4148	(.0293)****	.4129	(.0293)****	.4122	(.0293)****
<= 540 Credit Score at Mod	1.1357	(.0292)****	1.1294	(.0292)****	1.1286	(.0292)****	1.1300	(.0292)****	1.1308	(.0292)****	1.1294	(.0292)****
Credit Score 540 – 600	.7684	(.0300)****	.7633	(.0300)****	.7632	(.0300)****	.7638	(.0300)****	.7643	(.0300)****	.7639	(.0300)****
Credit Score 500 – 675	.3981	(.0318)****	.3950	(.0318)****	.3957	(.0318)****	.3951	(.0318)****	.3952	(.0318)****	.3958	(.0318)****
Credit Score > 675												
Orig LTV <= 60	-.5656	(.0525)****	-.5814	(.0526)****	-.5403	(.0529)****	-.5681	(.0526)****	-.5585	(.0527)****	-.5174	(.0530)****
Orig LTV 60-70	-.4435	(.0490)****	-.4538	(.0490)****	-.4174	(.0493)****	-.4455	(.0490)****	-.4381	(.0490)****	-.4014	(.0493)****
Orig LTV 70-79.5	-.3928	(.0467)****	-.4036	(.0467)****	-.3671	(.0470)****	-.3974	(.0467)****	-.3908	(.0468)****	-.3539	(.0471)****
Orig LTV 80	-.3776	(.0464)****	-.3904	(.0465)****	-.3550	(.0467)****	-.3852	(.0465)****	-.3789	(.0465)****	-.3432	(.0468)****
Orig LTV 80.5-90	-.2446	(.0464)****	-.2611	(.0465)****	-.2283	(.0467)****	-.2571	(.0465)****	-.2510	(.0465)****	-.2186	(.0468)****
Orig LTV 90-100	-.0894	(.0464)*	-.1075	(.0464)**	-.0742	(.0467)	-.1060	(.0464)**	-.1008	(.0464)**	-.0677	(.0467)
Orig LTV > 100												

** = p < 0.10, ** = p < 0.05, *** = p < 0.01, **** = p < 0.0001. LTV variables are normalized to LTV 100 = 1, LTV 200 = 2. See Table A4 notes for additional controls, not shown.*

Table A6. Null-2 hypothesis and alternatives, parameter estimates (models 2A-2F).

