Federal Reserve Bank of Philadelphia

Working Papers
Research Department

WP 18-02
January 2018
https://doi.org/10.21799/frbp.wp.2018.02

Redefault Risk in the Aftermath of the Mortgage Crisis: Why Did Modifications Improve More Than Self-Cures?

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SUPERVISION, REGULATION & CREDIT

ISSN: 1962-5361

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Abstract

This paper examines the redefault rate of mortgages that were selected for modification during 2008–2011, compared with that of similarly situated self-cured mortgages during the same period. We find that while the performance of both modified and self-cured loans improved dramatically over this period, the decline in the redefault rate for modified loans was substantially larger, and we attribute this difference to a few key factors. First, the repayment terms provided by modifications became increasingly generous, including the more frequent offering of principal reduction, resulting in greater financial relief to borrowers. Second, the later modifications also benefited from improving economic conditions — modification became more effective as unemployment rates declined and home prices recovered. Third, we find that the difference in redefault rate improvement between modified loans and self-cured loans is not fully explained by observable risk and economic variables. We attribute this residual difference to the servicers' learning process — so-called learning by doing. Early in the mortgage crisis, many servicers had limited experience selecting the best borrowers for modification. As modification activity increased, lenders became more adept at screening borrowers for modification eligibility and in selecting appropriate modification terms.

Keywords: mortgage modification, mortgage default, mortgage servicing
JEL Codes: G21, G28, G40

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Why Did Modifications Improve More Than Self-Cures?

1. Introduction

Mortgage lenders experienced an unprecedented surge of defaults as the housing market downturn, which began in 2007, worsened through 2008 and 2009. Lenders (or loan servicers acting on behalf of the lenders) can choose among various strategies for resolving a defaulted mortgage, with the objective of maximizing the present value of their net recovery amount (net of recovery costs). The traditional resolution strategy is a legal foreclosure process, whereby the lender takes possession of the property and puts it up for sale. Often, however, lenders pursue alternatives to foreclosure that may provide a shorter path to property liquidation including deed-in-lieu of foreclosure, short sale, or third-party sale.

Alternatively, the lender may modify the loan terms, such as reducing the interest rate, extending the maturity date of the loan, or reducing the principal balance, to facilitate financial relief for borrowers, enabling them to resume their regularly scheduled payments. Mortgage modifications had been used sparingly before the recent mortgage crisis, but during the crisis, their use increased substantially, with lenders seeking to avoid the increased costs associated with foreclosure delays and through government programs encouraging modification activity.

Our study is the first to measure the net impact of payment-reducing modification programs during 2008–2011 relative to similarly situated self-cured loans (without payment-reducing modification). Previous studies have documented the change in redefault rates across modification programs or in relation to modification terms. However, they did not control for factors impacting the sustainability of cure more generally, as we accomplish by comparing against similarly situated self-cured loans.

We find that the performance of both modified and self-cured mortgages improved (they were less likely to redefault) dramatically over this period. However, the redefault rate improvement of modified loans was substantially greater than that of similarly situated self-cures. For example, after matching modified to comparable self-cured loans, we find that in the Agency (Fannie Mae or Freddie Mac) loan categories, the 36-month cumulative redefault rate of modified loans declined by nearly three-fourths, from slightly above 80 percent to slightly above 20 percent. The redefault rate of self-cures declined from slightly above 70 percent to about 35 percent, for 2008 versus 2011.

Our analysis is divided broadly into two parts. First, we develop and implement a procedure for matching modified loans to similarly situated self-cured loans and compare the changes (declines) in their redefault frequencies. Second, we analyze the factors that contribute to the larger decline in redefault frequency of modified mortgages compared with self-cured loans, using logistic regression models of redefault.

One of the identified key factors that influenced the decline in the redefault rate of modified mortgages is the increasing share of principal-reduction modifications relative to other types of modification — a finding consistent with Goodman et al. (2012). In addition, we find that greater improvement in relative performance for modifications provided larger payment reductions (greater relief to borrowers). And, as expected, the favorable impacts of principal and payment reductions were enhanced by improving economic conditions, such as declining unemployment rates from 2008 to 2011, resulting in more effective modifications.

