Treatment Effects of Subprime Mortgage Modifications Under the Home Affordable Modification Program

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Abstract

The Home Affordable Modification Program (HAMP) was initiated in 2009 to encourage loan servicers to provide substantial payment relief to borrowers struggling to pay their home mortgages, and thereby help to reduce the high volume of defaults and foreclosures resulting from the subprime crisis and Great Recession. Evaluating the true net impact of HAMP is complicated by the likelihood of substantial selection effects: the population of delinquent borrowers who were able to provide hardship documentation and meet other requirements of the program could have differed from those who received non-HAMP modifications or whose loans were never modified. A selection bias correction model is constructed to measure the treatment effects of HAMP modifications made in 2010 and 2011, in comparison to two control groups of delinquent subprime loans: those that were never modified, and those receiving lenders' proprietary modifications outside of HAMP. Selection effects were found to account for up to one third of observed modification performance, because the higher-risk borrowers did not meet program requirements or never responded to lender contact efforts. In the first year of HAMP's implementation, modification performance slightly lagged that of non-HAMP modifications with the same levels of payment reduction. Following program changes in mid-2010, however, HAMP modifications had larger treatment effects than non-HAMPs even when controlling for borrower and loan characteristics, selection effects, and the modification terms. High early redefault rates observed for both HAMP and non-HAMP modifications were found to be driven by the behavior of homeowners who had accepted a modification after a delinquency period of one year or more; these borrowers tended to stop making payments within just two years of modification. This implies that longer-term modification redefault rates should stabilize, given that the impact of payment reduction on borrower performance does not appear to decay over time.

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I. INTRODUCTION

Since the inception of the Making Home Affordable Program (MHA), more than 1.3 million borrowers have had their first lien mortgages permanently modified through MHA's Home Affordable Modification Program (HAMP). This paper analyzes the performance of HAMP modifications and the key factors that most affect their performance. All data on the HAMP program used in this analysis was obtained from the MHA Program system of record.

In the first part of this paper, single-variable analysis and program-to-date data for all HAMP modifications are used to identify correlations between various HAMP modification characteristics and modification performance. In the second half, econometric analysis (regression testing) is used to isolate the key factors affecting HAMP modification performance and to compare the performance of loans modified through HAMP with other similarly delinquent loans. The innovation in this study comes from the merging of HAMP program data with a commercial loan performance database, which allows HAMP-modified loans to be compared directly with two alternate control groups consisting of loans that were modified outside of HAMP and loans that were similarly delinquent but never received a modification. Using these control groups, the average treatment effect of the modifications can be measured, independent of the underlying differences between the modified and unmodified loan populations. The HAMP loans and the two control groups were restricted to loans that are part of private label mortgage-backed securities (PLS).

Characteristics and Structure of HAMP Loan Modifications

In early 2009, the U.S. Department of the Treasury (Treasury) and the Department of Housing and Urban Development (HUD) launched MHA. MHA's first lien modification program, HAMP, combines financial incentives and a standardized modification structure to encourage borrowers, servicers, and investors to participate in the first nationwide mortgage modification program.[2]

Prior to MHA, there were other efforts within government and the mortgage industry to develop more effective foreclosure prevention options for borrowers. Such efforts, however, often consisted of re-capitalization of missed interest payments and recalculation of the borrower's monthly principal and interest payments based on the new, higher mortgage loan balance. Thus, most modifications prior to HAMP either raised the borrower's monthly mortgage payment or, at best, kept it flat. Modifications completed in 2007 and 2008 experienced high redefault rates in the early months following the modification. (OCC 2009a)

As the mortgage crisis worsened throughout 2008, the movement towards modifications reducing a borrower's monthly mortgage obligation gained momentum. The depth of payment reduction remained shallow, however, with only 39 percent of all modifications resulting in a monthly payment decrease of 10 percent or more by the fourth quarter of 2008. (OCC 2009b)

[2] For more information on the creation of MHA and HAMP see (Treasury and HUD, 2012).

HAMP both expanded upon and refined many of the principles that both public and private participants in the industry had begun to adopt regarding how to structure and process a modification. Generally, HAMP modifications share a number of key characteristics, including a trial period prior to permanent modification of the loan, as well as an affordability standard of 31 percent for the borrower's "front-end" debt-to-income (DTI) ratio (i.e., the ratio of the borrower's monthly mortgage payments to gross monthly income). In addition to the standard HAMP structure, the HAMP Principal Reduction Alternative Program (PRA) provides financial incentives to investors for reducing principal owed by borrowers whose homes are worth significantly less than the remaining balance owed on the mortgage. HAMP also incorporated a Net Present Value (NPV) model so that servicers could evaluate (on behalf of investors) whether modifying any given loan made economic sense.[3]

To date, more than 1.3 million borrowers have had their mortgages permanently modified through HAMP. Virtually all HAMP modifications reduce the borrower's monthly principal and interest payment, with a median payment reduction of approximately $500, or over a third of the median monthly payment before modification. (U.S. Treasury, 2014)

Performance of HAMP and Non-HAMP Modifications

As of March 2014, over 945,000 permanent HAMP modifications were performing and remained in good standing within the program. More than 380,000 or 28 percent had been disqualified from the program because the borrower missed three consecutive monthly payments on the modified loan. As shown in Table 1, through February 2014, HAMP modifications were experiencing overall redefault rates[4] of 5.2 percent, 13.4 percent, 20.3 percent, and 26.1 percent by months 6, 12, 18, and 24, respectively.

The data also indicate that the performance of HAMP modifications has gradually improved over time, with more recent vintages of modifications generally performing better than older vintages at any given seasoning point. For example, for modifications in effect for one year, 20.5 percent of modifications started in the third quarter of 2009 have disqualified, compared to 9.5 percent for modifications started in the first quarter of 2013.

In addition, as seen in Figure 1, the data show that the growth rate of redefaults on HAMP modifications is declining. Thus, while the cumulative redefault rate for each annual vintage of modifications grows over time, the redefault rate for each successive three-month period generally declines.

Studies by the Office of the Comptroller of the Currency (OCC) have found that borrowers in HAMP consistently exhibit lower delinquency rates (defined as 60 days or more delinquent) than those in non-HAMP modifications. The OCC data (Table 2 below) show that this is true across all vintages and seasoning points. In addition to confirming the improved performance of HAMP modifications over time, the OCC data also show that the performance of non-HAMP

[3] See (Holden, 2012) for a detailed discussion of the HAMP NPV model.
[4] Unless otherwise noted, this paper defines a redefault as a modification that becomes 90 days or more delinquent following modification.

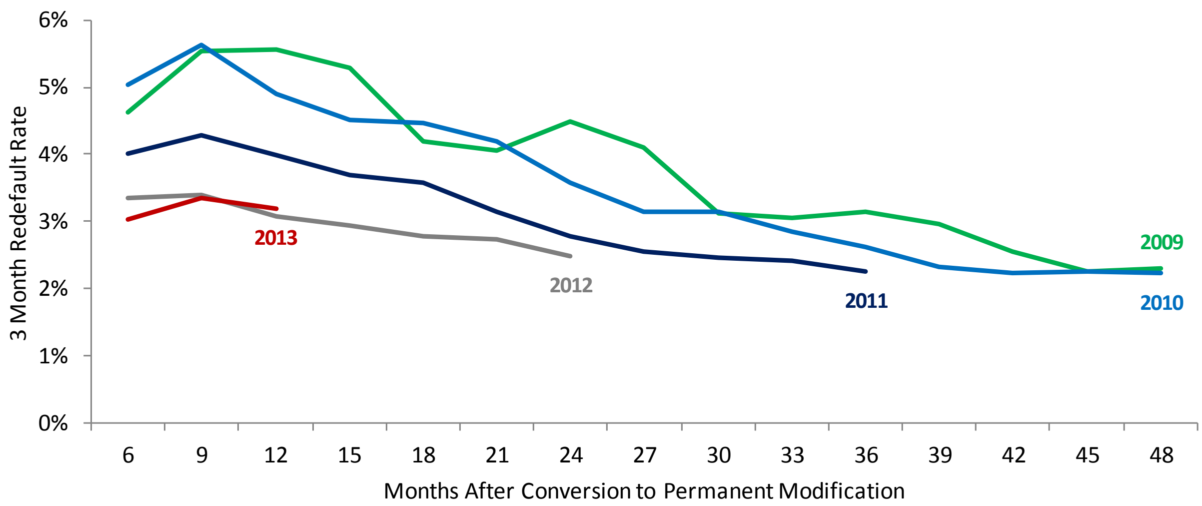
modifications has improved over time relative to the performance of HAMP modifications. Note, however, that the OCC comparison data do not take into account or control for differences in either loan or borrower characteristics.

Table 1: Permanent HAMP Modification Redefault Rates by Vintage

Modification Vintage	Month 6		Month 12		Month 18		Month 24		Month 30		Month 36		Month 42	
	#	90+ %	#	90+ %	#	90+ %	#	90+ %	#	90+ %	#	90+ %	#	90+ %
2009Q3	4,393	9.6%	4,631	20.5%	4,963	28.6%	5,074	33.3%	5,136	38.4%	5,179	41.6%	5,058	46.2%
2009Q4	47,396	5.6%	51,299	15.2%	54,530	21.9%	55,516	28.1%	56,647	32.6%	56,350	36.9%	56,183	40.4%
2010Q1	149,273	5.2%	160,873	15.7%	166,065	22.2%	168,118	28.6%	168,068	33.0%	166,319	37.3%	165,318	40.5%
2010Q2	156,588	6.9%	173,316	15.7%	170,552	23.8%	179,039	28.6%	177,439	33.3%	175,203	37.3%	175,433	40.1%
2010Q3	95,690	6.6%	103,944	14.1%	106,088	21.6%	106,227	26.6%	105,774	31.5%	104,535	35.1%	105,092	37.8%
2010Q4	62,311	5.4%	64,869	14.1%	66,529	20.9%	66,249	26.3%	65,940	30.8%	65,862	34.2%		
2011Q1	75,650	4.5%	79,534	13.3%	81,317	19.0%	80,866	24.6%	80,098	28.9%	81,201	31.8%		
2011Q2	88,878	5.3%	92,614	13.0%	91,922	19.9%	91,486	24.9%	92,103	28.5%				
2011Q3	85,882	5.4%	86,878	12.2%	86,540	18.7%	85,079	23.3%	86,458	26.7%				
2011Q4	67,416	4.2%	67,749	11.2%	67,876	16.7%	67,646	21.0%						
2012Q1	50,837	3.9%	50,839	10.7%	50,220	15.6%	50,744	19.8%						
2012Q2	44,959	4.4%	45,236	10.8%	44,782	16.0%								
2012Q3	48,945	4.4%	49,680	9.9%	50,259	15.0%								
2012Q4	41,207	3.8%	42,416	9.3%										
2013Q1	40,893	3.4%	42,039	9.5%										
2013Q2	33,018	3.7%												
2013Q3	33,446	4.0%												
Total	1,126,782	5.2%	1,115,917	13.4%	1,041,643	20.3%	956,044	26.1%	837,663	31.2%	654,649	36.0%	507,084	39.8%

Source: March 2014 MHA Program Data

Figure 1: HAMP Three-Month Conditional Redefault Rates by Modification Year[5]



[5] The three-month redefault rate was calculated as the number of permanent modifications disqualified within the three-month period divided by the number of permanent modifications remaining active at *month(T – 3)* and if still active at *month T*. Permanent modifications remaining active at *month(T—3)* excludes those permanent modifications that have paid off or disqualified by *month(T – 3)*.

Table 2: Performance of HAMP Modifications Compared With Non-HAMP Modifications[6]

Modification Vintage	# Mods	Month 3 60+ %	Month 6 60+ %	Month 9 60+ %	Month 12 60+ %	Month 15 60+ %
2012Q1 HAMP	37,240	4.90%	8.40%	11.30%	13.00%	13.30%
2012Q1 Non-HAMP	65,861	9.40%	17.50%	23.10%	25.50%	25.50%
2012Q2 HAMP	28,627	4.40%	7.90%	10.10%	11.00%	12.00%
2012Q2 Non-HAMP	68,088	7.50%	14.50%	17.90%	19.40%	19.40%
2012Q3 HAMP	31,745	4.30%	7.70%	9.40%	11.00%	12.30%
2012Q3 Non-HAMP	104,764	8.00%	14.60%	17.90%	21.20%	21.20%
2012Q4 HAMP	29,314	3.80%	6.20%	8.70%	10.30%	11.40%
2012Q4 Non-HAMP	114,181	8.30%	12.80%	17.50%	20.60%	20.60%
2013Q1 HAMP	28,030	3.20%	6.40%	8.90%	10.30%	
2013Q1 Non-HAMP	110,519	6.50%	13.00%	17.70%	18.60%	
2013Q2 HAMP	22,613	3.40%	6.90%	8.90%		
2013Q2 Non-HAMP	85,582	8.30%	15.40%	18.80%		
2013Q3 HAMP	23,159	3.90%	7.00%			
2013Q3 Non-HAMP	76,134	10.60%	15.90%			
2013Q4 HAMP	20,829	3.70%				
2013Q4 Non-HAMP	51,637	8.50%				

The performance of loan modifications is a topic that is subject to increasing interest from oversight and regulatory bodies, lawmakers, other policy officials, and the general public. Modification programs have been implemented through significant effort and expense on the part of the entire housing finance system with the goal of stabilizing the nation's housing market and helping borrowers avoid foreclosure. Since redefaults undermine this goal, it is important to understand the reasons that modifications succeed or fail and the types of modifications that maximize borrowers' likelihood of success.

This paper seeks to address fundamental questions raised by the known data on the performance of HAMP and non-HAMP mortgage modifications, including:

- What factors drive modification performance? In other words, are there inherent characteristics specific to the borrower and/or the modification that improve the likelihood of the borrower's success following modification?

- Controlling for borrower and loan characteristics, are there differences in the performance of HAMP and non-HAMP modifications? While there is considerable data on the likelihood of redefault for HAMP borrowers, what can be said about similarly situated borrowers with similar loans who received modifications outside of HAMP or no modification at all?

[6] Source: OCC (2014)

Section II of this paper provides a single-variable analysis of HAMP modification performance based on Treasury data for all HAMP modifications. Section III reviews existing published research on factors influencing redefault after modifications. Section IV then introduces our regression model of HAMP and non-HAMP treatment effects, which was constructed to test a series of hypotheses about the net effectiveness of modifications after correcting for borrower and servicer selection factors, as well as the relative performance of HAMP and non-HAMP modifications. Section V gives overall conclusions.

II. SINGLE-VARIABLE ANALYSIS OF FACTORS DRIVING HAMP MODIFICATION PERFORMANCE

Treasury data collected as part of the HAMP modification process helps shed light on the characteristics that most influence modification performance. Single-variable analysis of this data shows that payment reduction, the degree of loan delinquency at time of modification, and, to a slightly lesser extent, credit score at time of modification are important drivers of modification performance.[7] Post-modification mark-to-market loan-to-value (MTMLTV) ratio appears to have some impact on the performance, especially within certain segments of the HAMP population, while other criteria, such as the post-modification "back-end" DTI (i.e., the ratio of a borrower's total monthly payment obligations to gross monthly income) appear to be less meaningful drivers of performance.

The results of this analysis are limited both by the inherent limitations of single-variable analysis and by potential unobserved factors not found in the Treasury data. By definition, a single-variable analysis can identify correlations between modification performance and modification characteristics (such as payment reduction, credit score, etc.), but it cannot isolate or disentangle the effect of one factor that may be driving performance from others that may also be driving performance. Similarly, there may be factors driving modification performance about which there is no program data. For example, while income level is collected as part of the modification process, post-modification fluctuations in levels of income are unknown and may have a significant impact on performance.

Payment Reduction

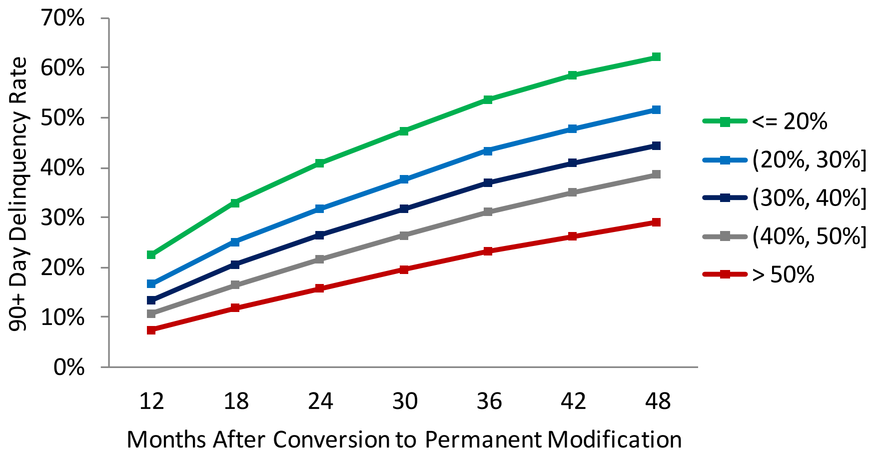
Most HAMP modifications result in significant payment reductions, with half of the population receiving a monthly payment reduction of approximately $500, or over a third of the median monthly payment before modification. (U.S. Treasury, 2014)

As seen in Figure 2, single-variable analysis shows that the amount of payment reduction has a significant impact on performance. Modifications with larger payment reductions consistently outperform those modifications with smaller reductions. This is true across all vintages and seasoning points. Over time, the gap in performance among payment reduction cohorts increases significantly. For example, only 16 percent of borrowers with a monthly payment reduction

[7] These three characteristics are independent variables which are incorporated into the redefault model that is embedded within the HAMP Net Present Value (NPV) model.

greater than 50 percent have redefaulted within 24 months, compared to a disqualification rate of 41 percent for HAMP borrowers whose payment was reduced by 20 percent or less.

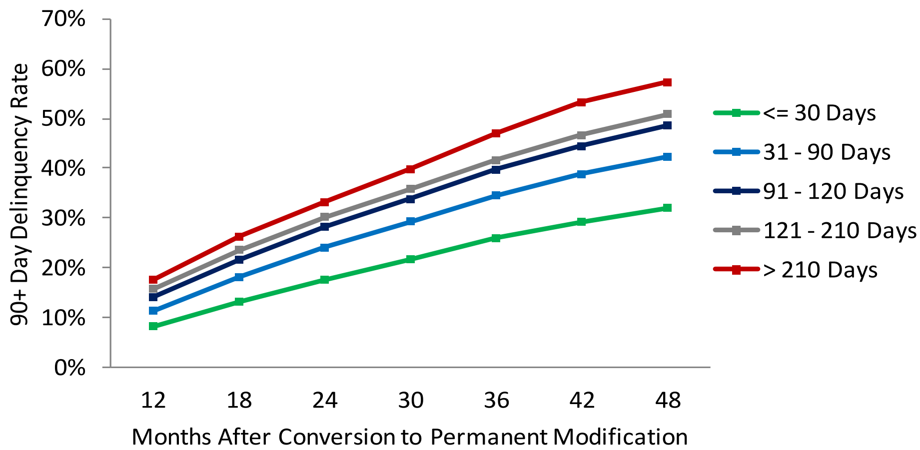
Figure 2: Cumulative Redefault Rate by Percent Reduction in Monthly Mortgage Payment



Delinquency at Time of Modification

The single-variable analysis also indicates that performance of the modification is influenced by the length of delinquency of the loan at time of modification. Borrowers who were 31 to 90 days delinquent at the start of the HAMP modification experienced a 24 percent redefault rate in the subsequent 24 months, compared to a rate of 30 percent for borrowers whose delinquency was between 121 and 210 days at the time of modification.[8]

Figure 3: Cumulative Redefault Rate by Delinquency at Time of Modification

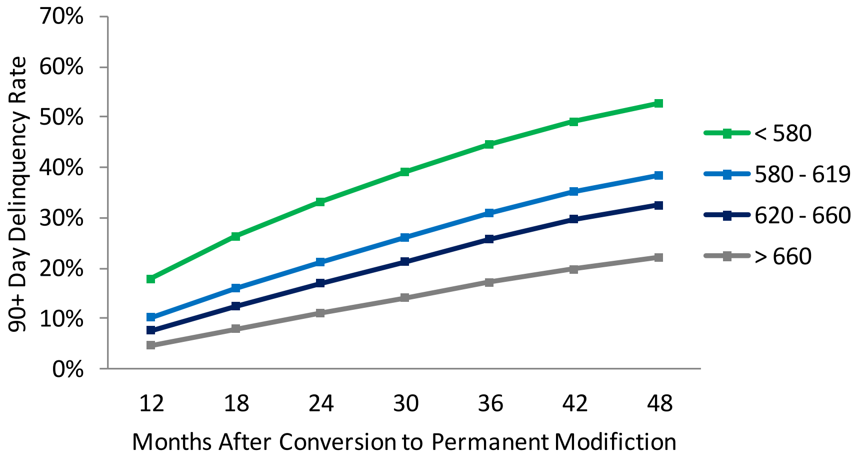


[8] Recognizing this correlation, both Treasury and the housing Government Sponsored Enterprises (GSEs) – Fannie Mae and Freddie Mac – adjusted their policies in 2011 to provide greater incentives for servicers to reach borrowers in the early stages of delinquency, adopting tiered incentive structures that increased incentive payments from $1,000 to $1,600 for servicers starting trial modifications for borrowers who are 120 days delinquent or less (Supplemental Directive 11-06).

Credit Score

The single-variable analysis also indicates that credit score at the time of modification also has a significant impact on performance.[9] For example, borrowers with credit scores below 580 at the time of modification experienced a 33 percent redefault rate in the subsequent 24 months, compared to a rate of 11 percent for borrowers whose credit scores were above 660.

Figure 4: Cumulative Redefault Rate by Credit Score at Time of Modification



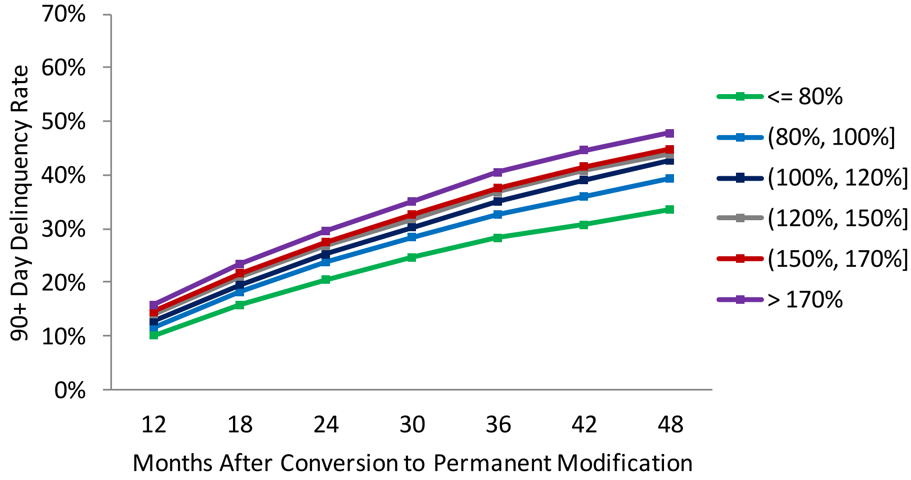
Other Characteristics

Single-variable analysis of HAMP data indicates that three additional characteristics also appear to influence modification performance, but to a lesser degree than the factors previously mentioned. These are MTMLTV, post-modification back-end DTI, and property location.

Post-modification MTMLTV does appear to have an impact on redefault rates, but to a lesser degree than the factors discussed above. For example as seen in Figure 5, the difference in 24-month redefault rates between borrowers with an MTMLTV less than or equal to 80 percent and those with an MTMLTV greater than 170 percent is about nine percentage points. Borrower outcomes do not vary greatly for MTMLTV between 80 and 170 percent.