	2A: Null-2 Baseline		2B: Add Principal Reduction Intercept Shift		2C: Add Principal Reduction Servicer, Investor interactions		2D: Add Principal Reduction LTV Curve Change		2E: Add Principal Reduction Shift & Curve Change		2F: Add Principal Reduction Servicer & Investor interactions & Curve Change	
Logit Model Parameters	est β	stderr	est β	stderr	est β	stderr	est β	stderr	est β	stderr	est β	stderr
Intercept	-4.2252	(.0838)****	-4.1202	(.0848)****	-4.1672	(.0850)****	-4.1319	(.0846)****	-4.1589	(.0853)****	-4.1895	(.0855)****
Principal Reduction Flag			-.2257	(.0289)****	-.2043	(.0895)**			.5542	(.2228)**	.2797	(.2381)
LTV After PR	.7266	(.0486)****	.7047	(.0487)****	.7157	(.0487)****	.7138	(.0487)****	.7354	(.0494)****	.7343	(.0494)****
[LTV After PR]^2	-.1611	(.0153)****	-.1573	(.0153)****	-.1600	(.0153)****	-.1586	(.0153)****	-.1650	(.0155)****	-.1647	(.0155)****
[LTV After PR]^3	.0106	(.0013)****	.0104	(.0013)****	.0105	(.0013)****	.0104	(.0013)****	.0109	(.0013)****	.0109	(.0013)****
[LTV After PR] & PR Flag							-.2168	(.0549)****	-.8959	(.2838)***	-.5575	(.2791)**
[LTV After PR]^2 & PR Flag							.0355	(.0340)	.2511	(.0984)**	.1570	(.0945)*
[LTV After PR]^3 & PR Flag							-.0014	(.0039)	-.0191	(.0093)**	-.0121	(.0086)
GSE	.0918	(.0181)****	.0647	(.0183)***	.0462	(.0186)**	.0642	(.0183)***	.0656	(.0184)***	.0472	(.0186)**
Private MBS	.2577	(.0192)****	.2463	(.0192)****	.2230	(.0198)****	.2455	(.0192)****	.2457	(.0192)****	.2231	(.0198)****
Portfolio												
Private MBS & PR Flag					.3042	(.0906)***					.2842	(.0912)***
Portfolio & PR Flag												
Servicer A	.7959	(.0244)****	.8330	(.0249)****	.8613	(.0254)****	.8350	(.0249)****	.8341	(.0249)****	.8616	(.0254)****
Servicer B	.2308	(.0207)****	.2385	(.0208)****	.2509	(.0210)****	.2403	(.0208)****	.2416	(.0208)****	.2512	(.0210)****
Servicer C	-.0348	(.0220)	-.0385	(.0220)*	-.0403	(.0220)*	-.0386	(.0220)*	-.0382	(.0220)*	-.0398	(.0220)*
Servicer D	.5017	(.0282)****	.5246	(.0284)****	.4829	(.0289)****	.5222	(.0284)****	.5172	(.0284)****	.4806	(.0290)****
Servicer A & PR Flag					-.1999	(.0918)**					-.1953	(.0921)**
Servicer B & PR Flag					-.4386	(.0711)****					-.3960	(.0731)****
<= 10% Pmt Chg	1.8229	(.0281)****	1.8125	(.0282)****	1.8054	(.0282)****	1.8122	(.0282)****	1.8124	(.0282)****	1.8062	(.0282)****
10 - 20% Pmt Chg	1.5848	(.0268)****	1.5749	(.0268)****	1.5690	(.0268)****	1.5743	(.0268)****	1.5742	(.0268)****	1.5691	(.0268)****
20 - 30% Pmt Chg	1.3073	(.0265)****	1.2991	(.0266)****	1.2952	(.0266)****	1.2983	(.0266)****	1.2980	(.0266)****	1.2950	(.0266)****
30 - 40% Pmt Chg	1.0192	(.0268)****	1.0108	(.0268)****	1.0077	(.0268)****	1.0098	(.0268)****	1.0093	(.0268)****	1.0072	(.0268)****
40 - 50% Pmt Chg	.7159	(.0274)****	.7084	(.0275)****	.7061	(.0275)****	.7073	(.0275)****	.7066	(.0275)****	.7054	(.0275)****
50 - 60% Pmt Chg	.4195	(.0292)****	.4140	(.0293)****	.4130	(.0293)****	.4130	(.0293)****	.4122	(.0293)****	.4121	(.0293)****
<= 540 Credit Score at Mod	1.1342	(.0292)****	1.1307	(.0292)****	1.1292	(.0292)****	1.1306	(.0292)****	1.1309	(.0292)****	1.1293	(.0292)****
Credit Score 540 - 600	.7669	(.0300)****	.7642	(.0300)****	.7638	(.0300)****	.7640	(.0300)****	.7643	(.0300)****	.7638	(.0300)****
Credit Score 500 - 675	.3968	(.0318)****	.3953	(.0318)****	.3959	(.0318)****	.3951	(.0318)****	.3952	(.0318)****	.3958	(.0318)****
Credit Score > 675												
Orig LTV <= 60	-.5548	(.0525)****	-.5738	(.0526)****	-.5261	(.0529)****	-.5678	(.0526)****	-.5589	(.0527)****	-.5187	(.0530)****
Orig LTV 60-70	-.4395	(.0489)****	-.4515	(.0490)****	-.4097	(.0493)****	-.4459	(.0490)****	-.4382	(.0491)****	-.4030	(.0494)****
Orig LTV 70-79.5	-.3938	(.0467)****	-.4036	(.0467)****	-.3622	(.0470)****	-.3982	(.0467)****	-.3909	(.0468)****	-.3559	(.0471)****
Orig LTV 80	-.3813	(.0464)****	-.3911	(.0465)****	-.3513	(.0467)****	-.3861	(.0465)****	-.3790	(.0466)****	-.3452	(.0468)****
Orig LTV 80.5-90	-.2520	(.0465)****	-.2622	(.0465)****	-.2262	(.0467)****	-.2576	(.0465)****	-.2509	(.0466)****	-.2207	(.0468)****
Orig LTV 90-100	-.1008	(.0464)**	-.1111	(.0464)**	-.0747	(.0467)	-.1069	(.0464)**	-.1006	(.0465)**	-.0697	(.0467)
Orig LTV > 100												

** = p < 0.10, ** = p < 0.05, *** = p < 0.01, **** = p < 0.0001. LTV variables are normalized to LTV 100 = 1, LTV 200 = 2. See Table A4 notes for additional controls, not shown.*