Interestingly, after controlling for the type of modification, the payment reduction amount, and the economic conditions, we still observe larger improvement in redefault rates for modification compared with self-cured loans. We observe a large drop in the redefault rate of modified loans relative to self-cures after the first quarter of 2009 and a moderate decline after 2010. We attribute this enhanced effectiveness of modifications (relative to self-cured), especially for the earlier vintages to servicer “learning-by-doing.” Servicers with limited experience in designing modification programs in 2008 may have learned their lessons as the modification activity ramped up, resulting in more successful modification programs for later vintages.

The paper is organized as follows. Section 2 discusses existing literature related to the motivation of mortgage modification as a foreclosure alternative and those related to the impact of modification on loan performance. Section 3 provides some institutional background for the increase in modification and evolution of modification terms since the onset of the financial crisis in 2008. Section 4 describes the data and our approach to identifying mortgage loans that were modified during the period 2008–2011. Section 5 compares cumulative redefault rate between modifications and self-cures by year of modification or cure. We use propensity score-matching methods to match modified loans and similarly situated self-cured loans to control for risk characteristics. In Section 6, we develop logistic regression models that predict redefault of modified loans and self-cured loans, seeking to draw insights into what the key factors are that drive a larger decline in redefault rates for modified loans. We offer concluding remarks in Section 7.

2. The Literature and Our Contribution

The literature on loan modification is roughly separated into two strands:1) important factors on the borrower (or servicer) side that determine which delinquent loans receive a modification, and 2) examination of repayment performance (or redefault rate) after modification. We are the first to systematically compare the delinquency performance of modifications with that of self-cured loans, using matched self-cures as a control group.

A lender or servicer's decision on whether to modify and on the modification terms may depend, at least in part, on the factors that gave rise to the borrower's default on the mortgage. A borrower's default may be caused by the *inability* to make the payments or by the *unwillingness* (or lack of incentive) to pay (Haughwout, Okah, and Tracy 2009). The ability to pay relates to borrowers having adequate cash flow or liquidity to make a monthly mortgage payment. Borrowers with a smaller equity stake in the home (higher current loan-to-value (LTV) ratio) have less incentive to pay, particularly when the value of the home falls below the mortgage loan amount. Past credit payment history (e.g., past Equifax Risk Scores) may reflect the ability to pay insofar as it reflects vulnerability to income or liquidity shocks; it may also in part reflect a willingness to pay.

Das (2012) reflects on the role of these factors on the borrower side and develops a theoretical model of optimal loan modification strategy in a stochastic environment of home prices and interest rates. According to this theory, a suitable loan modification scheme must be cognizant of both the borrower's ability to pay and willingness to pay. The model indicates that effective modifications require writing down the principal balance.[1]

Mayer, Tomasz, and Arpit (2014), also focusing on the borrower side, present evidence that borrowers behave strategically in response to news of the availability of loan modifications for delinquent borrowers. This study analyzes borrowers' response to the program introduced by Countrywide Financial Corporation at the end of 2008 to settle a lawsuit filed by U.S. state attorneys general, whereby interest rate modifications were offered to all subprime mortgages that were at least 60 days past due. The study finds a significant increase in borrower delinquency in response to the program, suggesting that borrowers were induced to become delinquent by the prospect of receiving a mortgage modification and payment reduction.

The modification literature also has examined potential differences between *investor* and *portfolio* loans with respect to modification decisions (reflecting differences in the behavior of servicers

[1] The model ignores any additional considerations on the servicer side and does not explain why principal write downs are relatively uncommon.

that act as agents for investors or for other lenders and those who service loans for their own portfolios). Piskorski, Seru, and Vig (2010) emphasize three main reasons securitized loans may be serviced differently from portfolio loans. First, servicer financial incentives may differ between the investor and portfolio contexts. Within the framework of Jensen and Meckling (1976), investors force servicers to fully internalize the costs and benefits of foreclosing or modifying a loan. Second, private service agreements (PSAs) may legally bar servicers from using certain modifications. Third, property rights are jointly held by many bondholders, and coordinating an agreement among the bondholders on a particular modification scheme is more difficult than agreeing to a simple foreclosure. Similarly, Piskorski, Seru, and Vig (2010) and Agarwal et al. (2011) find a higher incidence of loan modification for bank-held mortgages (portfolio loans) compared with similar securitized mortgages (investor loans).

Adelino, Gerardi, and Willen (2013), however, argue that the determinant of whether to modify a loan is based primarily on a cost-benefit analysis, whereby the servicer's assessment is based on the likelihood of success on modifications relative to the cost of proceeding through the foreclosure process, rather than on the status of the mortgage as either bank-held or securitized. They find evidence of increased servicers' reliance on modification as the likelihood of borrowers self-curing from the delinquency decline over the period 2006 through 2010.