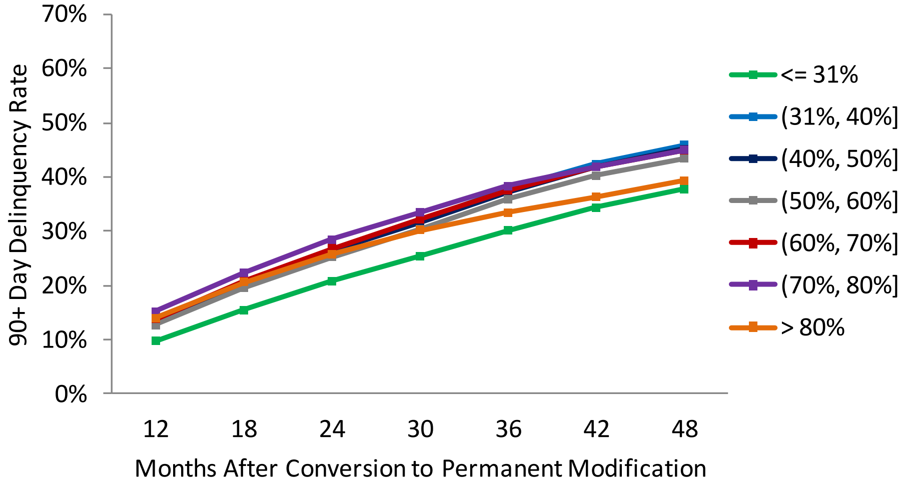
[9] Treasury's program data contain information on the borrower's credit score at the time of *modification*. The data show a correlation between degree of delinquency at the time of modification and credit score at the time of modification. Borrowers who were more delinquent at the time of modification tended to have lower credit scores, which is logical since delinquency on the mortgage has a significant impact on credit score. Note that Treasury's program data do not include the borrower's credit score at the time of *loan origination*, making it impossible to analyze the potential impact of this factor on modification performance in the single-variable analysis.

Figure 5: Cumulative Redefault Rate by Post-Modification MTMLTV



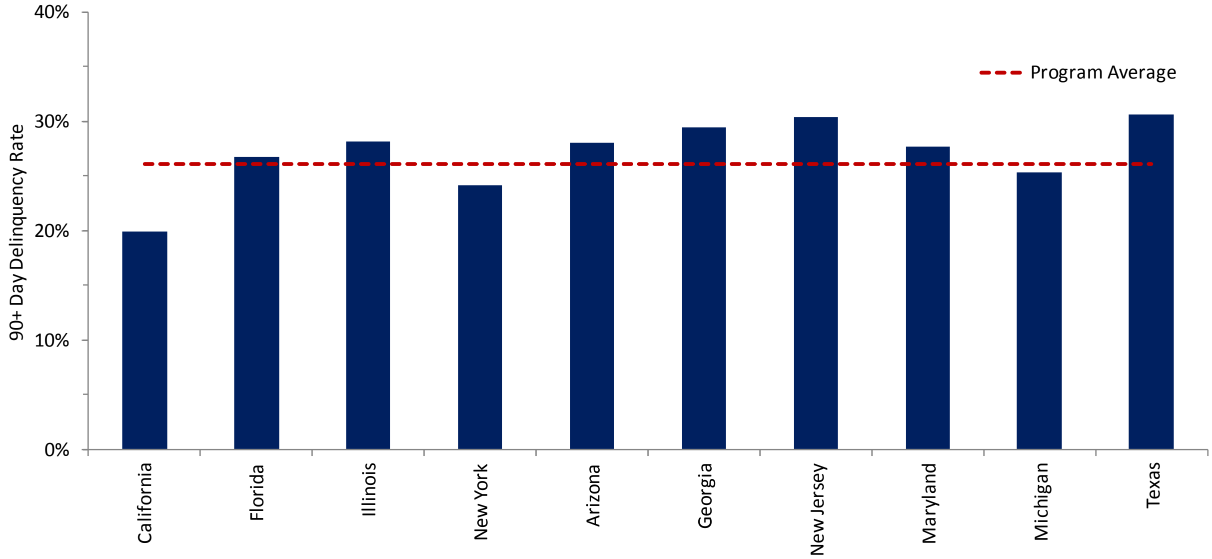
As shown in Figure 6, there appears to be little correlation between post-modification back-end DTI and modification performance, with the percentage of loans that are 90 days or more delinquent at any given seasoning point being fairly consistent regardless of post-modification back-end DTI.

Figure 6: Cumulative Redefault Rate by Post-Modification Back-End DTI



Finally, Treasury data show that geography appears to have some influence on modification performance. At 24 months after a HAMP modification, 21 of 50 states have redefault rates within three percentage points of the program average of 26.1 percent. As shown in Figure 7, among the 10 states with the most program volume, three – Georgia, New Jersey, and Texas – have redefault rates more than three percentage points above the program average (by 3.4, 4.3 and 4.5 percentage points, respectively). California modifications, however, significantly outperform those in other states with a redefault rate 6.2 percentage points below the program average.[10] The reasons for these variances are not well-understood and may merit additional research.

Figure 7: Cumulative Redefault Rate by State at 24 Months After Modification



III. LITERATURE REVIEW

Published research on mortgage modification effectiveness is comparatively recent, as loan modifications beyond short-term workouts were uncommon prior to the subprime crisis and Great Recession. The literature can be roughly divided into two periods, “pre-HAMP” and “post-HAMP”, depending on the time frame in which post-modification performance is observed (before or after mid-2009).

A consistent finding of these studies has been the importance of affordability (monthly payment reduction) in achieving successful modifications. For example, an early study published by the New York Federal Reserve Bank (Haughwout, Okah and Tracy, 2009) examined the performance of modified subprime mortgages through June of 2009, using the CoreLogic (LoanPerformance) PLS database. The authors found that overall redefault rates for that population and time period were quite high, with 57% of modified loans becoming 90 days or more delinquent within twelve months. Many of the modifications from this period were of the so-called “cap and extend” type, in which amortization terms were extended and accrued interest was capitalized into the loan balance. These modifications usually resulted in a similar or higher monthly payment for the borrower, and were relatively ineffective at preventing defaults. Modifications with more generous payment reduction led to substantially improved performance. Each 10% lowering of borrowers’ monthly payments was associated with a 4.4 percentage point reduction in twelve-month redefault rates, which translates into an 8 percent relative improvement.

[10] See Appendix Table A1 for HAMP redefault data for all 50 states, U.S. Territories and the District of Columbia.

Similar results were found by Agarwal, et al (2011) in their paper, “The role of securitization in mortgage renegotiation”, which examined loan performance from October 2007 through May 2009. This research utilized the OCC-OTS Mortgage Metrics database, which is based on direct reporting from 10 high-volume loan servicers. This data source allowed the authors to compare the rates of modification and delinquency between PLS loans and those held in lenders’ portfolios. They found that delinquent, portfolio-held loans were about 40% more likely to receive a modification than those held in PLS. Moreover, even when controlling for loan and borrower characteristics, the modified portfolio loans had a 9% lower relative redefault rate than equivalent securitized loans. Both types of loans responded strongly to payment reduction, with a 10% lowering leading to an 11% relative improvement in redefaults at six months.

An advantage of using the OCC-OTS data, or similar sources such as LPS McDash that are based on direct servicer reporting, is that a more representative sample of the total universe of modified loans can be used, compared to the CoreLogic PLS data used by several modification studies, including this one. However, a relative weakness of the servicer-based sources is that the data is restricted to the largest loan servicers by volume. This can lead to selection bias, because these servicers sometimes transferred high-risk or non-performing loans, causing the data associated with those loans to be censored. By contrast, the performance histories in CoreLogic will always track a loan to its ultimate disposition (payoff, foreclosure, third party sale, etc.).

HAMP and Non-HAMP Comparisons

Turning now to research from the “post-HAMP” era, the same OCC-OTS database was also leveraged by Voicu, et al (2012), using loan performance through November 2010, allowing for a direct comparison of the performance of HAMP and non-HAMP modifications. This study population was restricted to loans originated in New York City, to allow loan records to be matched with property deeds, allowing a rich set of neighborhood and demographic controls to be included in the analysis. Once again, a strong reduction in redefaults based on payment reduction was found: in this case, a 16% relative improvement per 10% in payment change was found. Along with payment reduction, other factors found by this study to affect modification success were the borrower’s FICO credit score, their post-modification equity position or loan-to-value ratio, and the extent of mortgage payment delinquencies prior to the modification.

Even when controlling for all of these factors, though, the authors found that HAMP modifications had a 7 to 9% lower relative redefault rate than non-HAMP modifications. This means, for example, that a HAMP modification offering a 25% payment reduction would be expected to perform as well as a non-HAMP modification with a 30% payment reduction, made on the same loan. Without any mechanism to control for possible selection bias, however, this analysis could not isolate the extent to which the HAMP benefit was an actual treatment effect, due to the program’s design or implementation features, or because HAMP’s documentation requirements or eligibility criteria might be “weeding out the borrowers least likely to succeed.”

Controlling for this sort of selection bias was a major consideration for Agarwal, et al, (2012) in a follow-up to their earlier modification research. Re-using the Mortgage Metrics data, and covering the period from July 2008 through December 2010, this study sought to isolate the treatment effects of the HAMP program in terms of the incidence and effectiveness of modifications. The primary identification strategy was to use mortgages on non-owner-occupied homes, which are not eligible for HAMP, as the control group in a difference-in-difference design. A secondary strategy was to compare "jumbo" loans which were ineligible for HAMP due to having balances over $729,750, with loans that were under that threshold.

Using these difference-in-difference strategies, the authors found that the *rate* of non-HAMP modifications was unchanged by the introduction of the HAMP program. Although there was some "crowding out" of loans modified under HAMP that would have received non-HAMP modifications in the absence of the program, this effect was offset by the additional borrower outreach and publicity associated with HAMP. Some borrowers who otherwise never would have sought a modification applied for the HAMP program, were denied, and then received proprietary modifications.

Curiously, the study showed that the generosity and effectiveness of non-HAMP modifications on HAMP-eligible loans decreased after HAMP was introduced, relative to that of the control group of non-HAMP eligible loans. The authors attribute this to a possible selection effect, where servicers may have steered borrowers with (unobserved) lower risk characteristics to the HAMP program, in order to maximize incentive payments associated with borrower performance.

Taking all of these side effects into account, this paper concluded that the HAMP program had a net impact of causing an additional 1.2 million modifications to be performed, with around 800,000 foreclosures being averted.

LTV and Principal Reduction Effects

More recently, Shmeiser and Gross (2014) compared HAMP and non HAMP modification performance using the LoanPerformance data. Their study population was a 5% sample of subprime, PLS loans that were modified between 2008 and 2013.They found that reductions in monthly payments and reduction in the loan's principal balance both improved post-modification outcomes. Furthermore, HAMP modifications were found to have better performance than non-HAMP modifications, even when controlling for the amount of payment reduction and other loan terms.

A unique advantage of the Shmeiser and Gross study is their use of CoreLogic TrueLTV data on second liens. This data set allowed the authors to construct a combined loan-to-value ratio (CLTV) for a given loan at a point in time, which should provide a more accurate picture of which borrowers were "underwater". They found noticable deteriorations in loan performance as these CLTV values crossed the 90% (low equity) and 100% (zero/negative equity) boundaries. The authors concluded that modifications that reduced principal balances (and thus, CLTV) were more effective, independent of the amount of P&I reduction.

Note, however, that the CoreLogic LoanPerformance data cannot distinguish between loan modifications that reduce a borrower's principal balance through forbearance (which still makes the borrower responsible for the full balance at payoff) or forgiveness. Since the present study is also based on LoanPerformance, this paper does not attempt to specifically measure the effect of principal forgiveness on modification outcomes.

In a similar vein, in their paper “Modification Success – What Have We Learned?”, also based on CoreLogic data, Goodman et al (2011) cite principal reduction as one of the three key ingredients of modification success, along with payment relief and modifying a delinquent loan as early as possible. However, they qualify this endorsement by noting the forgiveness/forbearance limitation of their source. This same caveat should be taken into account when evaluating the results of other studies that rely on the LoanPerformance data.

In order to isolate the specific effects of principal forgiveness on a modification’s effectivess, it is necessary to have performance data that can distinguish forgiveness from forbearance and other changes to loan terms, and to then statistically isolate the independent effects of improving a borrower’s equity position from the associated reductions in their payments. This strategy has been employed in two studies that have made use of the internal program data from HAMP to compare the performance of loans modified under HAMP PRA (Principal Reduction Alternative), in comparison to loans receiving HAMP modifications that did not reduce principal balances.

An early analysis, conducted by this author (U.S. Treasury, 2012), found that principal reduction did have an independent effect, but that payment reduction remained the dominant factor in predicting post-modification performance. In one illustration, a loan modification that reduced payments by 30% through principal reduction lowered the risk of redefault within six months from 10% to 3.5%, while a modification that achieved the same payment change without reducing principal lowered the predicted redefault rate to 4.6%. A later study (Scharlemann and Shore, 2013), based on more than two years of HAMP PRA performance data and utilizing a regression kink design, found a similar effect. The quarterly hazard rate for 90 day delinquencies was 3.8% for PRA modifications that reduced principal by an average of 29%, while the hazard rate without principal reduction was estimated to be 4.7%.

Servicer Heterogeneity

A recent working paper by Reid, Urban and Collins (2014) examined differences across 20 large servicers in the extent to which they modified delinquent mortgage loans, and how this affected subsequent loan cure rates. The study population was taken from a database of subprime and alt-A loans in private label securities for which Wells Fargo is the trustee. To be included in the sample, a loan must have been 60 days or more delinquent in June 2009; modification rates and borrower payment history was then tracked through the end of 2012. Servicers were found to vary quite widely in their overall modification rates – from 2 to 48% - and the extent to which they were willing to reduce interest rates or loan balances; these differences had a profound effect on borrower outcomes.

On the other hand, the authors found that, controlling for loan and borrower characteristics such as credit score, there were no differences *within a given servicer* in the rates of modifications offered to low-income or minority borrowers, in comparison to the overall population. The race of the borrower was inferred by matching the Wells Fargo loan population with HMDA (Home Mortgage Disclosure Act) mortgage origination data. This finding was broadly consistent with that of a prior study by two of the authors (Collins and Reid, 2010), which used the same matching technique for an earlier time period. The earlier paper actually found that minority borrowers were slightly *more* likely to receive a mortgage modification, even when controlling for FICO, borrower income, and other factors.

The wide variation in modification take-up rates by servicer, as seen by Reid, et al, and also reported on by Agarwal, et al (2012), is a key motivator for the estimation strategy used in this paper. Especially because servicing rights for subprime loans were often transferred after origination, the identity of the loan servicer at the time of a modification is essentially a random factor, outside of the borrower's control and unrelated to their own behavior. This suggests that the identity of the loan servicer at the time of modification, and the interactions between servicer identity and loan attributes, can be used as instruments that are predictive of modification rates, but are otherwise unrelated to borrower delinquency.

IV. TREATMENT EFFECT ANALYSIS OF THE EFFECTIVENESS OF HAMP AND NON-HAMP MODIFICATIONS ON SUBPRIME PLS LOANS

To gain greater insight into the factors driving modification performance and the effectiveness of both HAMP and non-HAMP modifications, this study used a treatment effect analysis to look at three populations of similarly delinquent PLS loans:

- Loans modified under HAMP;
- Loans modified outside of HAMP (proprietary modifications); and,
- Loans that were not modified.

As discussed in more detail below, the study population of HAMP loans was derived by matching data from a commercial loan performance database for PLS loans against the subset of HAMP modifications of PLS. In addition, the loans from the commercial database were restricted to loans that became at least 30 days delinquent during the timeframe of the HAMP program.

The performance of modified loans was measured in terms of their status after a fixed time interval (ranging from six to 36 months) from the time the modification became permanent. The loan was considered to have an adverse outcome (e.g., redefault) if by the end of a time interval it had: a) become 90 days or more delinquent; b) been liquidated at a loss; or c) required an additional modification. Loans that became delinquent but were not modified were examined over the same time interval. In this control group, a loan was considered to have an adverse outcome if by the end of the time interval it had: a) became 90 days or more delinquent; b) been liquidated; or c) been subsequently modified.[11]

Unlike single-variable analysis, the treatment effect regression analysis makes it possible to disentangle and isolate the impacts of different factors influencing the likely outcomes for loans in all three populations. It also allows for the separation of the true treatment effects of a modification from possible selection effects.[12] Modification effectiveness is measured as the selection-bias-adjusted average treatment effect on the modified loan (also known as the

[11] See Appendix III for additional information on the construction of the study population.
[12] See Appendix II for additional information on how the regression analysis controlled for selection effects.

"average treatment effect on the treated" or ATET). This is estimated from an econometric model that simulates random assignment of loans to the modification program. The ATET is the average difference between a loan's expected probability of an adverse outcome depending on whether the loan was modified under HAMP, modified outside of HAMP, or received no modification at all. For example, if the average loan has a 60 percent chance of an adverse outcome without modification but a 40 percent chance when modified, then the ATET is 20 percentage points.[13]

Hypotheses

Using this methodology, the analysis tested a series of hypotheses about modification effectiveness and the factors driving modification performance.

Hypothesis 1: Modifying a loan has a significant effect on borrower performance outcomes, even when controlling for borrower and loan characteristics. This looks at the ATET of any type of modification (HAMP or non-HAMP) compared to not modifying a similar loan to a similar borrower.

Hypothesis 2: HAMP modifications perform better than non-HAMP modifications, even when controlling for borrower and loan characteristics. This is similar to Hypothesis 1 but compares the ATET for a HAMP-modified loan to the ATET for a loan modified outside of HAMP.

Hypothesis 3: Controlling for borrower and loan characteristics, payment reduction is the most significant factor driving modification performance. This hypothesis tests whether differences in modification outcomes are explained more strongly by variations in the amount of payment reduction than by other factors, such as loan and borrower characteristics, or other changes in loan terms such as principal reduction.

Hypothesis 4: HAMP modifications perform better than non-HAMP modifications, even when controlling for borrower characteristics, loan characteristics, and changes in the loan terms. This is a stronger statement than Hypothesis 2. It asserts that HAMP modifications will perform better than non-HAMP modifications even for similar borrowers whose loans are similar before *and* after the modification. Thus, what is tested is whether any non-economic factors may be influencing post-modification borrower behavior. If a borrower's behavior was determined solely by objective economic self-interest, one would expect that modifications that made the same changes to loan terms, such as the amount of payment reduction, would have similar effects. However, if a borrower was affected by other factors, such as the process interactions with the servicer under a particular modification program, there might be differences between

[13] As with the single-variable analysis, the results may be influenced by variables that are unobservable due to limitations in the data set. For example, the commercial database employed by the study does not clearly indicate which modifications received principal forgiveness or forbearance, making it difficult to isolate their potential effects on modification performance. Similarly, data limitations made it impossible to test the effects of the back-end DTI or the borrower's credit score at the time of modification. Note that unlike the Treasury data used for the single-variable analysis, the data used for the regression analysis *do* include the borrower's credit score at the time of loan origination.

HAMP and non-HAMP modifications, even after controlling for borrower characteristics *and* the modification terms.

Hypothesis 5: Modifying a loan has a significant effect, even when controlling for borrower characteristics, loan characteristics, and the changes in loan terms. This is a stronger statement than Hypothesis 1. It seeks to test whether a modification that did not reduce the borrower's payments or principal balance but simply reset the borrower's delinquency status to "current" will have an effect on borrower outcomes two years later. In other words, the process of being made current is itself effective in changing the borrower's payment behavior.

The Study Population

The CoreLogic Loan Performance subprime database provides origination and performance history for approximately 90 percent of all subprime and Alt-A residential mortgages that were bundled into PLS and active in the 2010-2011 timeframe. By matching this data against the subset of HAMP PLS loans, it was then possible to perform a three-way comparison between subgroups of loans that received HAMP modifications, lenders' proprietary non-HAMP modifications, or no modification at all.

As a first step, the study population was restricted to non-jumbo first liens, active in the 2010-2011 timeframe, on owner-occupied residences. This insured that the study population did not include loans that are categorically ineligible for HAMP.[14] In addition, only loans that became delinquent were used in the regressions. This excluded from the study the loans that were modified without ever having gone delinquent. However, it helped ensure that the study compared like populations of loans since loans that become delinquent but are not modified are more similar in their characteristics to the group of modified loans than they are to loans that never became delinquent.

While servicers do report some information on loan modifications to CoreLogic, this information is considered proprietary and is not generally provided to PLS database subscribers. As a result, researchers typically must infer the existence and terms of modifications indirectly. This is done by comparing each loan's reported payment history to expected events as defined by the origination terms, such as ARM reset dates or the termination of an interest-only period. Modifications can then be imputed when there are significant changes to a loan's interest rate or payment that are not consistent with the original loan terms. CoreLogic offers a list of imputed modifications, as do other private companies. However, for this study, having access to the actual HAMP modification data made it attractive to develop and validate an independent process for imputing modifications; this process is described in Appendix III.

Once these initial rules were applied to impute a population of modified loans, several additional steps were taken.

[14] Prior to the introduction of HAMP Tier 2 in June 2012, loans where the residence was determined to be non owner-occupied were ineligible for a HAMP modification.

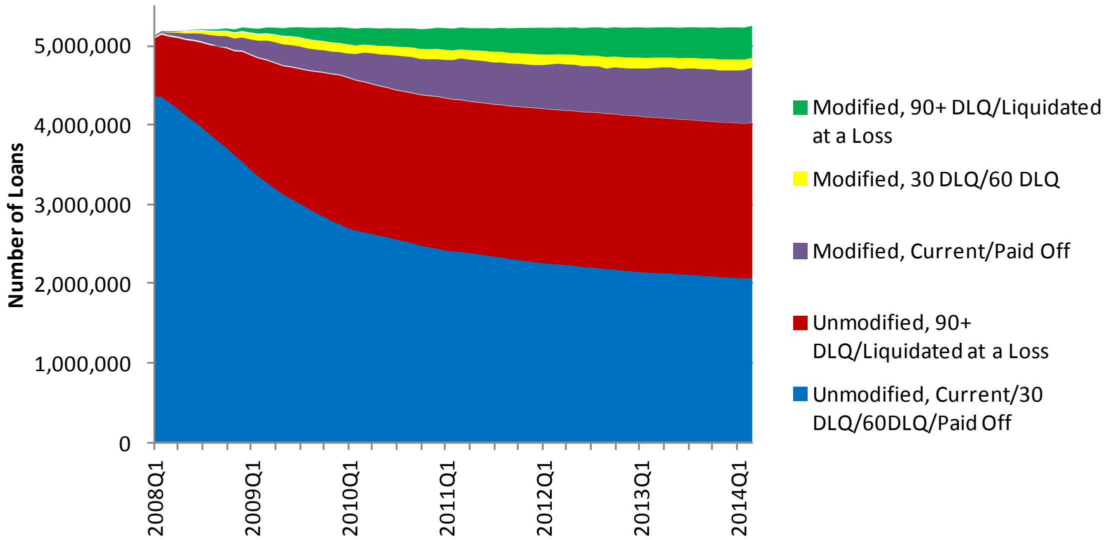
First, only loans whose new loan terms resulted in the reduction of the borrower's monthly payment were considered to have been "modified" for the purposes of this study. This helped to more effectively compare HAMP and non-HAMP modifications by eliminating those modifications (mostly in 2007-2008) that consisted primarily of capitalization of unpaid interest without any reduction in monthly payments. Restricting the population in this way also improved the accuracy of the imputation process, since it is more likely that a payment-increasing change in terms in the post-2008 period will have been due to the original loan terms rather than due to a modification.

Second, in order to construct the sub-population of HAMP modifications, the CoreLogic loans with imputed, payment-reducing modifications were then matched to the subset of loans within HAMP that were identified as being part of a PLS (regardless of whether the loan servicer or an outside investor holds the security). Matches were identified using the origination terms (e.g., origination date, loan amount, initial rate, and property ZIP code) and information about the HAMP modification itself (e.g., post-modification loan balance, payment, and interest rate).

Third, additional analysis was performed in order to align the HAMP and CoreLogic data elements. For example, knowing that the original appraisal values on subprime loans was often inflated, the MTMLTV for non-HAMP modifications was recalculated using a correction based on data from the HAMP program. For HAMP modifications, the HAMP database identifies the MTMLTV of each loan before and after the modification becomes permanent. This MTMLTV is based on an updated appraisal of the property performed by the servicer at the time of modification. Comparing these updated appraisal values of the property against the original appraisal values found in CoreLogic permitted a correction to be applied to the original loan-to-value ratios of both the non-HAMP and HAMP modifications.

Figure 8 shows how, using the modification imputation process, it is possible to track how the study population evolved over time. Of over five million potentially HAMP-eligible subprime and Alt-A loans active at the beginning of 2008, 2.1 million appear to never have been modified and were less than 90 days delinquent or paid off as of first quarter 2014. The imputation and matching algorithms identified over 220,000 payment-reducing HAMP modifications, of which approximately 177,000 are still in good standing or had paid off as of first quarter 2014. In addition, over 990,000 non-HAMP modifications were identified, of which over 638,000 were in good standing as of first quarter 2014.

Figure 8: Population of Potentially HAMP-Eligible PLS Loans from 2008 to 2014



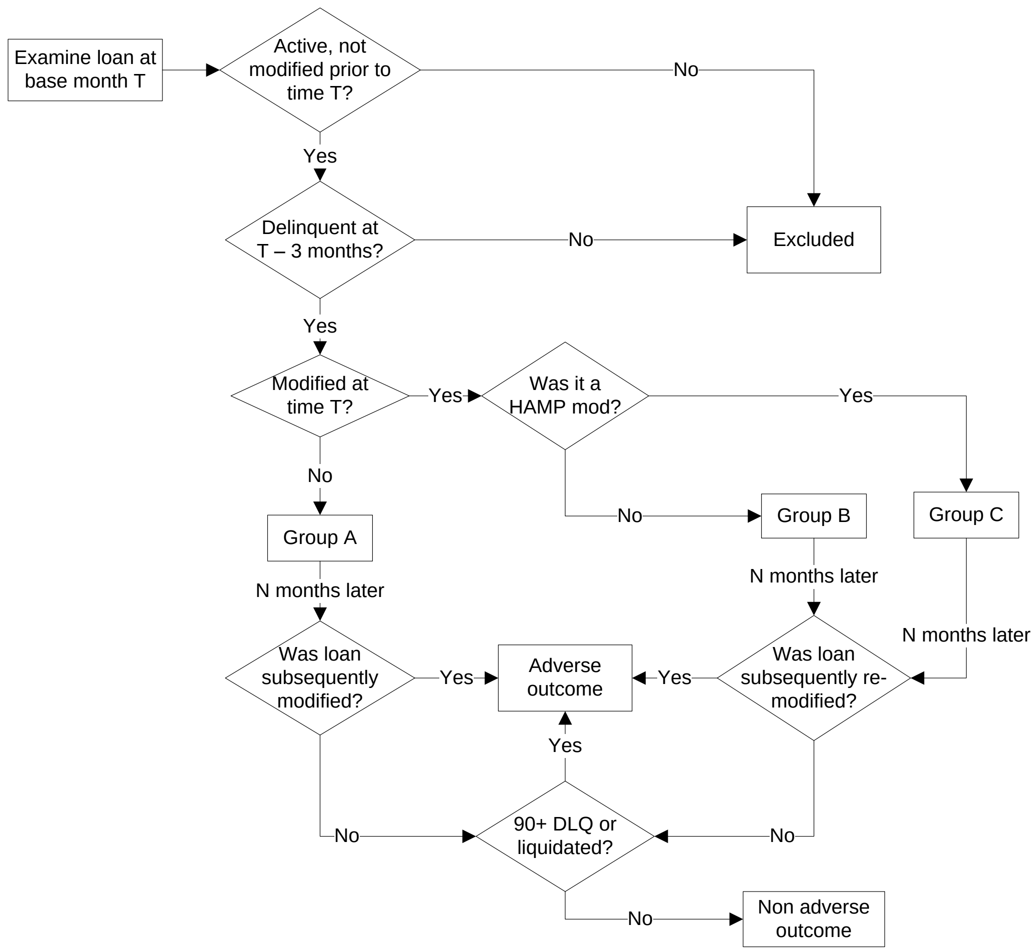
From this point, the study sub-populations were further defined in order to set up the regression analysis, using the concept of a *base month*. The base months for the study correspond to the date from which the performance of the loan begins to be tracked, and range from January 2010 through December 2011. To be included in the population for a base month *T*, a loan must have been active and unmodified as of the month prior to base month *T*, and it also must have been at least 30 days delinquent as of three months before base month *T*, which roughly corresponds to the beginning of a modification trial period.

Within this population, the Group A subpopulation consists of those loans that did not receive a modification during (or before) month *T*, while Groups B and C consist of loans whose earliest modification (if any) became permanent during month *T*. If that modification was matched to a HAMP modification, then the loan is placed in Group C; otherwise it is placed in Group B. Note that loans whose earliest modification was after month *T* would still be included in Group A. To make the three groups more comparable in size, only a sample from Group A was included in the regressions; the sampling methodology is described in Appendix III.

For each base month, borrower outcomes for all of the groups were examined at an *outcome month* that is a fixed span of time *M* months after the base month. This allowed for a head-to-head comparison of modified and unmodified loan performance over the same time periods. Each regression was performed by selecting a time span *M*, and by pooling the three groups of loans from 12 base months into a *base year*. For the base year of 2010, the study looked at outcomes between six and 36 months after each base month (ranging from January 2011 through June 2013); similarly, outcomes between six and 24 months were examined for the 2011 base year.

As seen in Figure 9, each loan, whether modified or unmodified, was assigned one of two outcomes: either *adverse* or *non-adverse*. When a loan was 90 days or more delinquent or had been liquidated at a loss at the outcome month, it was always considered to have an adverse outcome. Loans that received a modification in between the base month and the outcome month were also considered to have an adverse outcome regardless of their initial modification status.

FIGURE 9: Flowchart of the Treatment Effects Model for the Study Population



The Regression Analysis

When comparing performance between modified and unmodified loans, it is critical to separate the true treatment effects of the modification program from possible selection effects. Unlike groups in a randomized, controlled experiment, the populations that ultimately receive a permanent modification will differ substantially from those that do not. For example, this could be due to the program eligibility rules, such as a borrower failing to meet the 31 percent DTI threshold for HAMP, or due to borrower behavior, such as failure to provide required documentation. In addition, there could also be substantial differences across servicers in the execution of modification programs.

Some of the factors affecting these selection processes may be related to variables that can be observed, such as the origination terms and prior delinquency history in the CoreLogic database or in the HAMP program information. However, other information, such as the borrower's updated income or credit score at the point of modification, would have been visible to the loan servicer but is not available in the CoreLogic database for non-HAMP modifications. Also, many borrower-related factors affecting their willingness to participate in a modification or to make payments may be completely unobserved. To the extent that these unobserved selection factors are also related to loan performance, any regression estimates of the benefits (or lack thereof) of any particular type of loan modification may be incomplete or biased.

For example, loans with high credit scores, low origination DTI, and low MTMLTV will generally be less likely to receive a modification, even if they become 30 days or more delinquent, because such borrowers are less likely to have a financial hardship that qualifies them for a modification. The loan will therefore have a low probit score within the selection equation. If such a loan ends up being modified, it logically follows that there are *unobserved* borrower, loan, or servicer characteristics that made that specific loan more likely to get a modification. These loans will then receive a high, positive selection correction factor.

The correlation between such factors and loan outcomes may raise or lower the estimates of the effectiveness of a modification. If, controlling for all of the observable factors, the riskier loans also get modified more often (e.g., due to DTI eligibility thresholds), then this will cause modification effects to be understated. On the other hand, if it turns out modified loans have *lower* risk factors (e.g., because borrowers who cannot provide required documentation are also higher default risks), then this will cause modification effects to be overstated.

This analysis estimates and corrects for potential selection bias using a variant of a Roy model of treatment effects. Appendix II provides a more detailed description of the econometric model that was used. In this study, there were two probit *selection equations*.

The first equation estimated the probability of a given delinquent loan receiving any kind of modification during its base period. The second equation, which applies only to the modified loans, estimated what factors influence whether the loan receives a HAMP or proprietary modification. Three additional probit *outcome equations* then estimated the probability of an adverse outcome for each of the population subgroups: Group A (those unmodified in the snapshot month), Group B (those receiving proprietary modifications), and Group C (those receiving HAMP modifications).

When the outcome regressions were run using the correction factors, this allowed the observed outcomes to then be decomposed into *selection effects* and *treatment effects*. The total estimated modification effect (the ATET) was defined as the difference in the probability of default under two hypothetical scenarios:

> [A] Selection into the modification program *is random,* and the loan *is modified*, and
> [B] Selection into the modification program *is random,* and the loan *is not modified.*

The treatment effect was then determined as the difference between the actual proportion of adverse outcomes (in both the modified and unmodified groups) and the selection effect.

Overview of Results

The outcome regressions were used to evaluate each of the study hypotheses, with the following results.

Hypothesis 1: Modifying a loan has a significant effect on borrower performance outcomes, even when controlling for borrower and loan characteristics. This was strongly confirmed. While selection bias is a significant factor, typically accounting for 13 to 33 percent of the observed modification effects, there is a substantial modification treatment effect. A typical PLS loan receiving a HAMP modification in 2010, for example, had its likelihood of default reduced by 40 percentage points, 36 months after the date of modification.

Hypothesis 2: HAMP modifications perform better than non-HAMP modifications, even when controlling for borrower and loan characteristics. This was also confirmed, but more strongly for loans receiving a HAMP modification in 2011 than in 2010. Even when looking only at modifications that reduced borrowers' payments, borrowers receiving a HAMP modification in 2011 have on average a 17 percentage point lower redefault rate after 24 months than those receiving non-HAMP modifications. Borrowers receiving a HAMP modification in 2010 also perform better (seven percentage points lower redefault rate) than those receiving non-HAMP modifications through month 36. These differences in performance are likely the result of the more generous payment reductions typically offered by HAMP modifications versus non-HAMP modifications.

Hypothesis 3: Controlling for borrower and loan characteristics, payment reduction is the most significant factor driving modification performance. The results from testing this hypothesis are also time-dependent. Initially, the borrower's level of delinquency at the time of modification is the most important factor determining performance, with the level of payment reduction slightly less important. As time passes, however, payment reduction becomes relatively more significant, and by two years or more post-modification it becomes the most important performance driver.

Hypothesis 4: HAMP modifications perform better than non-HAMP modifications, even when controlling for borrower characteristics, loan characteristics, and changes in the loan terms. This hypothesis was confirmed with qualifications. For modifications made in early 2010 with equivalent changes in loan terms, HAMP and non-HAMP performance was roughly comparable. Since then, the average HAMP treatment effects have steadily improved, while the average effect of a proprietary modification has lagged. Loans with HAMP modifications have shown a stronger response to payment reduction, while non-HAMP modifications have had a relatively larger effect for borrowers who were extremely delinquent (12 months or more) prior to the modification.

Hypothesis 5: Modifying a loan has a significant effect, even when controlling for borrower and loan characteristics and the changes in loan terms. This hypothesis is confirmed with qualifications. The process of resetting a delinquent borrower to current status and having the borrower commit to making payments again appears to have a positive effect on borrower behavior that is independent of the changes in loan terms. However, most of this performance benefit has disappeared by 18 months after the modification, and the extent of any long-term impact is unclear.

The remainder of this paper will show how these results were obtained from the outcome regressions.

Selection and Treatment Effects

The summary statistics for the study population are shown in Tables A3 and A4 in the appendix. Some key differences between the modified and unmodified subgroups are shown below in Table 3. Not surprisingly, loans that received modifications tended to have higher credit risk characteristics at origination: they show higher DTI ratios, are more likely to have features such as balloon payments, and are more likely to have been originated as part of a cash-out refinancing. The HAMP-modified loans, on average, tend to have higher loan balances and are more underwater (higher MTMLTV) than the non-HAMP modified loans. On the other hand, HAMP-modified loans tend to have somewhat higher borrower credit scores at origination (unlike Treasury data, CoreLogic data has information on credit score at origination).

Table 3: Mean Values of Loan and Borrower Characteristics in the Study Population

Average Loan Characteristics	2010 Not Modified [25% sample]	2010 Non-HAMP Mod	2010 HAMP Mod	2011 Not Modified [25% sample]	2011 Non-HAMP Mod	2011 HAMP Mod
# of Loans in Sample	300,041	147,645	101,898	233,635	71,793	61,908
Origination FICO	640	631	633	642	629	646
Origination Loan Amount, $1000s	197	198	225	192	189	235
Origination Back End DTI	40	40	41	40	40	41
% Cash-Out Refis	48	54	58	49	56	57
% Balloon Loans	11	13	17	9	13	13
UPB at Base Date, $1000s	242	241	262	237	232	275
MTMLTV at Base Date	139	137	144	142	137	149
Modification Rate Reduction (1 = 100 basis points)		3.5	4.4		3.7	3.8
Modification Payment % Reduction		31	39		34	39

Figure 10 shows the proportion of loans in the three subgroups that had an adverse outcome. The performance of unmodified, delinquent loans in this population was consistently poor: at any given time period, around 80 percent of these loans were either seriously delinquent or liquidated. For both groups of modified loans (HAMP and non-HAMP), performance varied significantly over time. The vast majority of borrowers who made it through a trial modification period were then able to avoid serious delinquency in the following six months. However, a significant proportion of modified loans became seriously delinquent within 36 months. At the same time, the rate of increase in the redefault rate decreased with time. Thus, the redefault hazard rate fell from an initial high of one to two percent per month in months zero to 18, down to about 0.5 percent per month by month 24.[15]

[15] Note, this is the same trend that is depicted in Figure 1.

Table 4 shows a summary of these results for the 2010 and 2011 cohorts. The observed HAMP redefault performance was consistently better than the non-HAMP redefault performance. On average, modifications made in 2011 performed better in each time period for both HAMP and non-HAMP loans. However, these figures do not account for differences (both observed and unobserved) between the different populations.

Figure 10: Comparative PLS Loan Default/Redefault; by Modification Event and Year

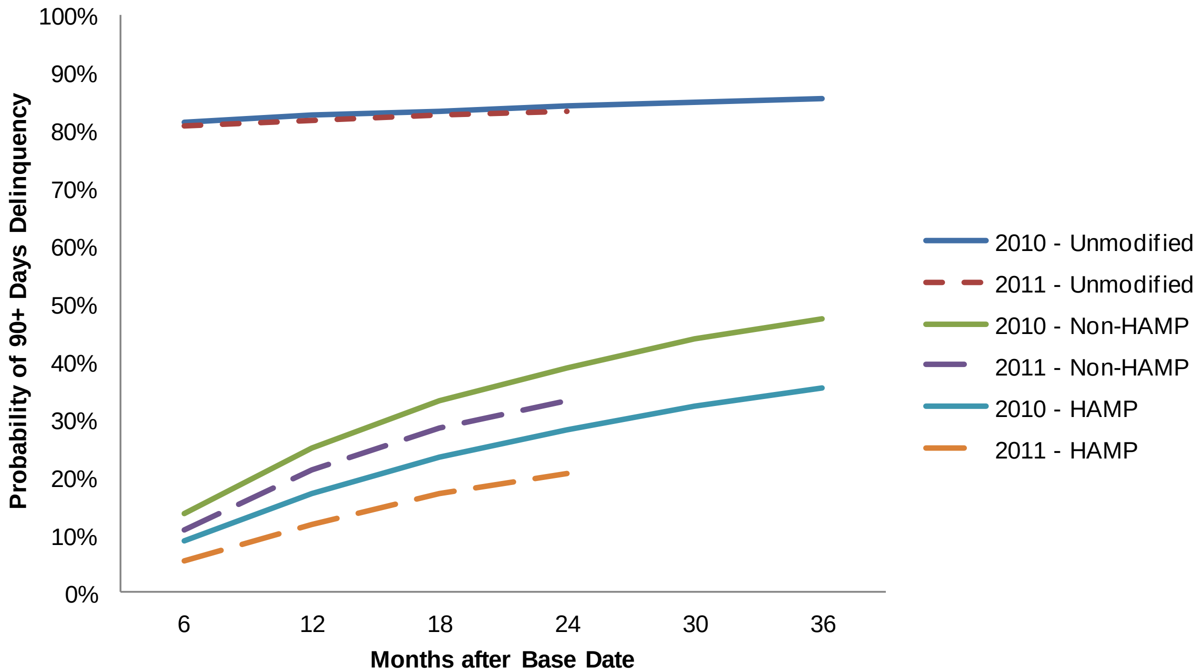


Table 4: Observed Performance (Percent Less Than 90 Days Delinquent) for 2010-2011 Modifications

Modification Vintage	Months After Base Date					
	6	12	18	24	30	36
2010 HAMP	73%	66%	60%	56%	53%	50%
2010 Non-HAMP	68%	58%	50%	45%	41%	38%
2011 HAMP	75%	70%	66%	63%		
2011 Non-HAMP	70%	61%	54%	50%		

The sample selection model makes it possible to break down the total difference in observed outcomes between modified and unmodified loans into treatment and selection effects. Tables 5a and 5b illustrate how this breakdown is derived, using the longest term available results for each base year population.

The selection effects in these tables include those due to observed differences between the modified and unmodified loans, as well as unobserved differences that can be statistically inferred from the model. For example, subtracting out the selection effects yields the unbiased ATET, which is 40.0 percentage points for 2010 HAMP-modified loans and 33.0 percentage points for 2010 non-HAMP modified loans. This represents the average reduction in adverse outcomes after 36 months for loans modified in 2010 (both HAMP and non-HAMP) compared to how loans with similar observed characteristics would have performed if they had not been modified.[16]

Table 5a: Average Treatment and Selection Effects on Modified Loans, 2010 Base Date, 36 Month Time Window

Estimated Selection and Treatment of Modified Loans	Unmodified	HAMP	Non-HAMP
Probability of 90+ DLQ Within 36 months of Modification	85.5%	35.3%	47.5%
Total Observed Effect		50.2%	38.1%
Total Selection Effects		10.2%	5.1%
Total Treatment Effects		40.0%	33.0%

Table 5b: Average Treatment and Selection Effects on Modified Loans, 2011 Base Date, 24 Month Time Window

Estimated Selection and Treatment of Modified Loans	Unmodified	HAMP	Non-HAMP
Probability of 90+ DLQ Within 24 Months of Modification	83.3%	20.5%	33.2%
Total Observed Effect		62.8%	50.0%
Total Selection Effects		12.0%	16.6%
Total Treatment Effects		50.9%	33.4%

The estimated selection effects for both HAMP and non-HAMP modifications are substantial, typically accounting for 13 to 33 percent of the observed differences in outcomes from unmodified loans.[17] But even after correcting for these selection effects, the remaining treatment effects of modifying a loan are both statistically and economically significant. Furthermore, the

[16] The sample selection technique is intended to simulate the effect of a controlled trial in which loans would be randomly selected to receive a modification. Limitations in the sample selection model do not allow for the measurement of how effective the HAMP program might have been had some of the loans that fell out of the program been able to then receive non-HAMP modifications. This is because it is too difficult to estimate what the actual terms of such modifications might have been, making it impossible to estimate an average treatment effect on the untreated loan.

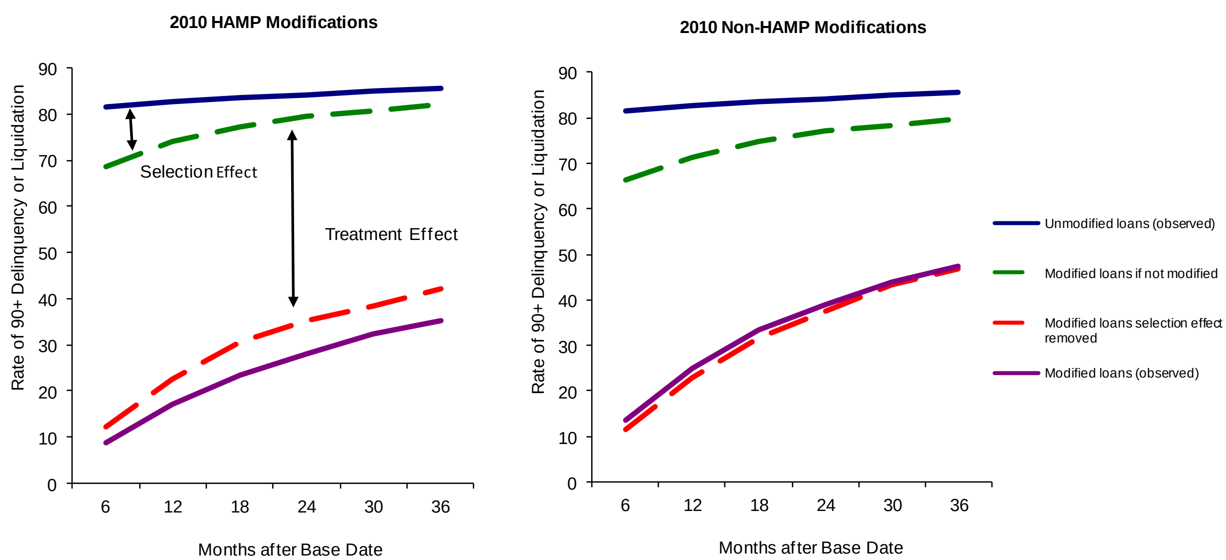
[17] A supplemental analysis of the HAMP program data supports this interpretation of modification selection effects. The participating servicers are required to report on borrowers who were evaluated for HAMP but did not ultimately receive a permanent modification. These loans are then said to have fallen out of the program. By comparing this program fallout data with CoreLogic derived history showing what happened to such loans afterwards, some additional details can be gleaned on the relationship between program selection and subsequent loan performance. The results of this investigation are described in Appendix IV.

estimated unbiased treatment effects are more stable over time compared to the raw redefault rates, particularly for the HAMP-modified loans.

These same results can be depicted graphically. Figure 11 shows how the modeled selection and treatment effects for delinquent loans receiving HAMP and non-HAMP modifications in 2010 change over time following the modification. The largest component of the modeled selection effect (the gap between the top two curves) is due to unobserved differences between the observed unmodified population and what that population would have looked like had modification selection been random. This performance gap is more pronounced in the first 18 months after loan modification, though it still persists 36 months after the modification.

The gap implies that some of the loans which might have benefited from the HAMP program instead fell out somewhere between initial delinquency and a completed trial. For example, these borrowers may not have been able to submit the required documentation, or they might not have been able to complete the mandated trial period. In addition, borrowers executing a strategic default may have declined to participate in HAMP or may not have qualified due to a low debt-to-income ratio (high ability to pay).

Figure 11: Breakdown of Estimated Selection and Treatment Effects of 2010 HAMP and Non-HAMP Loans



Selection bias also accounts for some of the observed performance differences between HAMP and non-HAMP modified loans. This effect is most pronounced for the loans modified in 2010, as shown in Figure 11, where selection effects act in opposite directions on the two loan populations. The regression analysis predicts that if loans had been randomly assigned to modification programs, expected overall HAMP performance would be worse, but non-HAMP performance would be better. This implies that a number of the loans that fell out of the HAMP pipeline but then received proprietary modifications during this time period had higher than average risk characteristics.

After accounting for all selection effects, the remaining difference between the performance of modified and unmodified loans is the estimated treatment effect of the modification. In econometric terms, this is known as a bias-adjusted or “pure” average treatment effect on the treated population (ATET). It compares the performance of modified loans to that of similar, unmodified loans, where “similar” includes not only observed data such as MTMLTV, but also unobserved factors, such as a borrower’s recent financial history or their attitude towards strategic default. Table 5c shows the estimated ATET for HAMP and non-HAMP modifications for all of the base year populations and time windows used in the study.