Gabriel, Iacoviello, and Lutz (2017) provide a multifaceted assessment of the effects of the California Foreclosure Prevention Laws (CFPL). They argue that the CFPL provided relatively strong incentives (particularly in relation to HAMP) for lenders to offer loan modifications by mandating consideration of foreclosure alternatives and imposing delays and other costs on the foreclosure process. They estimate that the CFPL prevented 380,000 foreclosures and helped stabilize the housing market, preserving $300 billion in housing wealth.

Studies examining the ex-post repayment performance of loan modifications granted during the initial stages of the mortgage crisis in 2007 and 2008 find troublingly high rates of redefault, thus suggesting a limited role of modification in loss mitigation. Haughwout, Okah, and Tracy (2009) analyze a sample of privately securitized, nonprime mortgages that were modified between December 2005 and March 2009, and find a "distressingly high" 56 percent average redefault rate within one year of modification. Quercia, Ding, and Ratcliffe (2009) examine a sample of privately securitized mortgages (mostly nonprime) that originated in 2005 and 2006 and were modified in the second quarter of 2008. By the end of 2008, 45 percent of the modified loans had returned to delinquent status. Both studies find that redefault rates decline with the size of the payment reduction or principal reduction offered by a modification. Adelino, Gerardi, and Willen (2013) attribute the relatively low frequency of modification of delinquent mortgages prior to 2009 in part to a high probability of redefault.

Haughwout, Okah, and Tracy (2009) caution, however, that "while we can tell that borrowers (and mortgages) that receive a modification are different from those that do not, we do not model how a mortgage gets into our modified sample." This possibility of selection effects precludes drawing strong inferences from the observed repayment performance of modified loans. Servicers may choose whether or how to modify a loan based on private information about the borrower quality at the time of modification, and the observed redefault rates among the modified loans may reflect these ex-ante characteristics. Thus, a high redefault rate among modified loans does not necessarily imply that loans not granted modification would also have a high likelihood of redefault if they were to receive a modification.

Subsequent studies (including U.S. Department of the Treasury, 2012; and Schmeiser and Gross, 2015) examining performance of loans modified later during the crisis period (through at least 2011), confirm the significant relationships to postmodification payment reduction and postmodification LTV ratio. Moreover, these studies demonstrate that principal reduction has a comparatively large impact on likelihood of redefault because of the joint effects of payment reduction and reduced LTV ratio.[2] Anderson, Kogler, and Kim (2012) conduct a multivariate analysis of 12-month redefault rates of privately securitized mortgages receiving modification in 2006 through March 2011. This study finds that the impacts of interest rate reduction and principal reduction on the likelihood of redefault are similar to those in the aforementioned studies. In addition, it finds a significantly higher probability of redefault for subprime loans and for loans receiving modification at a later stage of delinquency. This study also finds significant reduction in redefault rates after 2008 and notes that this may reflect improving macroeconomic conditions or "improvement in the design and targeting of modifications that is not captured in payment reduction or modification type variables" but, unlike our study, does not attempt to disentangle these effects.

Scharlemann and Shore (2015) apply a regression discontinuity approach to identify and neutralize the selection effect associated with modification type in evaluating the impact of principal reduction on redefault. They examine modifications provided under the government-sponsored HAMP

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[2] Voicu, Weselcouch, and Tschirhart (2011), in addition to demonstrating that the likelihood of redefault is inversely related to both the amount of payment reduction and the amount of principal reduction, finds that modifications associated with the Treasury Department's Home Affordable Modification Program (HAMP) were less likely to redefault compared with non-HAMP modifications. In addition, Schmeiser and Gross (2015) also find that term extension modifications that increase the amount of principal due are most likely to redefault.

Principal Reduction Alternative (PRA). This program provides principal reductions for borrowers with negative equity, up to the point of meeting a negative equity target (usually 115 percent for the current LTV ratio). On the margin, consistent with a PRA selection effect, the PRA principal reduction modifications have a more beneficial impact on redefault rate than is inferred from extrapolation of the relationship of LTV ratio to redefault in the HAMP population not eligible for PRA.

The most closely related study to ours is Goodman et al. (2013), which analyzes semiannual declines in the redefault rate on modifications of privately securitized mortgages over 2008 through 2012.[3] The authors discuss various factors that may have driven this downward trend, such as granting modifications earlier in the delinquency process and modifications with more generous payment relief.