Table 5c: Average Treatment Effect, with Sample Selection Effects Removed (Numbers Show Percentage Point Decrease in Likelihood of Redefault)

Modification Vintage	Months Post Modification					
	6	12	18	24	30	36
2010 HAMP	56	51	47	44	42	40
2010 Non-HAMP	55	48	43	40	35	33
2011 HAMP	64	60	55	51		
2011 Non-HAMP	54	43	37	33		

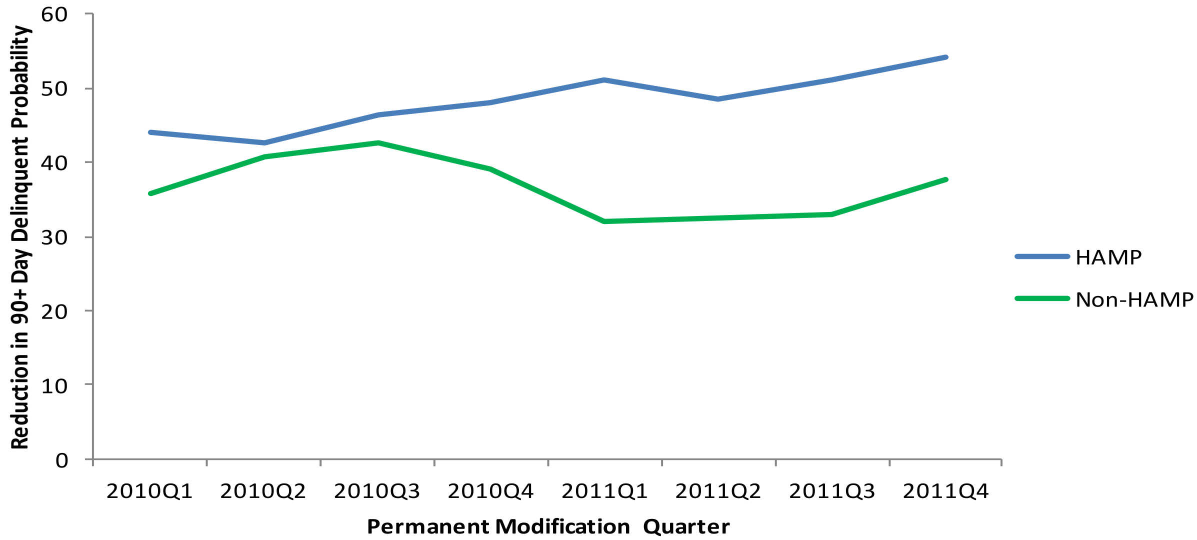
These results validate **Hypothesis 1:** even when controlling for borrower and loan characteristics, modifying a loan has a statistically and economically significant effect that persists over time. A given HAMP-eligible delinquent PLS loan is estimated to be 40 percentage points less likely to be seriously delinquent after 36 months than if it had not been modified.

Hypothesis 2 is also confirmed but more strongly for modifications made in 2011 than in 2010. In general, HAMP modifications outperform non-HAMP modifications even when controlling for observed and unobserved loan characteristics. This is true across all time intervals analyzed and across modification vintages. At 24 months, the ATET for 2011 HAMP modifications is 18 percentage points greater than for non-HAMP modifications and at 36 months the ATET for 2010 HAMP modifications is seven percentage points higher than for non-HAMP modifications.

The evolution of modification program outcomes can be seen in Figure 12, which details the 24 month average treatment effects for cohorts of loans modified in each quarter of 2010 and 2011. Non-HAMP and HAMP modifications perform similarly through the early parts of 2010. This coincides with a period in which HAMP servicers were converting a number of loans that had been in lengthy trial periods to permanent modifications.

By the fourth quarter of 2010, the HAMP program rules had been updated so that servicers were required to verify borrower income and assets prior to initiating a trial; from this point forward, HAMP modifications consistently show significantly larger treatment effects than non-HAMP modifications. At the same time, the average selection bias effect for non-HAMP modifications increased substantially in the second half of 2011, while the pure treatment effects declined. This suggests that some lenders may have expanded their proprietary modification programs in ways that brought in a lower risk loan population, artificially lowering the observed redefault rates.

Figure 12: Average Treatment Effect on the Treated (Modified) Population, at 24 Months Post Modification, by Quarter of Permanent Modification



Some of the differences in the treatment effect of modifying a loan under HAMP versus modifying a loan outside of HAMP likely reflect the degree of the modification's payment reduction. In general, the payment reduction in HAMP modifications is 23 percent greater than in non-HAMP modifications, even though modifications that did not reduce payments (almost entirely non-HAMP) were removed from consideration. Table 6 shows these differences, broken down by modification type.

Table 6: Modification Terms of Study Population HAMP and Non-HAMP Modifications

Modification Terms	All Modifications		UPB Not Reduced		UPB Reduced	
	Non-HAMP	HAMP	Non-HAMP	HAMP	Non-HAMP	HAMP
# of Loans	219,438	163,806	194,785	123,224	24,653	40,582
% Payment Change	-31.9%	-39.1%	-29.2%	-34.7%	-53.3%	-52.2%
Payment Pre-Modification	$1,541	$1,711	$1,522	$1,684	$1,688	$1,793
Payment Post-Modification	$1,030	$1,022	$1,062	$1,082	$780	$838
Rate Pre-Modification	7.44%	7.29%	7.5%	7.4%	7.1%	6.9%
Rate Post-Modification	3.90%	3.11%	4.0%	3.1%	3.2%	3.1%
% UPB Change	4.40%	-0.9%	8.5%	7.2%	-27.7%	-25.4%
MTMLTV Pre-Modification	137%	146%	135%	143%	153%	157%
MTMLTV Post-Modification	141%	144%	144%	151%	117%	123%

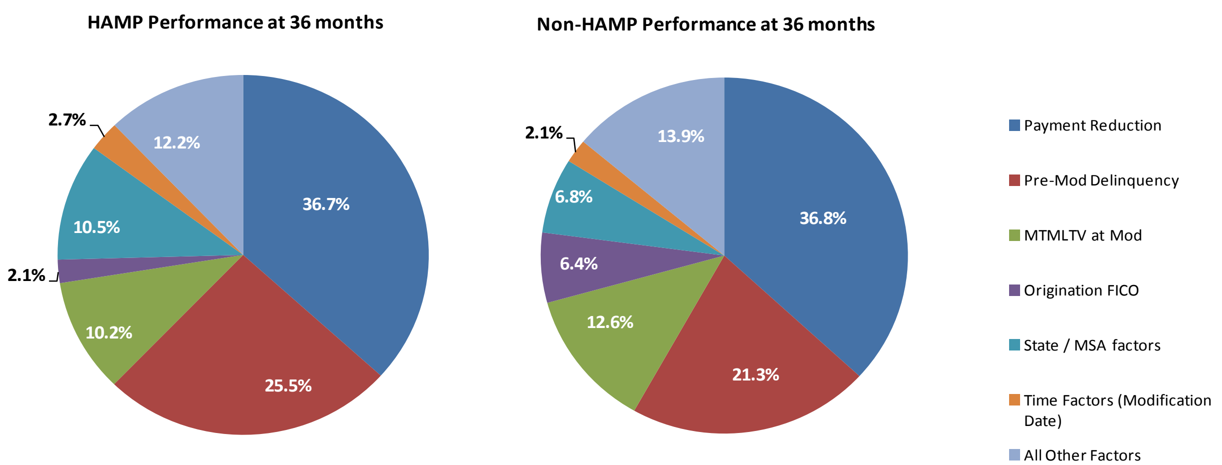
By breaking down the population of modified loans into unpaid principal balance (UPB)-reducing and non-UPB reducing, one can see that both rate and payment reductions were larger for HAMP modifications than non-HAMP modifications, even when forgiveness and forbearance were not included.

Note that the CoreLogic database reporting of UPB changes has significant limitations. For example, the database does not properly distinguish between UPB-reducing modifications with forbearance and those without forbearance. Due to this and similar limitations, it is difficult to use the CoreLogic data to evaluate the effectiveness of principal forgiveness or forbearance.

Relative Importance of Factors Driving Modification Performance

Hypothesis 3 asks whether payment reduction or some other factor is the most significant in determining performance after a modification. To answer this question, this study used an analysis of the variance from the outcome regressions for HAMP and non-HAMP modified loans. For example, Figure 13 shows a breakdown of the variance in post-modification performance at 36 months for loans modified in 2010. The performance indicator is each loan's logit score ($x\beta$) that drives its predicted chance of becoming 90 days or more delinquent after three years. A higher percentage indicates that a given *single* factor accounts for a greater proportion of the difference in adverse outcomes between loans. Note that the interactions between factors (covariances), which can be positive or negative, are included in the residual category of "all other factors".

Figure 13: Analysis of Variance, 2010 HAMP and Non-HAMP Modifications



As shown above, the most important factors impacting post-modification performance for both HAMP and non-HAMP modifications were the level of payment reduction and the level of borrower delinquency prior to the modification.

Table 7: Impact of Payment Change and Delinquency at Modification Over Time

Modification Type & Vintage	6 Mths		12 Mths		18 Mths		24 Mths		30 Mths		36 Mths	
	Pmt	DLQ	Pmt	DLQ	Pmt	DLQ	Pmt	DLQ	Pmt	DLQ	Pmt	DLQ
2010 HAMP	23%	34%	28%	33%	31%	31%	34%	30%	35%	27%	37%	26%
2010 Non-HAMP	28%	27%	35%	26%	36%	26%	38%	25%	36%	23%	37%	21%
2011 HAMP	27%	31%	32%	31%	35%	28%	38%	30%				
2011 Non-HAMP	33%	25%	35%	22%	35%	22%	37%	20%				

Table 7 shows how the relative contributions of payment change and pre-modification delinquency change over time. Generally, payment change becomes more significant in predicting performance by 12 months and beyond the base date, while the importance of pre-modification delinquency declines over time, thus confirming **Hypothesis 3 –** that payment change is the single most important driver of modification performance over the medium and long term. Other factors, such as the borrower's MTMLTV and credit score (for which CoreLogic only provides data at origination), do not account for as much of a difference in outcomes.

MTMLTV Effects

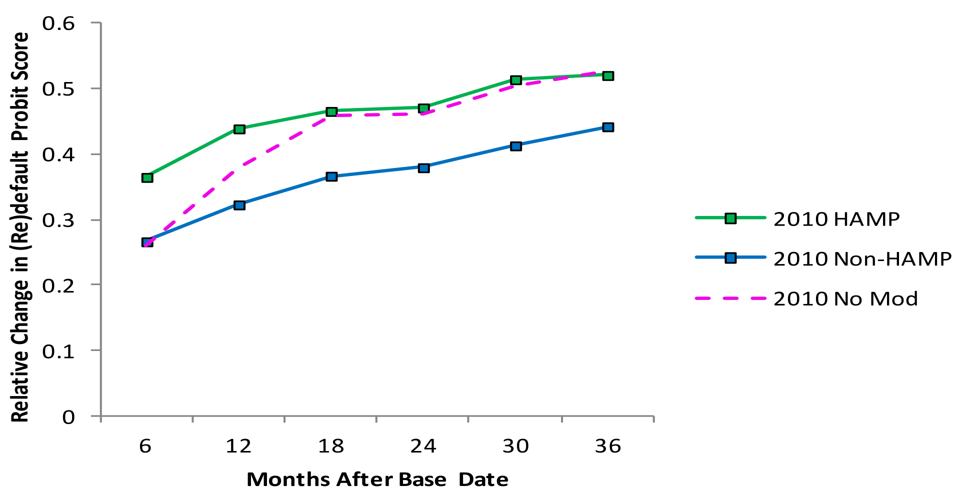
The current study analyzed the degree to which a borrower's level of (possibly negative) equity influenced loan performance across all three sub-populations. The MTMLTV for modified loans is taken to be the ratio of post-modification loan balance to the estimated home value. Appendix III describes in detail how MTMLTV at the base month was calculated.

As discussed in the previous sections, a limitation of the CoreLogic data affecting MTMLTV measurements for modified loans is the way in which principal forgiveness and forbearance are reported. Servicers do not appear to have used consistent procedures in updating a loan's principal balance when forgiveness or forbearance is applied. This makes it impossible to directly assess the impact of principal forgiveness within this population.

Figure 14 shows the estimated sensitivity of borrower default or redefault to MTMLTV at the modification date (or equivalent base month). The effects were measured in terms of the change in probit score for the default or redefault estimation associated with a 100 percent difference in MTMLTV. A higher probit score indicates a higher likelihood of default or redefault associated with the borrower being further underwater.

Generally, the redefault sensitivities to MTMLTV at six to 36 months after modification are similar in magnitude to the equivalent default sensitivity for unmodified loans, with HAMP-modified loans being more sensitive to MTMLTV than non-HAMP modified loans. Also, MTMLTV sensitivity is seen to increase slightly over time, although this difference could be partially due to changes in the economic environment.

Figure 14: Default/Redefault Sensitivity to MTMLTV



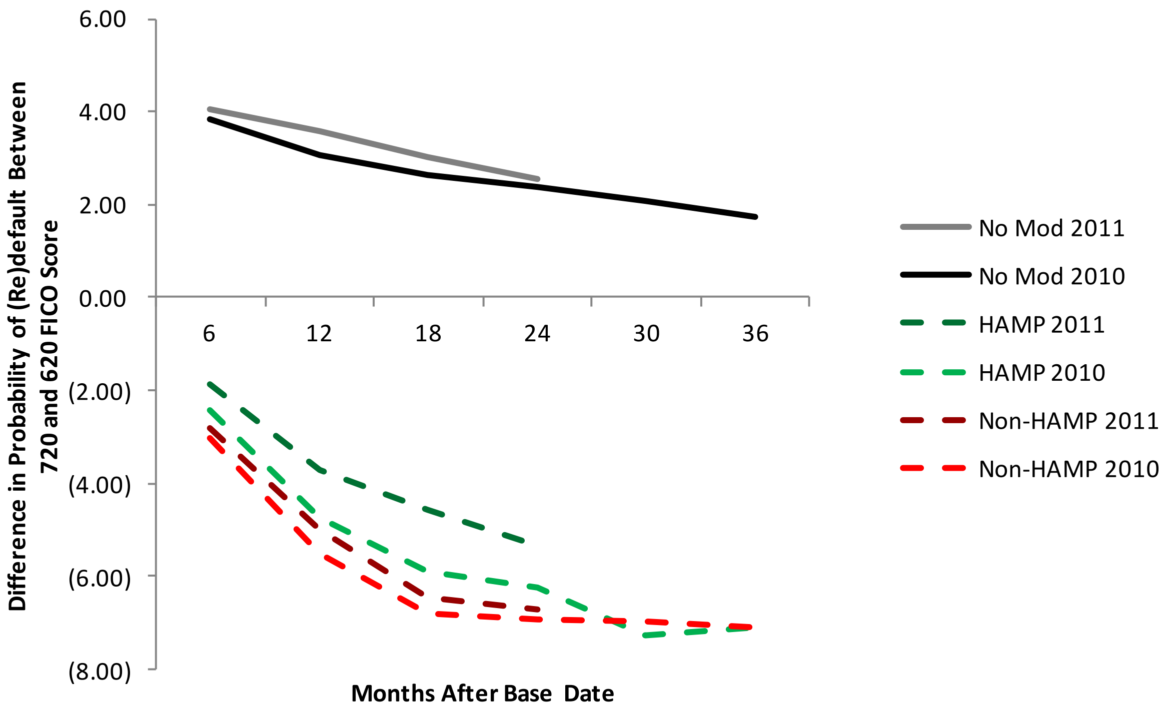
Borrower Credit Score

Although the HAMP database includes a borrower's credit score, or FICO, at the time of evaluation for a modification, this figure will be greatly affected by the borrower's recent mortgage delinquency. The CoreLogic data, which provides a FICO score at the time of loan origination, is a more independent measure of the impact of prior credit history on subsequent mortgage delinquency.

As shown in Table A4 in the appendix, the origination FICO was estimated in the outcome regression using a quadratic relationship; however, the second order term was usually fairly small, so the effect of FICO on subsequent default is roughly linear. Comparing two hypothetical, average borrowers, one with a 620 score and the other with 720, using the regression estimates, one can then measure the relative impact of a 100 point increase in FICO score on subsequent predicted default or redefault rates.

Normally, higher credit scores are associated with lower predicted defaults, with this difference increasing over time. This is, in fact, confirmed for modified loans. As shown in Figure 15, for non-HAMP loans modified in 2010, the high FICO loans are about seven percentage points less likely to redefault than low FICO loans. The differences between high and low FICO loans level off after 18 months, suggesting that prior credit history only affects the early redefaults, and not the long-term performance of a modification.

Figure 15: Estimated Impact of Credit Score at Loan Origination on Modification Default/Redefault



The most surprising results are those for unmodified loans. Borrowers with high FICO at origination who become delinquent and do not get a modification are significantly *more* likely to become or remain seriously delinquent (SDQ) six months later, by about three percentage points, than those who had lower FICO at origination. But after this initial period, the default rates for higher FICO borrowers then decline as expected.

A possible explanation for this effect is that it stems from borrowers with negative equity who are defaulting strategically. Some prior studies on strategic default have shown that the typical profile of such a borrower is indeed someone with a *high* FICO who suddenly "straight rolls" from current to seriously delinquent.[18] Such borrowers are also unlikely to consider a mortgage modification unless it entails significant principal forgiveness, and they may not qualify for a modification in any case if they cannot demonstrate financial hardship. This creates an initial spike in SDQ rates for high FICO borrowers with no mortgage modifications. Afterwards, though, there is no change in status for the strategic defaulters, but other high FICO borrowers who are not strategic defaulters are then slightly more likely to become current than low FICO borrowers, causing the FICO effect to move in the direction of better outcomes over time (downward), just as it does for borrowers who received modifications.

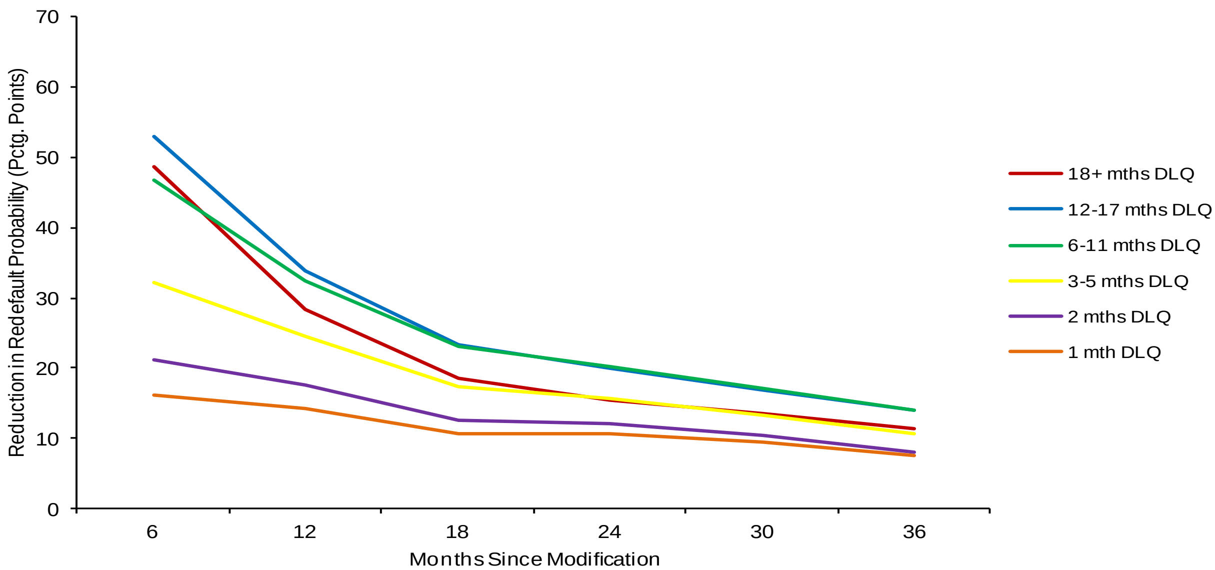
Delinquency at Time of Modification

While the analysis confirms the proposition that payment change is the single most important driver of modification performance, both the raw redefault results and the variance analysis paint a more complex picture. In addition to the longer term effect of payment reduction, there is also a significant short to medium term effect stemming from the process of making the borrower current after a delinquency and having the borrower recommit to regular mortgage payments.[19]

Isolating this "reset effect" is important in evaluating **Hypotheses 4 and 5**. It can be investigated in more detail by comparing the estimated treatment effects (again, controlling for selection bias) for subsets of loans that had different levels of initial delinquency. To isolate the reset effect as much as possible, the study population was restricted to modifications that did not significantly reduce the loan UPB (which would be associated with forgiveness or forbearance). In addition, the ATET has been adjusted to remove all of the estimated effects of payment reduction associated with the modification. The remaining unbiased treatment effect is thus intended to measure only those effects that have nothing to do with the changes in loan terms (aside from capitalization of accrued interest) but instead must stem from the modification experience itself. Figure 16 shows these pure modification treatment effects for loans that received HAMP modifications in 2010.

[18] See, for example, (Fair Isaac Co., 2011).
[19] As discussed earlier, a likely third factor, principal reduction, is difficult to measure with CoreLogic data.

Figure 16: Treatment Effect for 2010 HAMP Modifications by Delinquency at Time of Modification



In this graph, the magnitude of the treatment effect associated with making a borrower current can be seen as the vertical difference between the curves. The height of the bottommost curve indicates the residual treatment effect for borrowers who were only one month delinquent at time of modification.[20]

As expected, the effect of making a borrower current is strongly affected by the borrower's initial degree of delinquency, at least in the early months after modification. There is nearly a 35 percentage point difference in estimated treatment effects at six months after the modification between borrowers who were only one month delinquent and those who were 18 months or more delinquent. A borrower who stopped making payments for a long period of time (more than 18 months), receives a modification, and makes it through a trial period initially does very well. However, many of these borrowers with high initial delinquency then redefault within the next two years. By 36 months after the HAMP modification, there is only a four percentage point difference in redefault rates (adjusted for modification terms and other borrower characteristics) between the borrowers with high (more than 18 months) and low (one month) initial delinquency. Given the relative slopes of treatment effects across these subgroups of loans, it is reasonable to project that these differences in the reset effect for borrowers with different degrees of delinquency at the time of modification would largely disappear approximately five years after the modification.

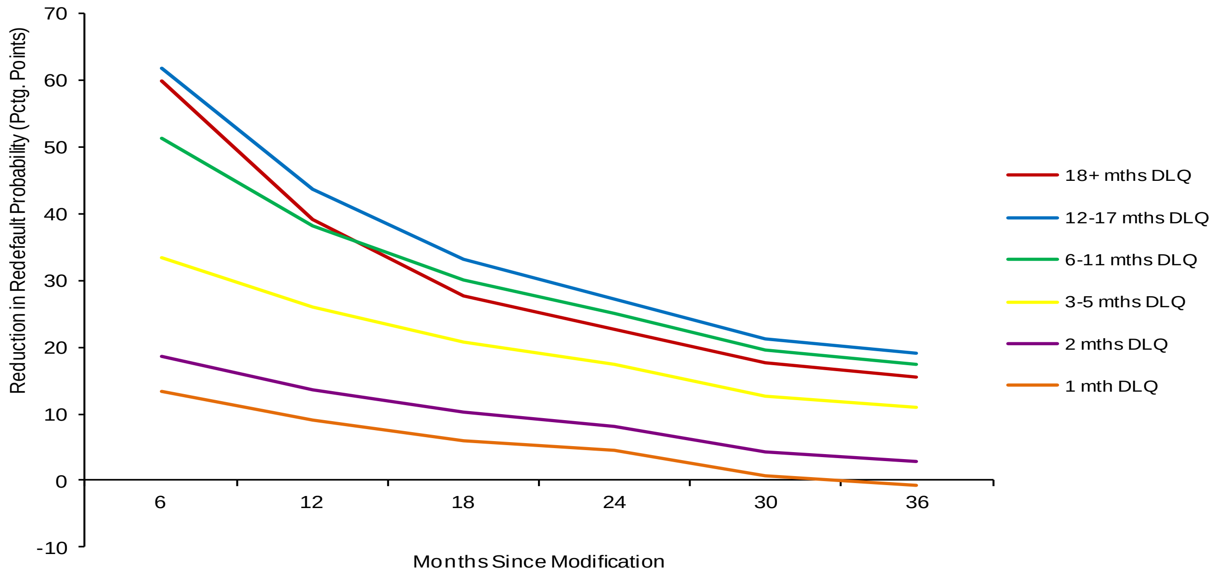
Notice that the process of receiving a HAMP modification appears to have a residual long-term effect on borrower performance – there is a roughly 10 percentage point improvement in redefault risk that is unrelated to selection effects, borrower characteristics, changes in loan

[20] Because of estimation issues, borrowers who were current prior to their modification are not included in the study, but it is reasonable to assume that their performance would be similar to those of the one-month-delinquent cohort. Both groups of borrowers are more likely to have proactively contacted their lender to seek a modification, rather than being solicited after passing a two-month delinquency threshold.

terms, or initial delinquency. The reasons for this – what can be characterized as the pure treatment effect or "reset effect" of the HAMP program – are not clear. Whether or not this "reset effect" will endure beyond the 36 months for which data currently exists is also not clear and will merit further study.

Significantly, the reset effect appears to persist longer for non-HAMP loans, but the pure treatment effect appears to persist longer for HAMP loans, as seen in Figure 17. As with HAMP modifications, the differences in redefault rates across groups of borrowers with different degrees of delinquency at trial dissipates rapidly, though it appears to still be significant at month 30. Unlike HAMP modifications, it appears that with time, the pure treatment effects will disappear altogether for loans with a pre-modification delinquency of less than six months. It is unclear how long this effect will remain for loans with other pre-modification delinquency levels.

Figure 17: Treatment Effect for 2010 Non-HAMP Modifications by Delinquency at Time of Modification



Going back to the original hypotheses, this analysis of the reset effect of modifications partially confirms **Hypothesis 4.** While the reset effect appears to dissipate more rapidly for HAMP modifications than for non-HAMP modifications, there appear to be pure treatment effects from HAMP modifications that non-HAMP modifications do not maintain. Similarly, this part of the analysis suggests a mixed result on **Hypothesis 5**: when controlling for changes in the loan terms, the pure act of resetting a loan to current has a strong short to medium term effect for both HAMP and non-HAMP modifications. However, for HAMP modifications this effect largely disappears in the long run and it is unclear whether this effect will remain for the non-HAMP population.

Payment Change Effects

To further test **Hypotheses 4 and 5**, the analysis also looked deeper into the presumably more permanent benefit of making the borrower's loan more affordable. In particular, the analysis sought to determine whether or not payment changes significantly affect borrower performance even when controlling for selection bias, and whether there is any difference in the effect of payment reduction between HAMP and non-HAMP modifications.

As noted in Table 6, even when restricting to modifications that reduce payments, the average HAMP modification is somewhat more generous in terms of the average level of payment reduction (about 39 percent) compared to non-HAMP modifications (about 32 percent).

The regressions in this study on borrower redefault controlled for the borrower's delinquency at the time of modification (and thus the amount of capitalized interest), as well as the level of payment change. The square of the payment change amount was also included as a covariate, in order to capture the diminishing effects of very large payment reductions on redefault levels.[21]

Figure 18: Reduction in Redefault Probability 24 Months after Base Month by Payment Reduction Percentage

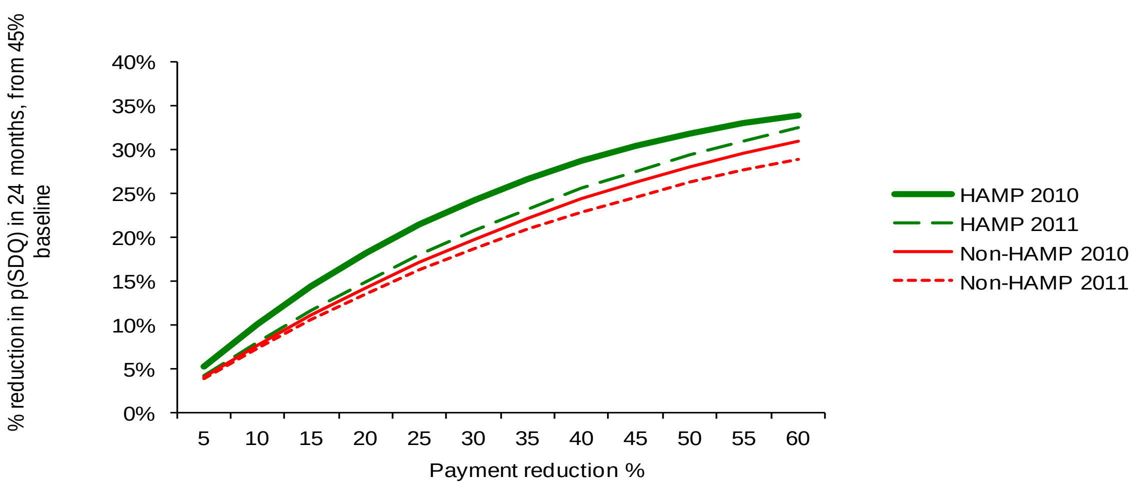


Figure 18 compares the redefault response at 24 months for different levels of payment reduction, for the 2010 and 2011 HAMP and non-HAMP modifications. Here, the estimated probit coefficients from these regressions have been applied to an average loan from the overall

[21] As mentioned earlier, the CoreLogic database does not track whether forbearance or forgiveness was included in a modification. Because of this, payment change effects of modifications may be conflated in a regression analysis with these other factors affecting the borrower's principal balance. To minimize this mixing of effects in the data, a separate regression analysis was performed on the subset of HAMP and non-HAMP modifications in which the borrower's UPB was not significantly reduced. Cross checking the HAMP-modified portion of this subpopulation to known HAMP modification characteristics significantly reduced the number of modifications with forgiveness or forbearance and reduced the possible confounding effects of forbearance and forgiveness to the order of magnitude of 10 percent of the reported results.

population of modified loans (both HAMP and non-HAMP), which was assumed to have (for purposes of creating a comparison baseline) a 45 percent chance of an adverse outcome after 24 months if the loan were made current but the payment was not reduced. The results are then shown in terms of the reduction in the loan's likelihood of redefault.

As expected, the level of payment reduction has a very significant effect on expected redefault. For example, for a 2011 non-HAMP loan modification with a 30 percent payment reduction, the estimated likelihood of redefault within 24 months has been reduced by about 20 percentage points – so, from 45 percent to just above 25 percent. At the average payment change level for HAMP modifications (39 percent), the risk of redefault is more than cut in half for the 2010 HAMP modifications (from 45 percent to about 16 percent) due solely to the change in payments (i.e., without counting other effects such as making the delinquent loan current or reducing principal balances).

Treatment Effects of Equivalent HAMP and Non-HAMP Modifications

Using these results for the effect of different levels of payment reduction on modification outcomes, **Hypothesis 4** can be tested by constructing a comparison of the average treatment effect (the number of percentage points by which default probability was reduced) of HAMP and non-HAMP modifications that have identical modification terms.

The structure of this test is similar to that presented previously in Table 5c, in which selection bias effects were isolated from treatment effects. However, instead of measuring treatment effects of each type of modification on its own population, the new test measures the average treatment effect of both HAMP and non-HAMP modifications on a combined population of loans that received either type of modification. In order to control as much as possible for the effects of different rates of principal forgiveness, the regression is estimated only on those modifications that did not reduce the loan's principal balance, measuring the effect of HAMP and non-HAMP modifications that offer the *same* amount of monthly payment reduction. This comparison therefore controls for loan and borrower characteristics, for selection bias, and for the terms of the modification.

Tables 8a and 8b show the results of this analysis for modifications that reduce borrower payments by 20% and 40%, respectively.

Table 8a: Average Treatment Effect of Rate/Term Modification with 20 Percent Payment Reduction, by Modification Program
(Effects are expressed as the percentage point reduction in redefault probability, averaged over a population of PLS loans that had received either HAMP or non-HAMP modifications.)

Modification Type	Months Post Modification					
	6	12	18	24	30	36
2010 HAMP	51.0%	44.2%	38.2%	**35.5%**	**32.9%**	**30.2%**
2010 Non-HAMP	**53.2%**	**45.3%**	**38.6%**	34.5%	29.3%	26.9%
2011 HAMP	**58.8%**	**52.6%**	**45.9%**	**42.1%**		
2011 Non-HAMP	55.2%	41.5%	34.7%	30.3%		

Table 8b: Average Treatment Effect of Rate/Term Modification with 40 Percent Payment Reduction, by Modification Program

(Effects are expressed as the percentage point reduction in redefault probability, averaged over a population of PLS loans that had received either HAMP or non-HAMP modifications.)

	Months Post Modification					
Modification Type	**6**	**12**	**18**	**24**	**30**	**36**
2010 HAMP	56.7%	53.8%	**50.5%**	**49.0%**	**46.9%**	**44.9%**
2010 Non-HAMP	**57.9%**	**54.0%**	49.5%	46.4%	41.6%	39.3%
2011 HAMP	**61.7%**	**59.2%**	**55.2%**	**52.9%**		
2011 Non-HAMP	58.8%	49.6%	44.4%	41.0%		

These results generally validate **Hypothesis 4.** The short term treatment effects of non-HAMP modifications made in 2010 are found to be slightly better than those of HAMP modifications. However, treatment effects at 18 months and onward are higher for the 2010 HAMP modifications. The outcomes for modifications made in 2011 consistently favor the HAMP program.

V. CONCLUSIONS

By combining a comprehensive subprime loan performance database with HAMP program administration data, HAMP-modified loans can be compared to unmodified loans and to loans receiving lenders' proprietary modifications. This allows the modification treatment effects to be isolated from loan and borrower characteristics, as well as bias stemming from non-random program participation.

The results of this study reinforce a number of prior findings on the performance of loan modifications, while also breaking new ground. As prior studies have indicated,[22] reducing a borrower's monthly mortgage payments continues to be the primary driver of long-term modification effectiveness. HAMP modifications continue to offer, on average, higher levels of payment reductions than non-HAMP modifications, which makes them more effective in reducing borrower redefault rates. But even when comparing modifications with the *same* level of payment reduction and other terms made to similar loans, the HAMP treatment effects observed in 2012 and 2013 were substantially lower than those of non-HAMP modifications.

The cause of this advantage would be a topic for future research. Possible factors that could have influenced outcomes, but were not incorporated into our analysis, are the HAMP program's borrower and servicer incentive payments. For example, program subsidies that reward servicers when borrowers continue to make payments may have caused those servicers to devote more resources to HAMP modified loans. The timing of the improvements in HAMP performance seen in Tables 8a and 8b strongly suggests that the changes to the HAMP program that were made over the course of 2010, such as requiring a servicer single-point-of-contact (SPOC), and mandating that borrowers document a financial hardship prior to entering a trial modification, had a substantial beneficial effect on the program's effectiveness.

[22] See e.g. Goodman, et al (2013).

This study also finds higher redefault risks associated with underwater borrowers, indicating that principal reduction may also have a substantial (though secondary) impact on borrower redefault rates, as observed in studies of the HAMP PRA program.[23] But there is also evidence that borrowers with negative equity who are less willing to continue making their mortgage payments also tend to select out of modification programs. This helps to explain why the remaining population of borrowers who do accept a modification are relatively less sensitive to changes in their MTMLTV.

Prior studies of the HAMP program have expressed concern over the initial rates of borrower redefaults, as measured up to three years after modifications.[24] The current analysis sheds some light on the drivers of these early redefault and suggests that the long-term program benefits may be greater than previously estimated. A substantial component of short-term modification performance, independent of the actual changes in loan terms, is associated with the process of resetting a delinquent borrower to "current" status and having the borrower commit to resuming monthly payments. This effect becomes more pronounced the longer the borrower was delinquent prior to the modification. However, this reset effect diminishes rapidly over time and would be expected to largely disappear by about five years after the modification. In contrast, the economic effects of the modification (by changing loan terms) either remain constant or only slightly diminish over time. This implies that redefault hazard rates for both HAMP and proprietary modifications should decline between three and five years after modification, ultimately leading to a lower foreclosure rate for borrowers receiving modifications than has been previously estimated.

[23] U.S. Treasury (2012), and Scarlemann and Shore (2013).
[24] E.g., SIGTARP (2013).

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Appendix I: Additional Tables and Charts

Table A1: 90 Days or More Delinquency Rate 24 Months After HAMP Modification by State & Territory

State	90+ Day Delinquency Rate
Alabama	34.0%
Alaska	27.7%
Arizona	28.0%
Arkansas	32.1%
California	19.9%
Colorado	22.9%
Connecticut	29.2%
Delaware	32.9%
District of Columbia	26.3%
Florida	26.8%
Georgia	29.5%
Guam	0.0%
Hawaii	21.3%
Idaho	26.4%
Illinois	28.2%
Indiana	30.4%
Iowa	32.5%
Kansas	32.1%
Kentucky	32.5%
Louisiana	34.9%
Maine	32.2%
Maryland	27.7%
Massachusetts	26.0%
Michigan	25.3%
Minnesota	27.3%
Mississippi	34.8%
Missouri	31.9%

State	90+ Day Delinquency Rate
Montana	22.3%
Nebraska	33.2%
Nevada	28.0%
New Hampshire	29.4%
New Jersey	30.4%
New Mexico	27.6%
New York	24.2%
North Carolina	31.0%
North Dakota	23.5%
Ohio	28.8%
Oklahoma	33.3%
Oregon	24.7%
Pennsylvania	32.0%
Puerto Rico	17.1%
Rhode Island	27.4%
South Carolina	31.4%
South Dakota	32.1%
Tennessee	33.9%
Texas	30.6%
Utah	24.1%
Vermont	27.4%
Virgin Islands	0.0%
Virginia	24.2%
Washington	26.8%
West Virginia	29.6%
Wisconsin	31.7%
Wyoming	25.6%

Table A2: Derivation of the PLS Loan Population

All loans in CoreLogic subprime database	**20,377,896**
Minus:	
a) Liquidated prior to Jan 2008	11,775,908
b) Not an owner occupied principal residence	1,343,158
c) Second lien	1,271,241
d) Origination date unknown	38
e) Property ZIP code unknown	9,763
f) Origination loan amount unknown	24
g) Missing or invalid property type	214
h) Jumbo loan (1)	124,157
i) Originated before 1976 (no HPI available) (2)	45
j) Missing or invalid UPB at mod	112
k) Missing or invalid delinquency at mod	10
Base population for sampling	**5,853,226**

1) For the purpose of this study, a jumbo loan is defined as a loan with an uncapitalized UPB greater than $729,750.

2) Based on the Home Price Index (HPI) developed for HAMP NPV evaluations.

Table A3: Origination Terms of the 2010 Study Population

2010	Not Modified		Non-HAMP Mod		HAMP Mod	
	#	%	#	%	#	%
Fixed Rate	108,527	36.17	56,848	38.5	37,697	36.99
ARM						
Monthly	28,675	9.6	8,861	6.0	5,496	5.4
2-year hybrid	91,405	30.5	50,347	34.1	35,231	34.6
3-year hybrid	29,605	9.9	14,243	9.7	10,498	10.3
5-year hybrid	32,767	10.9	13,898	9.4	10,109	9.9
7-year hybrid	3,664	1.2	1,471	1.0	1,094	1.1
10-year hybrid	3,458	1.2	1,335	0.9	1,456	1.4
Loan Term						
15 years	6,271	2.1	2,734	1.9	1,305	1.3
20 years	2,034	0.7	1,101	0.8	658	0.7
25 years	317	0.1	174	0.1	92	0.1
30 years	278,490	92.8	138,693	93.9	96,218	94.4
40 years	11,760	3.9	4,274	2.9	3,384	3.3
Negative Amortization						
Yes	36,964	12.3	11,463	7.8	7,234	7.1
No	178,980	59.7	94,169	63.8	57,869	56.8
Unknown	84,087	28.0	42,009	28.5	36,795	36.1
Documentation						
Full-Doc	142,897	47.6	76,694	51.9	2,418	1.6
Low-Doc	149,030	49.7	67,047	45.4	8,296	5.6
No-Doc	8,114	2.7	3,904	2.7	1,340	0.9
Loan Purpose						
Purchase	120,219	40.1	51,593	34.9	31,458	30.9
Rate/Term Refi	34,622	11.5	16,478	11.2	11,122	10.9
Cash-Out Refi	145,200	48.4	79,574	53.9	59,318	58.2

Table A3: Origination Terms of the 2010 Study Population (cont'd)

2010	Not Modified		Non-HAMP Mod		HAMP Mod	
	#	%	#	%	#	%
Property State						
California	60,123	20.0	33,264	22.5	26,925	26.4
Florida	48,311	16.1	16,004	10.8	11,955	11.7
Georgia	8,807	2.9	5,718	3.9	2,980	2.9
Illinois	12,520	4.2	6,661	4.5	4,978	4.9
Michigan	8,185	2.7	3,973	2.7	2,526	2.5
New Jersey	9,555	3.2	4,336	2.9	3,386	3.3
New York	16,143	5.4	8,005	5.4	6,052	5.9
Ohio	8,199	2.7	4,014	2.7	2,222	2.2
Pennsylvania	8,097	2.7	4,139	2.8	2,312	2.3
Texas	16,964	5.7	8,623	5.8	3,455	3.4
All Others	103,137	34.4	52,908	35.8	35,107	34.5
Origination Servicer (or successor)						
Ally/GMAC	6,207	2.1	5,057	3.4	2,151	2.1
Bank of America	28,444	9.5	6,453	4.4	3,576	3.5
Chase	34,541	11.5	14,288	9.7	15,111	14.8
Citibank	9,454	3.2	7,643	5.2	4,749	4.7
Ocwen	29,389	9.8	20,261	13.7	14,646	14.4
OneWest	9,150	3.1	1,989	1.4	5,809	5.7
SPS	4,204	1.4	1,391	0.9	4,129	4.1
Wells Fargo	16,906	5.6	15,378	10.4	3,807	3.7
Other or unknown	161,746	53.9	75,185	50.9	47,920	47.0
Balloon Type						
Fixed Ballon	7,300	2.4	4,854	3.3	4,344	4.3
ARM Ballon	24,395	8.1	14,588	9.9	13,188	12.9
Non-Balloon	268,346	89.4	128,203	86.8	84,366	82.8

Table A4: Origination Terms of the 2011 Study Population

2011	Not Modified		Non-HAMP Mod		HAMP Mod	
	#	%	#	%	#	%
Fixed Rate	90,788	38.86	31,510	43.89	25,900	41.84
ARM						
Monthly	23,085	9.9	3,963	5.5	6,274	10.1
2-year hybrid	64,857	27.8	22,413	31.2	15,431	24.9
3-year hybrid	21,998	9.4	6,775	9.4	5,299	8.6
5-year hybrid	25,413	10.9	5,437	7.6	6,667	10.8
7-year hybrid	3,097	1.3	730	1.0	921	1.5
10-year hybrid	2,843	1.2	719	1.0	1,142	1.8
Loan Term						
15 years	5,471	2.3	1,662	2.3	902	1.5
20 years	1,794	0.8	746	1.0	374	0.6
25 years	246	0.1	138	0.2	59	0.1
30 years	216,009	92.5	66,817	93.1	57,667	93.2
40 years	9,265	4.0	2,045	2.9	2,771	4.5
Negative Amortization						
Yes	30,049	12.9	5,254	7.3	8,509	13.7
No	138,768	59.4	45,802	63.8	34,451	55.7
Unknown	64,804	27.7	20,736	28.9	18,948	30.6
Documentation						
Full-Doc	112,638	48.2	38,962	54.3	26,757	43.2
Low-Doc	114,589	49.1	31,125	43.4	33,336	53.9
No-Doc	6,408	2.7	1,706	2.4	1,815	2.9
Loan Purpose						
Purchase	92,189	39.5	23,033	32.1	19,020	30.7
Rate/Term Refi	27,621	11.8	8,320	11.6	7,885	12.7
Cash-Out Refi	113,825	48.7	40,440	56.3	35,003	56.5

Table A4: Origination Terms of the 2011 Study Population (cont'd)

2011	Not Modified		Non-HAMP Mod		HAMP Mod	
	#	%	#	%	#	%
Property State						
California	42,287	18.1	14,292	19.9	18,110	29.3
Florida	38,544	16.5	7,624	10.6	7,395	12.0
Georgia	6,922	3.0	2,552	3.6	1,775	2.9
Illinois	9,819	4.2	3,166	4.4	2,837	4.6
Michigan	5,995	2.6	1,836	2.6	1,427	2.3
New Jersey	8,169	3.5	2,347	3.3	1,993	3.2
New York	13,762	5.9	4,864	6.8	3,733	6.0
Ohio	6,445	2.8	2,128	3.0	1,140	1.8
Pennsylvania	6,705	2.9	2,404	3.4	1,334	2.2
Texas	13,860	5.9	4,938	6.9	2,456	4.0
All Others	81,127	34.7	25,642	36	19,708	31.8
Origination Servicer (or successor)						
Ally/GMAC	4,096	1.8	1,477	2.1	1,084	1.8
Bank of America	24,552	10.5	3,238	4.5	5,251	8.5
Chase	28,165	12.1	6,199	8.6	11,327	18.3
Citibank	6,702	2.9	3,302	4.6	2,074	3.4
Ocwen	20,345	8.7	13,031	18.2	5,005	8.1
OneWest	6,903	3.0	464	0.7	2,729	4.4
SPS	2,710	1.2	711	1.0	754	1.2
Wells Fargo	11,719	5.0	3,823	5.3	2,229	3.6
Other or unknown	128,443	55.0	39,548	55.1	31,455	50.8
Balloon Type						
Fixed Ballon	5,509	2.4	2,369	3.3	2,310	3.7
ARM Ballon	16,432	7.0	6,677	9.3	5,805	9.4
Non-Balloon	211,694	90.6	62,747	87.4	53,793	86.9

Table A5: Distribution of Origination and Modification Terms, 2010 Population

Variable	Loans with Non-HAMP Modifications				Loans with HAMP Modifications			
	Min	Median	Max	Mean	Min	Median	Max	Mean
Initial DLQ months	1.00	7.00	36.00	9.06	1.00	7.00	36.00	8.85
% DLQ from origination	0.01	0.40	1.00	0.43	0.01	0.38	1.00	0.42
Pre-mod MTMLTV	0.00	0.98	3.00	1.04	0.01	1.04	3.00	1.10
Post-mod MTMLTV	0.00	1.03	3.03	1.09	0.01	1.06	3.01	1.11
Origination Backend DTI	0.00	0.40	0.94	0.40	0.00	0.40	0.95	0.41
Log(Origination UPB)	9.21	12.21	14.00	12.19	9.68	12.35	13.76	12.32
Log(Payment/MSA HP)	-11.21	-4.99	-2.38	-5.00	-10.71	-5.00	-2.85	-5.01
Credit Score (FICO - 680)/100	-2.92	-0.49	1.65	-0.49	-2.66	-0.48	1.48	-0.47
Origination LTV	0.02	0.80	3.29	0.80	0.06	0.80	1.15	0.80
Log(Zip code median household income)	7.82	10.91	12.43	10.93	7.82	10.92	12.24	10.93
Zip Code unemployment rate %	0.00	0.09	0.68	0.10	0.00	0.10	0.82	0.10
Zip Code % minority	0.00	0.37	1.00	0.43	0.00	0.41	1.00	0.45
Mod Payment Change %	-90.00	-28.59	-2.50	-30.84	-90.00	-39.10	-2.50	-39.07
Mod UPB Change %	-89.96	5.36	96.28	5.38	-87.25	4.06	95.39	1.35
Mod Rate Change %	-12.70	-3.49	5.85	-3.48	-12.99	-4.62	3.25	-4.40
Pre-mod UPB ($1000s)	0.16	199.37	1,202.50	241.15	3.87	229.22	948.91	261.82
Post-mod UPB ($1000s)	0.16	207.61	1,273.23	250.66	3.86	228.99	979.53	262.09
Pre-mod Rate	0.72	7.47	16.00	7.47	0.46	7.45	15.25	7.48
Post-mod Rate	0.50	4.00	14.99	3.99	1.13	2.00	13.74	3.08
Pre-mod Payment	1.90	1,347.44	37,330.26	1,555.65	11.73	1,526.39	10,140.68	1,705.85
Post-mod Payment	1.12	895.10	6,392.66	1,052.55	6.45	896.94	4,968.79	1,018.81