Our paper provides a more extensive and deeper analysis of the improvement in the repayment performance of loan modifications after 2008. In addition to investigating the repayment performance of privately securitized mortgages, we demonstrate the improved payment performance for Agency securitized and bank-held conventional mortgages and for government-insured mortgages. More importantly, in this paper, we evaluate the performance of borrowers receiving a loan modification relative to a matched sample of self-cured borrowers, thus controlling for factors that might be important in lowering the redefault rates of both groups (such as housing market recovery). Over the course of the downturn, we find improvement in the performance of modified loans relative to self-cures. In addition, we explore the factors that contribute to the larger decline in the redefault frequency of modified mortgages compared with self-cured loans.

Our findings are robust to restricting the sample to individuals in an advanced stage of mortgage delinquency. Thus, the observed improved repayment performance of loan modifications in this paper is not owing to the selection effect described by Mayer et al. (2014) whereby borrowers who have capacity to pay observe others benefiting from modification and intentionally miss some payments to qualify themselves for modification.

Finally, the potential selection effect associated with borrowers being selected to receive a loan modification, which clouds interpretation of the results in some previous studies, is by design neutralized in our analysis, for two reasons. First, matching modifications and self-cures, including the use of propensity scores, narrows the scope for selection effects as it ensures that the comparison is between borrowers who are observably as similar as possible in terms of ability and incentive to pay.

[3] Richter (2010) cites an expanded offering of concessionary modifications that present significant payment reductions as the primary factor underlying a decline in redefault rates on modifications over the 2008–2010 period.

Second, if any selection effect associated with loan modification remains, the observed impact was changing over the sample period such that the redefault rate of modified loans was declining relative to self-cures, which is consistent with a learning-by-doing interpretation.

3. Institutional Background

At the onset of the crisis, most mortgage servicers were oriented toward foreclosing quickly on delinquent borrowers rather than engaging in loan modifications (Cordell et. al., 2009). A mortgage foreclosure, however, imposes significant costs on not only the homeowner and on investors and servicers, but it is also costly to local governments and induces a drop in price of adjacent homes.[4] These costs encourage both public and private institutions to promote modifications to keep borrowers in their homes and avoid foreclosure costs.

In 2008, the Federal Deposit Insurance Corporation (FDIC) published the Mod in a Box guide that provided a template for payment-reducing modifications for distressed mortgage borrowers. The guide emphasized an adjustment in the interest rate, an extension of the term of the loan, or the process of forgiving principal to reduce monthly payments to sustainable levels (characterized as a 31 to 38 percent ratio of debt payment to income). The guide was accompanied by a net present value (NPV) calculator that servicers could use to compare the NPV of the loan with and without the modification, and thus facilitate the decision whether to offer a loan modification and with what terms.

Later in 2008, the Federal Housing Finance Agency (FHFA) introduced a formal program to modify delinquent government-sponsored enterprise (GSE) loans. The program was characterized by a set of borrower eligibility requirements; a recommended "waterfall" of maturity date, interest rate, and principal adjustments to achieve a target reduction in monthly payments as well as an $800 incentive paid to the servicer for each implemented modification.

In 2009, this early effort was succeeded by the HAMP with the objective of further encouraging standardized modifications. HAMP mirrored the FHFA program with a waterfall modification protocol and servicer financial incentives but had an expanded budget and larger pool of eligible loans (Cordell et al., 2011). At the onset of the program, 85 percent of all delinquent mortgages were eligible for HAMP modification (U.S. Department of the Treasury, 2009).

In June 2010, HAMP was expanded further to allow for more principal modifications under the Principal Reduction Alternative. The development of these streamlined programs, along with the direct

[4] See, for example, Kingsley, Smith, and Price (2009).

financial incentives offered to servicers, likely encouraged them to scale up their modification activity and facilitated the learning-by-doing process.[5] In pursuit of efficiency, servicers had opportunities to learn-by-doing; that is, servicers could improve the selection of loans for modifications and decrease the probability of further delinquency because modification practices became more refined from 2008 to 2011.

In addition to streamlining the modification process and offering financial incentives to servicers, government agencies also made data related to mortgage modification and repayment performance more readily available to the public. For example, the Office of the Comptroller of the Currency (OCC)'s quarterly *Mortgage Metrics Report* in mid-2008 vastly improved the public reporting of foreclosure and modification frequency and performance. The U.S. Treasury published the *Making Home Affordable Program Performance Report* to track the growth of HAMP modifications and their success after modification. The availability of these data may have facilitated learning-by-doing by lenders and servicers.