Variable	Loans Not Modified			
	Min	Median	Max	Mean
Initial DLQ months	1.00	9.00	36.00	11.08
% DLQ from origination	0.01	0.43	1.00	0.45
Pre-mod MTMLTV	0.00	0.99	3.00	1.06
Post-mod MTMLTV	0.00	0.99	3.00	1.06
Origination Backend DTI	0.00	0.40	0.92	0.40
Log(Origination UPB)	9.02	12.22	14.10	12.19
Log(Payment/MSA HP)	-8.01	-5.00	-2.64	-5.02
Credit Score (FICO - 680)/100	-2.80	-0.39	1.86	-0.40
Origination LTV	0.02	0.80	3.50	0.80
Log(Zip code median household income)	7.82	10.91	12.43	10.93
Zip Code unemployment rate %	0.00	0.09	1.00	0.10
Zip Code % minority	0.00	0.34	1.00	0.41
Mod Payment Change %	-89.96	-36.14	-2.50	-37.05
Mod UPB Change %	-89.76	2.80	96.68	-2.88
Mod Rate Change %	-13.53	-3.88	5.38	-3.65
Pre-mod UPB ($1000s)	0.00	200.00	1,323.00	241.89
Post-mod UPB ($1000s)	0.00	200.00	1,323.00	241.89
Pre-mod Rate	0.62	7.25	17.65	7.17
Post-mod Rate	0.75	2.75	13.88	3.52
Pre-mod Payment	28.10	1,409.30	7,320.98	1,608.45
Post-mod Payment	21.79	845.66	5,804.82	986.86

Table A6: Selection Model Probit Coefficients

Base Year:	2010 pr(mod)	2011 pr(mod)	2010 pr(HAMP)	2011 pr(HAMP)
Intercept	-4.313****	-4.784****	-2.691****	-3.235****
	(0.203)	(0.241)	(0.333)	(0.464)
Base Month in Q1	0.099****	0.129****	1.093****	-0.550****
	(0.013)	(0.016)	(0.052)	(0.074)
Base Month in Q2	0.115****	0.157****	0.691****	0.052
	(0.013)	(0.016)	(0.052)	(0.074)
Base Month in Q3	0.148****	0.079****	0.156***	0.182***
	(0.013)	(0.016)	(0.054)	(0.076)
Base Month in Q4				
Lambda-1 [1]*Q1			0.017	0.585****
	N/A	N/A	(0.079)	(0.105)
Lambda-1*Q2			0.238***	0.429****
	N/A	N/A	(0.079)	(0.105)
Lambda-1*Q3			0.413****	0.357***
	N/A	N/A	(0.079)	(0.104)
Lambda-1*Q4			0.401****	0.402****
	N/A	N/A	(0.078)	(0.104)
Base DLQ [2]	-0.083****	-0.005	-0.052****	-0.031***
	(0.005)	(0.006)	(0.011)	(0.012)
Base DLQ ^2	0.000	-0.003****	0.003****	0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Prior DLQ [3]	-0.705****	-1.411****	-2.601****	-3.828****
	(0.060)	(0.074)	(0.145)	(0.210)
Prior DLQ ^2	1.347****	2.400****	4.230****	5.613****
	(0.130)	(0.159)	(0.305)	(0.425)
Prior DLQ ^3	-0.860****	-1.368****	-2.341****	-2.879****
	(0.087)	(0.106)	(0.203)	(0.275)
Credit Score [4]	-0.118****	-0.131****	-0.006	-0.061**
	(0.010)	(0.012)	(0.020)	(0.027)
Credit Score ^2	0.004*	0.011***		
	(0.003)	(0.003)	N/A	N/A
Ln(Origination Amount)	0.114****	0.145****	0.088****	0.134****
	(0.010)	(0.012)	(0.010)	(0.015)
Orig Backend DTI	0.812****	0.377****	1.245****	3.877****
	(0.059)	(0.068)	(0.131)	(0.160)
Orig Backend DTI Missing	-0.022**	-0.057****	0.004	-0.033
	(0.011)	(0.014)	(0.023)	(0.032)
Ln(Med HH Inc in Zip)	0.097****	0.111****	-0.006	0.010
	(0.017)	(0.020)	(0.013)	(0.017)
Avg Unempl % in Zip	0.886****	(24295.70		
	(0.167)	0)	N/A	N/A
% Minority in Zip	0.189****	0.186****	0.019	0.141***
	(0.021)	(0.025)	(0.037)	(0.049)
15 year term	0.035	-0.154****	0.057**	0.007
	(0.031)	(0.037)	(0.025)	(0.031)
20 year term	0.189****	-0.016	0.110***	-0.017
	(0.051)	(0.059)	(0.035)	(0.045)
25 year term	0.284***	0.392***	-0.052	-0.028
	(0.122)	(0.114)	(0.089)	(0.110)
40 year term	-0.063*	0.040	-0.115****	-0.138****
	(0.038)	(0.048)	(0.018)	(0.022)

Base Year:	2010 pr(mod)	2011 pr(mod)	2010 pr(HAMP)	2011 pr(HAMP)
Monthly ARM	-0.413****	-0.262****	-0.602****	-0.171**
	(0.042)	(0.050)	(0.092)	(0.103)
2 yr Hybrid ARM	0.010	-0.073****	0.034*	-0.038
	(0.013)	(0.015)	(0.025)	(0.033)
3 yr Hybrid ARM	-0.045***	-0.142****	0.114***	0.033
	(0.017)	(0.020)	(0.034)	(0.045)
5 yr Hybrid ARM	-0.182****	-0.348****	-0.776****	-0.633****
	(0.016)	(0.022)	(0.039)	(0.060)
7 yr Hybrid ARM	-0.244****	-0.219****	-1.525****	-1.247****
	(0.046)	(0.057)	(0.172)	(0.177)
10 yr Hybrid ARM	-0.094*	-0.015	-1.418****	-0.691****
	(0.068)	(0.075)	(0.226)	(0.180)
Other Hybrid	-0.134**	0.066	-0.905***	-0.338*
	(0.073)	(0.092)	(0.246)	(0.222)
2 yr Interest Only	0.112*	0.050	0.320**	0.281*
	(0.075)	(0.078)	(0.140)	(0.174)
3 yr Interest Only	-0.193***	-0.230***	-0.614***	-0.423**
	(0.069)	(0.096)	(0.167)	(0.251)
5 yr Interest Only	0.006	-0.045**	0.004	0.101***
	(0.016)	(0.019)	(0.031)	(0.042)
10 yr interest Only	-0.151****	-0.179****	-0.484****	-0.253****
	(0.015)	(0.020)	(0.033)	(0.047)
Purchase	0.057****	0.076****	0.078***	-0.006
	(0.015)	(0.018)	(0.031)	(0.041)
Cash Out Refi	-0.032**	-0.035**	-0.064**	-0.078**
	(0.015)	(0.019)	(0.032)	(0.042)
Rate/Term Refi				
Low Doc	0.081****	0.117****	0.052****	0.144****
	(0.010)	(0.012)	(0.007)	(0.011)
No Doc	0.155****	0.187****	0.128****	0.287****
	(0.030)	(0.037)	(0.024)	(0.032)
Unknown Doc	-0.086**	-0.022	-0.092**	-0.007
	(0.049)	(0.056)	(0.047)	(0.060)
MTMLTV 80-90%	0.150****	0.178****	0.239****	0.244***
	(0.020)	(0.025)	(0.049)	(0.067)
MTMLTV 90-100%	0.221****	0.274****	0.412****	0.405****
	(0.020)	(0.025)	(0.050)	(0.068)
MTMLTV 100-110%	0.304****	0.319****	0.559****	0.435****
	(0.023)	(0.028)	(0.057)	(0.074)
MTMLTV 110-120%	0.333****	0.439****	0.599****	0.625****
	(0.027)	(0.032)	(0.064)	(0.086)
MTMLTV 120-130%	0.321****	0.454****	0.561****	0.475****
	(0.032)	(0.036)	(0.075)	(0.094)
MTMLTV 130-140%	0.371****	0.467****	0.583****	0.604****
	(0.035)	(0.042)	(0.082)	(0.107)
MTMLTV 140-150%	0.362****	0.511****	0.585****	0.660****
	(0.037)	(0.047)	(0.085)	(0.118)
MTMLTV 150-160%	0.379****	0.470****	0.692****	0.642****
	(0.041)	(0.050)	(0.093)	(0.123)
MTMLTV 160-170%	0.392****	0.499****	0.585****	0.769****
	(0.046)	(0.054)	(0.105)	(0.134)
MTMLTV 170-180%	0.356****	0.678****	0.810****	0.667****
	(0.059)	(0.063)	(0.132)	(0.156)
MTMLTV > 180%	0.394****	0.520****	0.996****	0.623****
	(0.055)	(0.056)	(0.120)	(0.140)
MTMLTV < 80%				

Key and Notes for Table 6: Selection Model Probit Coefficients:

*pr < 0.10

**pr < 0.05

***pr < 0.01

****pr < 0.0001

[1] Lambda-1 is the selection bias correction term (inverse Mills ratio) from the modification selection equation (see text).
[2] Base delinquency as of three months prior to the permanent modification date or equivalent base date.
[3] Prior delinquency is the percent of months borrower was at least 30 days delinquent, between origination and base months.
[4] Credit score has been normalized to (FICO – 680) / 100.

In addition to the factors shown in Table A6, the selection model also included instruments (factors that were found not to affect outcomes other than through modification selection) and other controls:

- Current servicer;
- Property state;
- Origination LTV;
- Missing origination credit score;
- Missing property ZIP demographics;
- Negative amortization flag;
- Balloon code;
- TPO Code;
- Flag if loan was transferred from a prior servicer; and,
- Base month delinquency interaction w/ MTMLTV.

In addition, the following interacted with current servicer:

- Mod/base date (year and quarter);
- Number of quarters after servicing transfer;
- Property state;
- Origination back-end DTI;
- Origination DTI missing flag;
- Borrower FICO;
- Mod/base date delinquency;
- Log of origination UPB;
- Origination year;
- Prior delinquency percent;
- Log of median household income in property ZIP;
- Percent minority in property ZIP;
- Balloon code;
- Loan purpose;
- ARM type;
- Interest-only term;
- Negative amortization flag;
- Origination term; and,
- Documentation level.

Table A7: Outcome Model Probit Coefficients (2010 Population)

Post Modification Period:	18 months			36 months		
2010 Base Date	HAMP	Non-HAMP	No Mod	HAMP	Non-HAMP	No Mod
Intercept	-0.861**** (0.174)	-1.015**** (0.118)	-1.834**** (0.090)	-1.046**** (0.160)	-0.949**** (0.114)	-1.729**** (0.091)
Modified in Q1	0.230*** (0.072)	0.008 (0.046)	0.114**** (0.017)	0.388**** (0.066)	0.095** (0.044)	0.104**** (0.018)
Modified in Q2	0.282**** (0.076)	-0.066* (0.047)	0.006 (0.018)	0.335**** (0.069)	-0.047 (0.046)	-0.010 (0.018)
Modified in Q3	0.150** (0.083)	-0.077* (0.048)	-0.006 (0.018)	0.164** (0.076)	-0.022 (0.046)	-0.022 (0.019)
Modified in Q4						
Lambda-1 / Q1 [1]	-0.162**** (0.030)	0.011 (0.023)	-1.180**** (0.039)	-0.169**** (0.027)	-0.008 (0.022)	-0.980**** (0.041)
Lambda-1 / Q2	-0.275**** (0.034)	0.099**** (0.024)	-1.273**** (0.042)	-0.223**** (0.032)	0.087*** (0.024)	-1.081**** (0.043)
Lambda-1 / Q3	-0.202**** (0.042)	0.106**** (0.025)	-1.222**** (0.047)	-0.168**** (0.039)	0.077*** (0.025)	-1.012**** (0.048)
Lambda-1 / Q4	-0.226**** (0.042)	-0.031 (0.025)	-1.279**** (0.051)	-0.129*** (0.038)	-0.026 (0.024)	-1.022**** (0.052)
Lambda-2 / Q1 [1]	-0.030 (0.026)	-0.105**** (0.020)	N/A	-0.022 (0.024)	-0.080**** (0.020)	N/A
Lambda-2 / Q2	0.063** (0.029)	0.016 (0.025)	N/A	0.052** (0.027)	0.008 (0.024)	N/A
Lambda-2 / Q3	0.015 (0.033)	0.173**** (0.033)	N/A	0.056** (0.030)	0.227**** (0.031)	N/A
Lambda-2 / Q4	0.108*** (0.034)	0.210**** (0.032)	N/A	0.095*** (0.031)	0.196**** (0.030)	N/A
Pre Mod Delinquency [3]	0.214**** (0.006)	0.154**** (0.005)	0.494**** (0.004)	0.208**** (0.006)	0.144**** (0.004)	0.419**** (0.005)
Pre Mod Delinquency ^ 2	-0.010**** (0.001)	-0.007**** (0.001)	-0.028**** (0.001)	-0.011**** (0.001)	-0.006**** (0.001)	-0.024**** (0.001)
Payment Change [4]	0.258**** (0.010)	0.198**** (0.007)	N/A	0.251**** (0.009)	0.187**** (0.007)	N/A
Payment Change ^ 2	0.014**** (0.001)	0.007**** (0.001)	N/A	0.010**** (0.001)	0.005**** (0.001)	N/A
No UPB reduction [5]	-0.005 (0.017)	-0.003 (0.016)	N/A	0.012 (0.015)	0.028** (0.015)	N/A
Credit Score [2]	-0.194**** (0.010)	-0.196**** (0.008)	0.113**** (0.007)	-0.188**** (0.009)	-0.184**** (0.007)	0.079**** (0.007)

Table A7: Outcome Model Probit Coefficients (2010 Population, cont'd)

Post Modification Period:	18 months			36 months		
2010 Base Date	HAMP	Non-HAMP	No Mod	HAMP	Non-HAMP	No Mod
MTMLTV < 80%						
MTMLTV 80-90%	0.076**** (0.020)	0.059**** (0.014)	0.151**** (0.011)	0.073**** (0.018)	0.085**** (0.013)	0.185**** (0.011)
MTMLTV 90-100%	0.128**** (0.020)	0.111**** (0.014)	0.220**** (0.012)	0.131**** (0.018)	0.157**** (0.013)	0.272**** (0.012)
MTMLTV 100-110%	0.162**** (0.020)	0.165**** (0.015)	0.263**** (0.014)	0.189**** (0.018)	0.212**** (0.014)	0.335**** (0.014)
MTMLTV 110-120%	0.220**** (0.022)	0.209**** (0.016)	0.334**** (0.017)	0.246**** (0.020)	0.287**** (0.016)	0.429**** (0.017)
MTMLTV 120-130%	0.251**** (0.024)	0.275**** (0.018)	0.374**** (0.020)	0.293**** (0.022)	0.349**** (0.017)	0.480**** (0.020)
MTMLTV 130-140%	0.325**** (0.027)	0.309**** (0.020)	0.425**** (0.022)	0.366**** (0.025)	0.372**** (0.020)	0.527**** (0.022)
MTMLTV 140-150%	0.383**** (0.029)	0.333**** (0.022)	0.468**** (0.024)	0.423**** (0.026)	0.411**** (0.022)	0.570**** (0.025)
MTMLTV 150-160%	0.413**** (0.030)	0.326**** (0.024)	0.500**** (0.026)	0.444**** (0.028)	0.426**** (0.024)	0.562**** (0.027)
MTMLTV 160-170%	0.426**** (0.032)	0.391**** (0.026)	0.483**** (0.029)	0.462**** (0.030)	0.480**** (0.025)	0.607**** (0.031)
MTMLTV 170-180%	0.481**** (0.035)	0.382**** (0.028)	0.607**** (0.036)	0.547**** (0.033)	0.487**** (0.027)	0.710**** (0.039)
MTMLTV > 180%	0.582**** (0.031)	0.490**** (0.024)	0.594**** (0.034)	0.635**** (0.029)	0.624**** (0.024)	0.722**** (0.037)
Insufficient Docs	N/A	-0.088**** (0.018)	0.146**** (0.023)	N/A	-0.134**** (0.017)	0.120**** (0.024)
Trial Not Accepted	N/A	0.092*** (0.033)	0.370**** (0.043)	N/A	0.100*** (0.032)	0.303**** (0.044)
Trial Failure	N/A	0.020 (0.024)	0.152**** (0.032)	N/A	0.018 (0.024)	0.182**** (0.033)
DTI at Eval <31%	N/A	-0.193**** (0.027)	-0.417**** (0.028)	N/A	-0.210**** (0.026)	-0.328**** (0.029)
NPV Negative	N/A	-0.255**** (0.028)	0.004 (0.036)	N/A	-0.204**** (0.026)	-0.011 (0.036)
Excessive Forbearance	N/A	-0.189**** (0.040)	0.322**** (0.051)	N/A	-0.190**** (0.037)	0.254**** (0.052)

Table A8: Outcome Model Probit Coefficients (2011 Population)

Post Modification Period:	12 months			24 months		
2011 Base Date	HAMP	Non-HAMP	No Mod	HAMP	Non-HAMP	No Mod
Intercept	-1.131**** (0.260)	-0.259* (0.187)	-0.868**** (0.104)	-0.439** (0.226)	-0.175 (0.172)	-0.859**** (0.102)
Modified in Q1	0.079 (0.116)	0.045 (0.071)	0.010 (0.020)	0.000 (0.100)	0.118** (0.066)	0.025* (0.019)
Modified in Q2	-0.005 (0.108)	0.048 (0.079)	-0.103**** (0.021)	0.028 (0.092)	0.083 (0.073)	-0.076**** (0.020)
Modified in Q3	0.065 (0.106)	0.104 (0.082)	-0.022 (0.020)	0.039 (0.091)	0.107* (0.076)	-0.002 (0.020)
Modified in Q4						
Lambda-1 / Q1 [1]	-0.082* (0.051)	-0.009 (0.032)	-1.853**** (0.054)	-0.103*** (0.044)	-0.046* (0.029)	-1.617**** (0.054)
Lambda-1 / Q2	-0.088** (0.052)	-0.023 (0.039)	-2.117**** (0.061)	-0.166**** (0.045)	-0.016 (0.036)	-1.864**** (0.061)
Lambda-1 / Q3	-0.212**** (0.054)	-0.079** (0.039)	-1.933**** (0.065)	-0.234**** (0.046)	-0.098*** (0.036)	-1.635**** (0.065)
Lambda-1 / Q4	-0.143*** (0.056)	-0.038 (0.040)	-1.851**** (0.066)	-0.198**** (0.048)	-0.063** (0.036)	-1.616**** (0.066)
Lambda-2 / Q1 [1]	0.131*** (0.046)	0.192**** (0.040)	N/A	0.124*** (0.040)	0.149**** (0.036)	N/A
Lambda-2 / Q2	0.213**** (0.047)	0.200**** (0.038)	N/A	0.173**** (0.041)	0.175**** (0.034)	N/A
Lambda-2 / Q3	0.329**** (0.054)	0.161**** (0.041)	N/A	0.216**** (0.048)	0.120*** (0.037)	N/A
Lambda-2 / Q4	0.230*** (0.065)	0.173*** (0.047)	N/A	0.172*** (0.056)	0.139*** (0.042)	N/A
Pre Mod Delinquency [3]	0.116**** (0.008)	0.052**** (0.006)	0.531**** (0.005)	0.122**** (0.007)	0.054**** (0.006)	0.445**** (0.005)
Pre Mod Delinquency ^ 2	-0.004**** (0.001)	0.000 (0.001)	-0.028**** (0.000)	-0.004**** (0.001)	0.000 (0.001)	-0.023**** (0.000)
Payment Change [4]	0.187**** (0.015)	0.189**** (0.011)	N/A	0.189**** (0.013)	0.191**** (0.010)	N/A
Payment Change ^ 2	0.006*** (0.002)	0.009**** (0.001)	N/A	0.003** (0.002)	0.008**** (0.001)	N/A
No UPB reduction [5]	-0.013 (0.019)	-0.016 (0.019)	N/A	-0.025* (0.016)	0.000 (0.017)	N/A
Credit Score [2]	-0.209**** (0.015)	-0.183**** (0.011)	0.145**** (0.008)	-0.207**** (0.013)	-0.192**** (0.010)	0.107**** (0.007)

Table A8: Outcome Model Probit Coefficients (2011 Population, cont'd)

Post Modification Period:	12 months			24 months		
2011 Base Date	HAMP	Non-HAMP	No Mod	HAMP	Non-HAMP	No Mod
MTMLTV < 80%						
MTMLTV 80-90%	-0.022 (0.028)	0.033** (0.020)	0.105**** (0.013)	0.016 (0.024)	0.061*** (0.018)	0.131**** (0.013)
MTMLTV 90-100%	0.016 (0.028)	0.061*** (0.021)	0.166**** (0.014)	0.070*** (0.024)	0.095**** (0.019)	0.211**** (0.014)
MTMLTV 100-110%	0.068*** (0.029)	0.104**** (0.022)	0.170**** (0.016)	0.100**** (0.025)	0.136**** (0.020)	0.239**** (0.015)
MTMLTV 110-120%	0.115*** (0.031)	0.158**** (0.024)	0.254**** (0.019)	0.174**** (0.027)	0.192**** (0.022)	0.331**** (0.018)
MTMLTV 120-130%	0.163**** (0.034)	0.230**** (0.027)	0.315**** (0.022)	0.200**** (0.030)	0.279**** (0.025)	0.378**** (0.021)
MTMLTV 130-140%	0.203**** (0.038)	0.253**** (0.031)	0.335**** (0.025)	0.291**** (0.033)	0.309**** (0.028)	0.440**** (0.025)
MTMLTV 140-150%	0.290**** (0.041)	0.283**** (0.034)	0.374**** (0.028)	0.314**** (0.036)	0.377**** (0.032)	0.466**** (0.028)
MTMLTV 150-160%	0.294**** (0.047)	0.380**** (0.037)	0.389**** (0.030)	0.325**** (0.041)	0.428**** (0.035)	0.481**** (0.029)
MTMLTV 160-170%	0.320**** (0.051)	0.355**** (0.042)	0.358**** (0.032)	0.402**** (0.044)	0.390**** (0.039)	0.484**** (0.032)
MTMLTV 170-180%	0.403**** (0.055)	0.394**** (0.046)	0.422**** (0.038)	0.439**** (0.049)	0.432**** (0.043)	0.516**** (0.038)
MTMLTV > 180%	0.453**** (0.045)	0.525**** (0.035)	0.494**** (0.033)	0.539**** (0.039)	0.632**** (0.033)	0.601**** (0.033)
Insufficient Docs	N/A	-0.070*** (0.029)	-0.061** (0.030)	N/A	-0.134**** (0.027)	-0.041* (0.030)
Trial Not Accepted	N/A	0.056 (0.048)	0.301**** (0.054)	N/A	0.002 (0.045)	0.245**** (0.052)
Trial Failure	N/A	0.157**** (0.034)	0.074** (0.041)	N/A	0.131**** (0.033)	0.033 (0.040)
DTI at Eval <31%	N/A	-0.218**** (0.049)	-0.254**** (0.040)	N/A	-0.197**** (0.044)	-0.180**** (0.040)
NPV Negative	N/A	-0.191**** (0.047)	-0.073* (0.049)	N/A	-0.223**** (0.042)	-0.063* (0.047)
Excessive Forbearance	N/A	-0.183*** (0.059)	0.174*** (0.062)	N/A	-0.146*** (0.051)	0.278**** (0.064)

Key and Notes for Table A7 and Table A8: Outcome Model Probit Coefficients:

*pr < 0.10
**pr < 0.05
***pr < 0.01
****pr < 0.0001

[1] Lambda-1 is the selection bias correction term (inverse Mills ratio) from the modification selection equation (see text); Lambda-2 is the corresponding term from the HAMP selection equation. Both terms are interacted with the (quarterly) date of permanent modification.

[2] Credit score has been normalized to (FICO – 680) / 100.
[3] Initial delinquency (normalized to units of 90 days), as of three months prior to the permanent modification date or equivalent base date.
[4] Modification payment change, normalized (e.g. -1.0 = 10 percent payment reduction).
[5] See text. Modifications with no reported substantial reduction in UPB are more likely to be rate/term changes only, with no principal forgiveness or forbearance.

In addition to the factors shown in Table A7, the outcome regressions also include the following controls:

- Log of origination UPB;
- Origination year;
- Percent minority in property ZIP;
- Unemployment rate in property ZIP;;
- Hybrid ARM period;
- Interest-only period;
- Loan purpose; and,
- Current servicer.

Appendix II: Econometric Model Details

The econometric theory of program evaluation describes two major factors that make it difficult to estimate the true effect of an economic program on its participants. The first is *selection bias:* because participants in a program are not randomly selected, and indeed may to some extent be self-selected, some of the apparent modification program benefits may simply be due to unobserved characteristics of the participating population that may make them less (or more) likely to default. The second is *out-of-sample estimation:* even when differences between the modified and unmodified population can be captured in covariates, such as MTMLTV, FICO scores, or initial delinquency status, a regression model fit to unmodified loans may not be accurate for a typical modified loan, and vice versa.

In this study, the main out-of-sample estimation issue is the difference in initial delinquency status. The populations of modified and unmodified loans do not differ from each other much along dimensions of credit score, MTMLTV, or loan origination features. However, the populations are skewed in that loans that become even 30 days delinquent are far more likely to receive a modification than loans that always remain current. It is also reasonable to assume that the subset of current borrowers who receive modifications (due to some change in hardship status that they proactively report to their servicer) differ substantially in unobserved ways from those not receiving modifications. As a result, a model based on unmodified default expectations for current borrowers will not accurately reflect the no-modification expectation for a current borrower who does receive a modification. For this reason, borrowers who were current prior to modification were excluded from this regression analysis.

The selection bias problem was approached using Heckman sample selection correction factors. Alternative methods were considered but rejected for a variety of reasons:

- Because there are significant unobserved characteristics that affect both selection and outcome (such as the borrower's current financial situation), propensity scoring, matching, and similar methods that rely on an unconfoundedness assumption have been ruled out.

- A difference-in-difference design was also considered, based on time frames before or after adoption of loan modification programs by servicers. This approach was abandoned because servicers' modification rates changed slowly over time and early HAMP modifications were not representative of the program as a whole.

- Various eligibility criteria for HAMP were considered for a regression discontinuity or instrumental variables analysis but were largely rejected. For example, investment properties are not eligible for Tier 1 HAMP modifications, but these loans also have very different performance characteristics than loans on a borrower's primary residence. Borrowers are also ineligible for HAMP if their DTI ratio is below 31 percent, but the borrower's current DTI is generally not known for loans that did not receive a HAMP modification.

- The available information on loans that were evaluated for HAMP NPV, while incomplete, does allow for the construction of experiments that are not possible for the broader loan population. Appendix V describes a regression discontinuity analysis of a subset of these loans, based on the NPV score.

In order to effectively identify the effects of selection bias on outcomes using the Heckman approach, it is important to isolate any factors that influence whether a delinquent loan gets modified, but do *not* affect loan's chance of progressing to a serious delinquency, other than through that selection effect. Such factors, analogous to the instruments in an instrumental variable regression, are then excluded from the outcome regression. Identifying these factors can be a challenge, as most characteristics of a loan or borrower that a servicer will use for selecting the borrower for modification are, in fact, the risk factors that predict future delinquency and default.

A special experiment was conducted to help identify the selection instruments. A 10 percent sample was taken of all subprime loans that met the basic HAMP eligibility criteria (owner-occupied, originated before March of 2009, etc.), had not previously been modified, and which were exactly 30 days delinquent at some base date in the first half of 2007. A probit regression was then performed on the rate of serious delinquencies six months after the base date. This time period was chosen because it reflects the first wave of subprime delinquencies, before servicers had started to implement modification programs. While the overall rate of serious delinquency outcome in this sample was 27 percent, less than half of one percent of the loans in this sample received a modification within six months of the base date. This experiment allows the factors affecting serious delinquency to be examined independently of modifications.

A number of borrower and loan characteristics were found that fit the exclusion criteria of having a significant influence on modification selection, but no significant effect (using a Wald Chi-Square test at the five percent level) on the outcomes of the 2007 sample. In particular, the *interactions* between the current servicer and most borrower and loan characteristics fit this pattern. The borrower's back-end DTI at origination was also excluded as it had a p-value of just 0.078 in this experiment. Because these variables are not guaranteed to influence selection outcomes for all borrowers in the same direction, they cannot be employed for a local average treatment effects (LATE) design, but they can aid in the identification of treatment effects in the Heckman framework, by being included in the 2010 and 2011 selection models but not in the outcome model.

The specific Heckman correction method used is a series of probit regressions with correction terms constructed from selection equations into outcome equations. This technique produces correct, unbiased beta coefficients but with incorrect standard errors (confidence levels). As a check on the confidence levels, sensitivity tests were also done to execute the same model on a subsample of data but using a full information maximum likelihood algorithm (FIML) implemented in *proc qlim* of SAS/ETS. This algorithm takes much longer to run and is prohibitive for the full data sample, but it produces correct standard errors. In general, the data sample is large enough such that a beta (regression coefficient) that is significant has a p value of < 0.0001, so that even with "incorrect" standard errors, there is extremely low risk that a value reported as significant is actually insignificant, or vice versa.

The study model consists of two selection probit equations (selection of loans into modification, and selection of modified loans into HAMP), and three outcome equations, one for each of the three subgroups (HAMP-modified, non-HAMP modified, and no modification). The outcome is a binary variable defined as "adverse" if, as of the outcome month, the loan is either 90 days or more delinquent or has been modified *after* the base month (which is seen here as an impairment). The outcome month may be 6, 12, 18, 24, 30, or 36 months past the base month. A loan that is liquidated via foreclosure or short sale prior to the outcome month is considered to have an adverse outcome. A loan that is paid off fully is considered to have a non-adverse outcome.

Because the study views modifications as impairments, the definition of what constitutes a modification will affect outcome estimates. For this study, ”modifications” have been restricted to *those that reduce the borrower's payments.* This means that loan workouts and capitalization-only modifications (which will be exclusively non-HAMP) are not given the status of 'real' modifications. This has several implications for how the study regressions are constructed:

- A loan is considered modified for initial selection purposes only if the HAMP or non-HAMP modification under consideration is the *first payment-reducing imputed modification* observed *during the study period.* The study ignores any imputed payment-reducing modifications prior to January 1, 2008, which were very rare.

- The study also ignores the fairly large volume of capitalization-only modifications performed on this population in 2008 and early 2009, which have been demonstrated in other studies to be ineffective (White, 2009). This has the effect of giving non-HAMP modifications more of a head-to-head comparison with HAMP.

- Also, a step-up of an initial modification that increases the payment was ignored and had no effect on the outcome variables. This can potentially affect quite a number of non-HAMP modifications, which may have earlier step-ups than HAMP.

- Hopefully, the payment-reducing restriction caused a modified loan to be considered to have an adverse outcome only if it gets disqualified through SDQ or otherwise has to be given a new modification that involves a further concession from the investor.

No single source in the literature has been found with a model structure precisely like this (binary outcome variable with a nesting of two selection equations). However, the correct methodology can be deduced from consulting a number of sources on selection correction, such as Maddala (1983). Pages 265-266 of Maddala briefly discuss the problem of a nested series of selection factors. This corresponds to this study's treatment of selection-into-modification and selection-into-HAMP. There are several ways in which this selection process could be modeled. Because HAMP modifications are at the top of a servicer's waterfall, then a strictly chronological ordering of selection processes would produce a sequence as follows:

[A] Selection of delinquent loan into HAMP vs. fallout
[B] Selection of fallout loans into non-HAMP modification vs. no modification.

There are some problems with this ordering. First, the population of HAMP modifications in proportion to an entire delinquent population is fairly small, making the estimation more difficult. Second, this ordering does not map well to the hypotheses being considered, which are to measure modification effectiveness vs. non-modification, and then HAMP modifications vs. non-HAMP modifications.

For this reason, the selection steps have been reversed so that selection-into-modification is estimated first, and then selection-into-HAMP, conditional on a loan having been modified, is estimated in a second stage. This thus generates the following two equations:

[A] $pr(Mod) = \Phi[\alpha_1 + \beta_1 X_1]$

[B] $pr(HAMP | Mod) = \Phi[\alpha_2 + \beta_2 X_2 + \rho_{1,2} \lambda_1]$

When the outcome equation is estimated, *both* inverse Mills ratios from the two selection equations must be carried forward. This is because the unobserved factors that may influence a loan's selection into modification (lambda-1) and its selection into HAMP vs. non-HAMP modification (lambda-2) may be correlated with redefault rates.

[A] $pr(Adverse | NoMod) = \Phi[\alpha_A + \beta_A X_A + \rho_{1,A} \lambda_{1A}]$

[B] $pr(Adverse | NonHampMod) = \Phi[\alpha_B + \beta_B X_B + \rho_{1,B} \lambda_{1B} + \rho_{2,B} \lambda_{2B}]$

[C] $pr(Adverse | HampMod) = \Phi[\alpha_C + \beta_C X_C + \rho_{1,C} \lambda_{1C} + \rho_{2,C} \lambda_{2C}]$

The correction terms are derived from the selection equation estimates as indicated in the table below. The 'beta' variables are the estimated probit regression coefficients from the selection equations; each 'X' represents an observable characteristic of each loan. Each resulting 'lambda' factor is the expected value of the probit error term, which represents unobserved factors that influence whether a loan receives a HAMP modification, a non-HAMP modification, or no modification at all.

Table A9: Modification and HAMP Selection and Correction Factors

	Modification selection correction factor	**HAMP selection correction factor**
Unmodified Loans	$\lambda_{1A} = -\phi(\beta_1 X_1)/[1-\Phi(\beta_1 X_1)]$	$\lambda_{2A} = 0$
Loans with non-HAMP modifications	$\lambda_{1B} = \phi(\beta_1 X_1)/\Phi(\beta_1 X_1)$	$\lambda_{2B} = -\phi(\beta_2 X_2)/[1-\Phi(\beta_2 X_2)]$
Loans with HAMP modifications	$\lambda_{1C} = \phi(\beta_1 X_1)/\Phi(\beta_1 X_1)$	$\lambda_{2C} = \phi(\beta_2 X_2)/\Phi(\beta_2 X_2)$

In each case, there are two kinds of correction factors, one based on a loan *not* being selected, in which case the correction will be downward, and one based on a loan being selected, so that the correction will be positive. The ultimate effects of these 'lambda' factors on the outcomes depends on the sign of the correlation variable 'rho' that is calculated in the course of the outcome probit estimation.

The use of Heckman selection correction with a *binary* rather than a continuous outcome is common enough that Stata has a built-in command called *heckprob* that performs this kind of two-stage probit estimation automatically. The theory is fairly straightforward: in a two-stage estimator, one can carry forward the inverse Mills ratio term from the selection equation into the second stage probit equation, just as one would with a second stage OLS. A standard reference paper for this approach is Van de Ven and Van Praag (1981). When the outcome is binary, there is a slight change in the interpretation of average treatment effects. Any treatment effects equation that is based on a continuous outcome variable can be applied instead to the hidden predicted probability of default.

To separate the selection and treatment effects, five probabilities were calculated from the outcome probit equations:

P1 is the estimated probability of an adverse outcome using the model coefficients for a HAMP or non-HAMP modification, conditional on that loan having received that modification type. In other words, this is the in-sample outcome propensity score for modified loans. On average, it will be very close to the actual proportion of adverse outcomes in each modified population.

P2 is the pure treatment effect probability of an adverse outcome conditional on the loan's observable variables *only*. Here, the probit score component attributable to the influence of unobserved variables on the outcome was subtracted out. This then simulated what outcomes would happen if borrowers with a given set of *observable* characteristics could be randomly assigned to modification or not.

P3 is the estimated probability of an adverse outcome using the out-of-sample coefficients for an unmodified loan, as applied to a loan that actually did get a modification. Then, the bias effects of selection-into-modification were removed so that the study simulates a loan with a set of observed characteristics being randomly assigned to *not* get a modification and estimating what would have happened to that loan.

P4 is the probability of an adverse outcome for an unmodified loan, conditional on the observable characteristics only. It is the no-modification equivalent of **P2.**

P5 is the raw estimated probability of an adverse outcome for an unmodified loan, without any correction. It is the no-modification equivalent of **P1.**

The ATET is calculated as the average difference between P2 and P3 over a given population of loans, either HAMP-modified or non-HAMP modified. Thus, it measures the expected change in probability of an adverse outcome due to the modification for a given population of loans with the distribution of observable characteristics matching that of the actually modified loans if one could have done a controlled experiment on those loans.

Going further than this and trying to calculate an average treatment effect on a larger population presents some difficulties. It is not practical to try to extrapolate an out-of-sample outcome "if treated" for an *unmodified* loan since it is not clear what the terms of such a modification would be. However, the difference between P3 and P4 will show, at least, how much of a difference in no-modification outcomes is due to the difference in *observable factors* between the modified and unmodified populations. This difference in outcomes can be computed by multiplying the no-modification betas by the average population difference in covariances.

The variance calculations in the study are made directly from the *xbeta* probit scores for HAMP modifications and non-HAMP modifications [equations B and C]. These scores determine the predicted probability of a given loan having an adverse outcome after some period of time. Differences in this score between two modified loans could be due to differences between modification terms, or they could stem from characteristics of the loans or borrowers. Mathematically, the variance of the total *xbeta* statistic can be decomposed into variances and covariances of each loan and modification attribute:

$$\mathrm{var}(Adverse \mid HampMod) = \mathrm{var}[\alpha_C + \beta_C X_C] = \sum \beta_{ic}^2 \mathrm{var}(X_{iC}) + \sum \sum \beta_{ic} \beta_{jc} \mathrm{cov}(X_{iC}, X_{jC})$$

The variance decomposition in this report looks at the variance subcomponents associated with key attributes, such as the level of payment reduction and borrower FICO score. The remaining variance associated with other attributes, as well as from covariances (effects stemming from combinations of variables) or selection effects, is referenced as "all other factors."

Appendix III: Data Transformations

The source data for the study was comprised of:

- A Fannie Mae internal database with loan-level data and monthly performance data which is derived from a subset of about 85 percent of the CoreLogic Loan Performance subprime database, corresponding to all loans for which Fannie Mae owns or has owned an interest in a related collateralized debt obligation (CDO). The HAMP program administration database which contains data on NPV calculator submissions and loan modifications under the HAMP program;
- A time series of MSA-level historic and projected home price indices used within the HAMP program, as well as a ZIP code to MSA lookup table;
- ZIP code-level demographics from the US Census Bureau's American Community Survey of 2007-2011.

The data transformations that were used to set up the probit regressions were:

- Selection of initial study population;
- Imputation of loan modifications in the CoreLogic database;
- Matching of imputed modifications to known HAMP modifications on PLS loans;
- Data sampling for a given base year and post-modification time span; and,
- Derivation of additional regressors including MTMLTV.

Selection of Initial Population

The filtering of the loan population was done in two stages. The first set of filters generated a broad set of potentially HAMP-eligible loans. This population was used for the modification imputation and HAMP matching stages. After this, some secondary filters were applied to eliminate loans that were useful to the matching algorithm but for which not all of the covariates needed for the regressions were properly populated.

The first stage filters determining HAMP eligibility, in order, were:

- Loan must not have a liquidation date prior to January 1, 2008 (i.e., it must have been active during the study period);
- Loan must have an occupancy status of owner-occupied principal residence (not a vacation home or investor-owned property);
- Loan must be a first lien;
- The origination date must be populated (for matching purposes) – if the origination date is not populated, it is taken to be two months prior to the first payment due date, if this is known;
- Five-digit ZIP code must be populated (for the matching algorithm);
- Origination UPB must be populated (for the matching algorithm); and,
- Loan must be for one to four units and must be within the conforming loan limits to be HAMP eligible.

The second stage, post-matching filters were:

- Origination date must be after January 1, 1976 so that MTMLTV can be calculated from the home price index series that was used;
- Origination LTV and/or property value at origination must be populated. Origination LTV must have a reasonable value (<= 500 percent); and,
- For modified loans:
    - Pre- and post-mod payment must be $1 to $100,000;
    - Pre- and post-mod UPB must be $1 to $2,000,000;
    - Percent change in UPB must be -99 percent to +99 percent;
    - Delinquency before modification must be no more than 10 years;
    - Pre- and post-mod interest rate must be > 0 percent and <= 99 percent;
    - Percent change in payment must be -99 percent to +99 percent; and,
    - Change in interest rate must be -2000 to +2000 basis points.

Modification Imputation

The CoreLogic database identifies, for each month, the loan's scheduled principal and interest payment, the current interest rate, the remaining unpaid principal balance, as well as delinquency status. Each loan's payment history was compared to its origination loan terms to identify when and how many times the loan had been modified.

For a regular, fixed-rate mortgage, the interest rate and payment should remain unchanged from month-to-month while the principal balance will slowly decline. If there is an interest-only period, then the principal balance will remain fixed during that period, and then the payment will jump up at to an amortizing level, possibly accompanied by a rate change. Subprime ARMs typically take the form of a hybrid loan with a fixed-rate period of two to 10 years, followed by an initial rate reset and then periodic resets every six months. Subsets of subprime ARMs have rates that reset every month over the life of the loan. Modifications to an ARM loan can usually be readily identified because the expected pattern of periodic rate or payment changes comes to an end, and no recurring changes occur afterwards. Conversely, some rate changes can be immediately identified as a modification if they violate the origination terms of the loan, such as a periodic or lifetime rate floor. The margin of note rate over an ARM index can also effectively be used as a lifetime floor because the underlying index, such as the six month LIBOR, cannot go below zero.

Therefore, a cutoff point was established for each of these loans at the date of the last observed expected rate change that was not preceded by an illegal rate change. Changes in loan terms after the cutoff date were then considered to be potential modifications. The rate change occurring exactly at the cutoff date is handled as a special case, as described below.

For example, a 2/28 hybrid ARM whose first payment was in April of 2007 would have an initial rate reset in March 2009, and expected subsequent rate changes in following March or September periods. Slight timing variations were allowed for: if the initial rate reset is one month earlier or later than expected, and the subsequent rate changes all follow the same pattern, those rate changes are considered to be expected rate changes. Suppose that for such a loan, rate changes were observed in February 2009, then again in August 2009 and February 2010, but the only rate change after this is in December 2010. The December rate change (and any other change in loan terms after February 2010) would then be considered as a possible imputed modification.

For a subset of subprime ARMs, the note rate is scheduled to reset continuously over the life of the loan on a monthly basis, once any hybrid (fixed rate) period has ended. The borrower's monthly payment is then recast at 12-month intervals. For these loans, the last sequence of three or more consecutive monthly rate changes was observed, and a check was made to see if a payment recast occurred at the next scheduled anniversary date. The cutoff was set either to the final payment recast, or to the final rate change if no recast was observed.

The rate reset periods of subprime ARMs are usually either monthly, or every six or 12 months. If a loan coded as a 12 month reset showed patterns of rate changes every six months, these rate changes were treated as expected, and the origination data was assumed to be incorrect.

As the first step in the imputation process, the CoreLogic payment history was scrubbed by removing stated changes to loan terms that were entirely reversed in the following month. These data anomalies were presumed to be due to servicer reporting errors. Following this, expected events were flagged, including any change to an ARM loan taking place before the cutoff points described above. Any payment change of more than one percent and any UPB drop of five percent or more was provisionally marked as an unexpected event. However, changes in loan terms occurring within one month of a loan's interest-only reset date were flagged as expected unless they involved an illegal rate change.

An actual modification may end up being recorded in CoreLogic over a two- to three-month span. For this reason, unexpected changes in loan terms that took place over two or three consecutive months were grouped together as one event for the purposes of imputation. For example, if a loan were recorded as having gone from six months delinquent to current, with the accrued interest being added to the loan balance in June, and in July the interest rate and payment were reduced, then this was considered to be one modification event.

Once the unexpected events in consecutive months were merged together in this manner, each unexpected event was identified as a modification if:

- A delinquent loan was made current (or had its delinquency reduced to one month) and had a payment change (either up or down) of greater than one percent, *or*
- The loan remained current while having a payment reduction of 2.5 percent or more.

Occasionally, a borrower will become 30 days delinquent in the very first month after their modification becomes permanent. Because of this, a loan whose delinquency status drops from two months or more down to one month was also considered to have been made current.

Rate change events occurring just at the cutoff point (i.e., the last observed rate change at the expected periodic interval) are considered ambiguous, and are therefore classified as modifications only if the loan was also made current. Also, a payment reduction stemming from a drop in the principal balance on a current loan was interpreted as a curtailment by the borrower rather than a modification.

HAMP Matching

The imputed modifications in CoreLogic were matched to known HAMP modifications by comparing data elements associated with loan origination and modification terms present in both databases. A HAMP match was identified if the imputed modification and the HAMP terms showed:

- The same five-digit property ZIP code *and*
- Origination date within 45 days, *and*
- Modification date within 75 days, *and*
- Some combination of correspondences from the table below totaling seven points or more:

Table A10: Derivation of CoreLogic to HAMP Matching Score

Loan Origination / Modification Terms	Closeness of Match	Point Score
Origination Terms		
Loan origination date	15 days	1
Principal balance at origination	0.5 %	5
Principal balance at origination	1.0 %	4
Principal balance at origination	2.5%	3
Principal balance at origination	5.0%	2
Principal balance at origination	7.5%	1
Origination note rate	1 basis point	4
Origination note rate	6.25 basis points	3
Origination note rate	31.25 bp	2
Modification Terms		
Loan modification effective date / change in official loan terms	15 days	1
Post-mod interest rate	6.25 basis points	1
Pre-mod interest rate	6.25 basis points	2
Pre-mod interest rate	20 basis points	1
Post-mod payment	Exact match	5
Post-mod payment	0.6%	4
Post-mod payment	1.2%	3
Post-mod payment	2.5%	2
Post-mod payment	5.0%	1
Post-mod principal balance	Exact match	7
Post-mod principal balance	0.5%	4
Post-mod principal balance	1.0%	3
Post-mod principal balance	2.0%	2

Post-mod principal balance	4.0%	1

The point scores were assigned so that differences in terms with similar frequencies in the population of potential matched pairs would be given the same weight. This calibration was performed by creating all possible matches between HAMP and CoreLogic modifications that met the base criteria. For example, there is a three percent chance that a HAMP modification and a randomly matched imputed modification, sharing the same ZIP code and with a modification date within 75 days, will have post-modification payments within 2.5 percent of each other. Similarly, there is a three percent chance that the pair will have post-modification principal balances agreeing within two percent. Each of these correspondences is given a point score of two. A one point score increase roughly corresponds to a decrease in the chance of a random pairing by a factor of two. In practice, the calibration of point scores for matching requires some judgment because different attributes are subject to data errors in both the HAMP and CoreLogic database.

In some cases, potential HAMP matches were disqualified if there were two or more HAMP modifications with a high matching score to a CoreLogic loan modification, or two or more CoreLogic modifications matching the same HAMP. Each high scoring match was compared to the next runner-up in point score. A disqualification occurred if this runner-up exceeded a threshold score, as indicated below:

Table A11: HAMP Matching Uniqueness Conditions

High Match Score (S)	7-10	11	12	13	14	15	16+
Runner Up Threshold	7	8	8	9	9	10	S - 5

The HAMP database also identifies origination data for some loans that were evaluated for the program but did not ever receive permanent modifications. The most common reasons for a disqualification are either, eligibility-related (failure to meet the 31 percent DTI threshold or an NPV negative result), failure of the homeowner to complete documentation requirements, or to respond to the trial offer, or failure of the homeowner to make the required trial payments. CoreLogic loans that received a point score of 10 or greater when matching on the subset of origination terms were thereby matched to these HAMP fallout cases.

Sampling Methodology

Each regression defined three population groups (A: unmodified loans; B: non-HAMP modifications; C: HAMP modifications) for a collection of 12 base months. Given a choice of base month, loans were classified by their modification status:

- If the loan was never modified during the study period (January 2008 to March 2013), or if its first payment-reducing modification occurred after the base month, then for econometric purposes the loan is classified as not modified (Group A).
- If the loan received a payment-reducing modification that became permanent on the base month, then it is counted as non-HAMP or HAMP-modified (Groups B and C) depending on whether the modification was matched to the HAMP database or not.

- If the loan received a payment-reducing modification during the study period before the base month then it was excluded from the study population for that base month.

An additional filter was applied based on the loan delinquency status. The study sought to exclude loans that were initially current prior to their modification. As noted in the body of the paper, loans that remained current are very different from those that ever became even 30 days delinquent, so it is difficult to include the two populations in a single model. However, it would not be appropriate to simply look at the period just prior to the modification to assess loan delinquency, because some servicers may report a loan as being delinquent while it is in trial and the borrower is making timely (but reduced) payments. Because of this, the borrower delinquency level was tested *three months prior to the base month***.** Loans that were current at this point in time were excluded from the study population for that given base month.

Finally, some downsampling was performed on the unmodified loan population, since otherwise the modified loan population would be relatively small. The downsampling was performed as follows:

- For a given loan month, all modified loans (groups B and C) were included, but only 1/48 of the not modified loans (group A) were selected.
- Each regression was based on a base year; that is, the sampled populations for 12 base months within the base year were combined together.
- Note that it is possible for a single loan to appear more than once in a regression sample but under different base months; this is an expected aspect of the sampling methodology. The occurrence of duplicate loan instances was low enough that clustering of the standard errors was not thought to be necessary.
- The non-modified loans were given a sampling weight of **4** in the selection regressions, compared to **1** for the modified loans. This was based on the fact that for a set of N loans that were never modified in the base year, a subset of N/4 of them, in expectation, were included in the sample for a given base year. However, for a set of M loans that *were* modified in the base year, exactly all M of them appeared in the sample as modified loans. (An additional subset of about M/8 of them *also* appeared as unmodified loans in base months prior to their modification becoming permanent.) The weighting factor put the unmodified and modified loans on equal footing.

Calculation of Covariates

Many of the covariates used in the selection and outcome regressions were taken directly from the CoreLogic database and have straightforward interpretation. Regressors taken from other sources or computed are described below. The internal HAMP database loan modification attributes were *not* used once a match to an imputed CoreLogic modification was detected; instead, the corresponding fields from CoreLogic were used. This ensures that HAMP and non-HAMP modifications were compared as fairly as possible.

ZIP Code

Three demographic variables were taken from the 2007-2011 American Community Survey of the US Census. Each variable represents an average value over the five year survey period for each property ZIP code. These variables are the log of median household income, the mean unemployment rate, and the percentage of the population reported as belonging to an historically underserved minority group, here defined as any race/ethnicity code other than Asian or non-Hispanic white.

Delinquency Status

The borrower's delinquency status was used for three different variables. First, the *base delinquency* corresponds to the delinquency at the start of modification trial period in the single variable analysis. Since the length of the trial period is unknown for non-HAMP modifications, and has no meaning for the unmodified loans, this variable was defined consistently for all loans as the delinquency status three months prior to the base date.

An additional covariate used in the selection model was the *prior delinquency.* This is the percentage of months between origination and the base date that a loan was at least 30 days delinquent. This covariate allowed some of the prior delinquency history provided by CoreLogic and not available in HAMP to be used. Finally, the borrower delinquency level at the outcome month affects their outcome status variable.

Servicer

To effectively control for differences in *servicer* policies or practices that could affect modification rates, it was critical to identify which servicer was handling a delinquent loan in some particular base month. Although this information is not included in the Loan Performance loan history table, it can be extracted from monthly historic snapshots of the loan's current state. Acquisitions of servicing portfolios from defunct institutions and other transfers can be observed in this way.

Since the study period only starts in January 2010, a great number of subprime loans in the study population had already been transferred at least once due to industry consolidations. For example, all CountryWide originated loans were grouped with Bank of America, and Wachovia loans with Wells Fargo. In some cases when a servicer's portfolio in 2010 or 2011 had significant sub-populations associated with specific prior transfers or acquisitions, these sub-portfolios were tagged separately, as follows:

Table A12: Servicer Sub-Portfolio Groupings

Prior Servicer	*Post-transfer Servicer*	*Servicer Sub-Portfolio*
Citigroup	American Home Mortgage (AHMSI)	Citi/AHMSI
All others	AHMSI	Other/AHMSI
Washington Mutual	JP Morgan Chase	WAMU/Chase
EMC (Bear Stearns)	JP Morgan Chase	EMC/Chase
All others	JP Morgan Chase	Other/Chase
Litton (Including Avelo and Equity One)	Ocwen	Litton/Ocwen[25]
Saxon	Ocwen	Saxon/Ocwen
HomEq	Ocwen	HomEq/Ocwen
All others	Ocwen	Other/Ocwen

MTMLTV

Some adjustments were made to MTMLTV-related fields when the CoreLogic data was incomplete or inconsistent. On a *purchase loan*, the origination LTV (which is usually a round number such as 80 percent) was taken as a reference point, and the property appraised value was recalculated as the ratio of origination UPB to origination LTV. If the origination LTV was missing, however, the stated appraised value was used to back-calculate the origination LTV. If the appraised value and origination LTV were *both* missing, then the sale price was used as an approximation of appraised value. On a *refinance*, the appraised value at the time of refinance was used as the reference point and the origination LTV was recalculated from that value and the origination UPB. If the appraised value was missing then it was reconstructed from the stated origination LTV and UPB.

The MTMLTV for modified loans was taken to be the ratio of post-modification loan balance to the estimated home value in that month. The home value was estimated from the original appraised value, as calculated above, and adjusted for changes in MSA-level home prices from the origination date through the date of modification. The home price index used was the same Treasury proprietary index that is used for the HAMP NPV model calculations. The MTMLTV for unmodified loans was calculated in the same way, using the appropriate base month.

These CoreLogic-based calculations were found to result in a higher average home value (and, therefore, a lower MTMLTV) at the time of modification than the value reported by servicers at the time of HAMP modification. This may be due to inflated appraisals at subprime origination or because of actual deterioration of the property when the loan is in default. A regression comparing the LTVs derived by both methods was performed, resulting in a linear rescaling of:

[25] Note that the transfer of Litton's portfolio to Ocwen occurred in the middle of 2011, so that depending on the month of evaluation, a loan's servicer might be tagged either as "Litton" or "Litton/Ocwen."

HAMP-estimated MTMLTV percent = 11 percent + 1.21 * [CoreLogic-estimated MTMLTV]

Because the HAMP data was taken to be more accurate, all of the CoreLogic-derived MTMLTV figures were rescaled for all loans in the sample, regardless of their modification status. Because all loans were rescaled by the same linear factor, this did not materially affect the regression results or hypothesis tests, but it does place results within a reasonable and consistent metric for comparison to other studies.

Appendix IV: HAMP Trial Fallout Effect

Loans that were initially evaluated by a servicer for a possible HAMP modification but did not ultimately receive one are considered to have fallen out of the HAMP modification pipeline. These loans may have then be evaluated for a servicer's non-HAMP proprietary modifications.

Some (but not all) of this fall-out population was reported by servicers to the HAMP program administrator. In general, the further along a loan makes it in the pipeline before being rejected for a modification, the more likely its status will have been recorded. The most common reasons for such fall-out, in order of evaluation, are:

- Loan or borrower was *categorically* ineligible for the program (not owner-occupied, etc.);
- Borrower did not provide necessary documentation such as verification of income;
- Loan or borrower was found to be *currently* ineligible for the program in view of data collected at the time of evaluation (e.g., borrower income was too high, borrower was not in hardship);
    - In particular, a borrower whose current mortgage payment to income ratio was already below the program target of 31 percent was deemed ineligible, and
    - A borrower with a very *high* ratio may have been denied a modification because an excessive amount of principal forbearance would have had to be applied in order to bring their ratio down to the 31 percent target;
- Loan did not pass HAMP NPV test;
- Borrower did not respond to trial modification offer; and,
- Borrower initiated a trial but failed to make timely payments.

The origination data provided by servicers about these loans is limited, particularly if the loan was disqualified prior to an NPV test being run. Nevertheless, it was possible to match some of these loans to those in the CoreLogic database, including loans imputed to have received non-HAMP modifications. This made it possible to at least partially classify these loans in terms of the type of fall-out and subsequent modification.

Table A13 shows the result of this partial classification. The "no modification" group consists of PLS loans that became delinquent but were not modified in the period from 2010 to 2011. The "non-HAMP" group consists of delinquent loans that received proprietary modifications over this time frame. Within each group, loans for which one of the common HAMP fallout reasons (listed above) was indicated by the servicer are broken out for comparison. With a few exceptions, the loan characteristics did not show strong differences across categories. Notably, loans that had reduced documentation requirements at origination were more likely to be ineligible for HAMP due to excessive forbearance (which is associated with very high DTI), and are less likely to be disqualified due to low DTI. Also, loans with chronically late payments, as measured in the percentage of delinquent periods between origination and the NPV test, were more likely to fail to complete a HAMP trial.

Table A13: Characteristics of Loans, by HAMP Fallout Type and Subsequent Modification Status

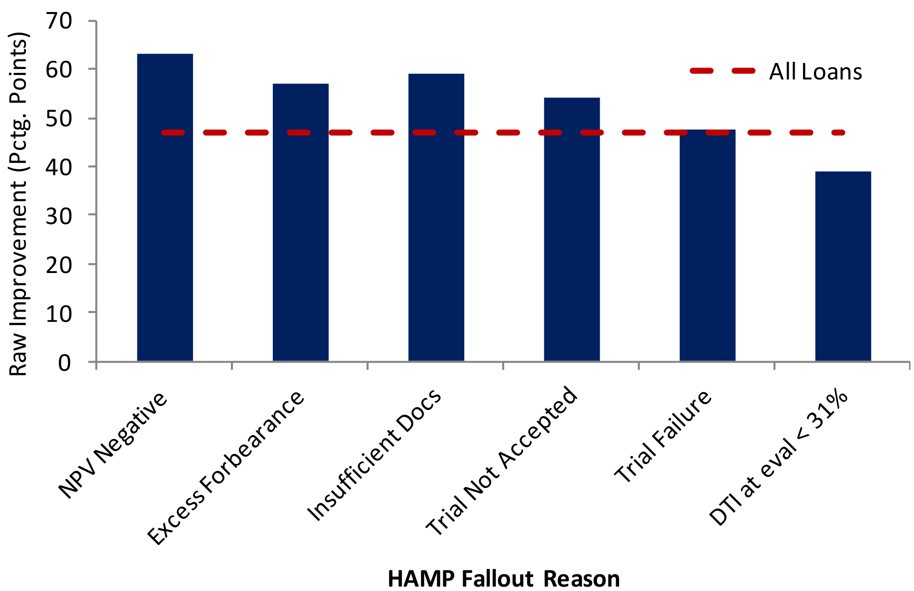
HAMP Fallout Reason	Got Non-HAMP	# of Loans	At Origination: Back-end DTI	FICO	Low/ No Doc %	Cash out Refi %	At HAMP Eval: % of time DLQ	MTM LTV	% 6-11 months DLQ	% 12+ months DLQ
Insufficient Docs	No	12,178	40	632	51	53	50%	107	23	50
DTI at eval < 31%	No	4,400	40	622	32	52	48%	101	25	31
Excess Forbearance	No	2,976	41	651	71	53	46%	104	23	48
NPV Negative	No	5,006	41	647	63	52	49%	109	22	55
Trial Not Accepted	No	5,194	41	635	48	51	50%	112	19	58
Trial Failure	No	8,516	41	622	48	53	56%	110	20	63
All 30+ dlq loans	*No*	*515,150*	*40*	*641*	*51*	*49*	*46%*	*107*	*18*	*45*
Insufficient Docs	Yes	10,434	41	627	46	57	43%	105	32	36
DTI at eval < 31%	Yes	3,578	40	615	29	56	46%	101	33	27
Excess Forbearance	Yes	2,287	41	628	67	56	54%	108	33	43
NPV Negative	Yes	4,250	41	651	68	54	44%	108	29	50
Trial Not Accepted	Yes	2,716	42	622	43	59	48%	108	34	41
Trial Failure	Yes	5,053	41	615	47	58	54%	109	29	57
All 30+ dlq loans	*Yes*	*218,072*	*40*	*631*	*47*	*55*	*44%*	*104*	*28*	*33*

Table A14 then compares the raw outcomes for these groups, in terms of whether the loans were 90 days or more delinquent, as of 24 months after the HAMP NPV evaluation (or, alternatively, the submission of a report by the servicer that the loan was ineligible for HAMP). For example, the average SDQ rate after 24 months for a non-HAMP modified loan is 37 percent overall, but just 31.5 percent for those loans that were denied a HAMP due to the borrower submitting insufficient documentation. Similarly, the overall 24 month default rate for delinquent but unmodified loans is 84 percent, but it is over 90 percent for those with insufficient documentation for HAMP. This suggests that lenders may have been able to perform successful modification by relaxing documentation requirements, or by giving a borrower another chance to submit documents.

Table A14 HAMP Fallout Category Marginal Effects on Subsequent Borrower Performance 24 Months after NPV Fallout Date

HAMP Fallout Reason	Non-HAMP pmt % reduction	Marginal Effect, Non-HAMP	Marginal Effect, No Mod	Difference in Marginal Effect
Insufficient Docs	37	-2.6	0.7	3.3
DTI at eval < 31%	22	-4.1	-4.4	-0.3
Excess Forbearance	41	-5.1	-0.4	4.7
NPV Negative	41	-4.7	3.4	8.0
Trial Not Accepted	39	1.3	3.7	2.5
Trial Failure	33	1.4	1.1	-0.3
All 30+ dlq loans	*32*			

Figure A1: HAMP Fallout Category Influence on Subsequent Borrower Performance 24 Months after NPV Fallout Date



Keep in mind, however, that differences in raw outcomes can be due to a number of factors, including differences in borrower and loan characteristics, selection bias, and the relative levels of payment reduction offered to the different groups (which is also shown in the table). To adjust for these factors, the common HAMP fallout categories were also included in the outcome regressions for the 2010 and 2011 populations. This allows the effect of a borrower being in each category to be statistically isolated, and measured as a marginal effect on an average loan. This marginal effect (taken as a weighted average of the 2010 and 2011 measurements, and using a time span of 24 months) is shown in Table A14 and Figure A1 for both the non-HAMP modified and unmodified loans. The difference between these two marginal effects (if positive) represents a further improvement in the probability of default, when a borrower in the given category gets a non-HAMP modification, and can be directly compared to the raw improvement.

Note that while the isolated effects are smaller than the raw effects in magnitude, the relative rankings of each fallout category are roughly equivalent. Loans receiving a non-HAMP modification that had previously failed to get a HAMP due to a negative NPV result or high DTI show a greater treatment effect than other non-HAMP modified loans. Loans that are rejected from HAMP due to a low DTI are relatively low risk and do not show as high a treatment effect as other loans when they get a proprietary mod. Loans that fail their HAMP trial period are significantly higher risk than other loans, but in terms of non-HAMP treatment effect are no better or worse than average.

Generally, loans that fell out of the HAMP modification process tend to have riskier characteristics, such as lower FICO scores and higher MTMLTV, than those for which no fallout data was recorded. These loans also generally had worse subsequent performance, particularly if they did not subsequently receive a non-HAMP modification. Also, loans that fell out due to borrower behavior, and particularly those that fail during trial, were riskier and have worse performance than those that were found ineligible by the servicer.

It is interesting to note that loans that fell out of the HAMP pipeline prior to trial and then received a non-HAMP modification performed better than other non-HAMP modifications on average, while such loans that received no modification at all perform worse than average. This implies that some of the loans that were disqualified from HAMP but found to be eligible for non- HAMP modifications have *better* than average unobserved risk factors. Some of these loans could possibly belong to borrowers whose DTI at evaluation fell below the HAMP threshold of 31 percent, but who have a high MTMLTV or interest rates that made them eligible for alternative modification offers.

These fallout effects help explain why the observed performance of delinquent, unmodified loans is so high: the pool of these loans is over weighted with many borrowers who fell out of the modification process due to factors that also put them at a high risk for default.

Appendix V: HAMP Fallout Analysis to Check on Results of Overall Study

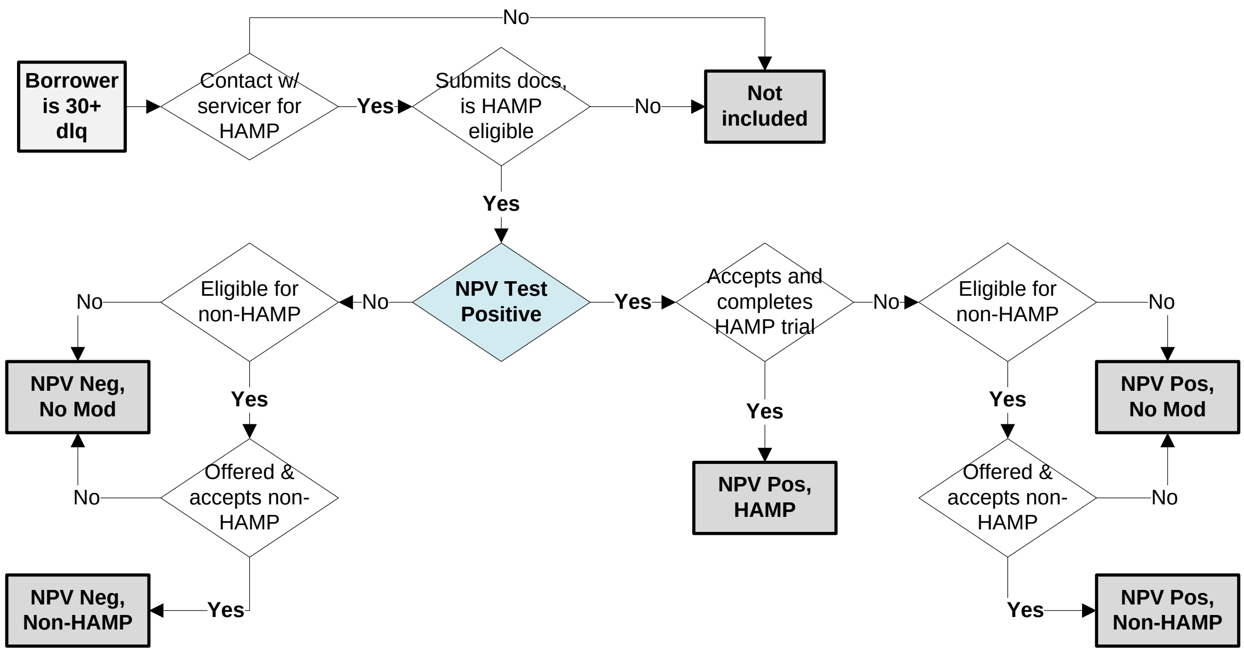
At each of the steps in the HAMP evaluation process, some combination of borrower and servicer selection effects will be present. However, for certain steps, there is a potential for a kind of natural experiment in which two groups of borrowers, who are very close to the threshold of being selected, can be thought of as randomly assigned:

- Borrowers whose front-end DTI ratio is just above 31 percent (making them HAMP eligible) or just below (making them ineligible);
- Borrowers whose DTI is sufficiently high that they become ineligible due to excessive forbearance, or those who just barely pass this test; and,
- Borrowers who are ineligible for HAMP because their modification NPV is a small negative amount compared to those getting HAMPs with a small positive NPV.

Unfortunately, the first two comparisons cannot be made because the available data from servicers is incomplete. If a borrower is found to be ineligible via a HAMP waterfall test according to the servicer's own calculations, then an NPV test is not required to be run, and so information about such a loan may or may not be present in the HAMP database. However, whenever a servicer runs an NPV test, they are required to submit the results (whether positive or negative) to the HAMP system of record. This allows an experiment to be constructed using an instrumental variables design known as local average treatment effect (LATE).

Figure A2 shows the position of the NPV test in a sequence of possible outcomes for a delinquent subprime loan. Borrowers who were never evaluated for HAMP or were deemed ineligible prior to the NPV test are excluded from the population. Loans with an NPV negative result are divided into two groups based on whether they were matched to an imputed non-HAMP modification that occurred within 12 months of the NPV evaluation. A loan that is NPV positive can have three possible outcomes, depending on whether the HAMP modification offer is accepted by the borrower and a trial is completed, or if instead a non-HAMP modification is made, or no modification at all.

Figure A2. Waterfall for NPV Test Treatment Effects Experiment



The population for the experiment was restricted to those subprime, securitized loans that had a HAMP NPV evaluation between October 1, 2009 and October 1, 2011, and received a score between negative ten thousand and positive ten thousand dollars. HAMP modifications within this sample become permanent, on average, about four months after the NPV test, while proprietary modifications did so after about six months, so that this time frame roughly corresponds to the 2010-2011 study period. The outcome variable is the SDQ status of each loan 27 months after the NPV evaluation date, or roughly two years after a permanent HAMP modification.

Although a regression discontinuity design was considered for this experiment, the LATE method was chosen instead because it can still be used to measure a pure treatment effect with selection bias removed, even though there are selection biases affecting the loan's handling after the NPV test takes place. For example, borrower selection effects will affect whomever completes a trial successfully, and servicer selection effects will affect whomever receives a non-HAMP modification.

The LATE method can sidestep these issues because the NPV test has a monotonic effect on selection into a HAMP modification: a positive NPV result will move some subset of loans from either a no modification or non-HAMP modification outcome to a HAMP modification outcome. This is called the 'complier' group. It is reasonable to assume that no loans are moved from a HAMP modification outcome to a non-HAMP modification or no modification outcome as a result of getting an NPV positive result; that is, there is no possibility of a 'defier' population. Therefore, the pure treatment effect of a HAMP modification can be calculated as:

$$LATE = \frac{[pr(SDQ\ |NPV\ neg) - pr(SDQ|NPV\ pos)]}{pr(HAMP|NPV\ pos)}$$

That is, the treatment effect is the change in a loan's default probability based on its having come out slightly NPV positive rather than slightly negative (which is taken to be more or less random), divided by the induced change in probability of the loan getting a HAMP modification (from zero).

This treatment effect is shown in table A15 below, broken out by three month cohorts, and compared with the corresponding Heckman treatment effect calculation at 24 months after modification.

Table A15: Local Average Treatment Effect of HAMP modifications, for NPV Test subsample

NPV Test Date	# of loans	Treatment effect, local	Treatment effect, full population (Heckman)
2009 Q4	14,537	37.4	42.3
2010 Q1	13,240	30.0	41.0
2010 Q2	6,225	38.2	44.5
2010 Q3	7,066	32.8	46.1
2010 Q4	4,283	30.1	50.5
2011 Q1	4,506	55.1	47.6
2011 Q2	3,067	51.2	50.0
2011 Q3	1,814	38.1	53.5

The LATE test confirms that the treatment effects of HAMP modifications are substantial, ranging from 30 to 55 percent, and it parallels the Heckman results in that HAMP performance improves over time. However, the local results show a somewhat lower overall treatment effect, with greater variation over time, compared to the Heckman results which range from 41 to 53 percent. These differences in results could be due to a number of factors. For example, the population with NPV results reported may not be representative of the larger group, and the HAMP modifications that had a low NPV score might have lower treatment effects than other HAMP modifications.