In 2013, the Consumer Financial Protection Bureau (CFPB) released new servicer guidelines that all large mortgage servicers must follow beginning in 2014 as Mortgage Servicing Rules under the Truth in Lending Act.[6] Publishing these servicing guidelines suggests that the learning-by-doing process has materialized in the form of uniform servicing standards that emphasize mortgage modification as an effective best-practice loss mitigation tool.

4. The Data

In exploring redefault after modification or self-cure, we use a database that merges loan-level mortgage servicing data from McDash Analytics, LLC (a wholly owned subsidiary of Black Knight, Inc.) with borrower credit report data from the Federal Reserve Bank of New York/Equifax Consumer Credit Panel. This database is named Equifax Credit Risk Insight Servicing™ McDash (Equifax CRISM).[7]

[5] As discussed in Gabriel, Iacoviello, and Lutz (2017), loan modification activity in California was particularly encouraged via introduction of the California Foreclosure Prevention Laws.

[6] The Truth in Lending Act primarily features rules regarding how loss mitigation efforts should be handled and when foreclosure processes can begin after a loan becomes delinquent; specifically, it establishes longer timelines for nonforeclosure activities to occur.

[7] The algorithm used by Equifax CRISM to merge the two data sets, which is proprietary, uses information common to both component databases, including mortgage origination amount, mortgage origination date, zip code of the property (Black Night McDash), zip code of the borrower (Equifax), current balance on mortgage (at the end of each quarter), and the borrower's payment history.

The mortgage servicing component provides payment status (days past due), loan terms (interest rate maturity date), and current balance for each mortgage (updated monthly).[8] For mortgages that enter into delinquency and subsequent foreclosure, the start and end dates of the foreclosure process are reported. This information is used to identify mortgages that become seriously delinquent, those that receive a modification, and those that self-cure out of delinquency.

Our initial sample consists of first-lien mortgages for primary (owner-occupied) residences that became at least 90 days past due or subject to foreclosure in 2008, 2009, 2010, or 2011. We then draw a 20 percent random sample from this overall population. We then narrow the sample even more to borrowers who went through a modification process or who self-cured from their mortgage delinquency during the period of 2008–2011 and who were no less than 90 days past due and no more than 540 days past due at the time of modification or cure, yielding a sample size of about 365,000 mortgages. We apply a process to identify mortgage modification and/or self-cure that is adapted from Adelino, Gerardi, and Willen (2013), as described in what follows.

Next, we exclude all mortgages indicated (in the credit report data) to have an associated junior lien, which reduces the sample size to about 273,000. This exclusion is intended to simplify the analysis; the presence of a second lien is a complicating factor because the borrower may prioritize one mortgage payment over the other. Finally, we exclude modified loans that were remodified and self-cured loans that subsequently were modified, within 42 months after the initial modification or cure. This latter exclusion, which amounts to less than 1 percent of the sample, addresses the concern that remodification might have prevented redefault, causing the borrower's performance status to be ambiguous. The final sample contains 268,023 mortgages, of which 139,935 are self-cures and 128,808 are modifications.[9]

For each mortgage loan included in the sample, we track payment history through the second quarter of 2014 or until the loan terminates through redefault or payoff. As noted, our analysis compares the redefault behavior of borrowers who have received modifications with matched borrowers (with similar characteristics) who have self-cured. The matching process further reduces the sample size owing to our inability to identify suitable matches for all modifications or all self-cures, as described in the next section.

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[8] The Black Knight McDash data are collected from the 10 largest U.S. mortgage servicers and account for approximately 75 percent of all mortgages in the U.S. as of year-end 2010 (Black Knight McDash estimate).

[9] A few loans with missing information on loan balance, maturity date, or interest rate are excluded from our sample.

In addition to dynamic information on payment status of the first-lien mortgage, the Equifax CRISM data provide various updated information from the borrower's credit record. These include credit score (the Equifax Risk Score), total balance of the first-lien mortgages plus any second-lien mortgages, and a variety of indebtedness and payment history information, refreshed on a monthly basis.

The Equifax CRISM data also indicate a loan's investor or guarantor category as one of the following: loans securitized and guaranteed by Fannie Mae and Freddie Mac (Agency), loans insured by the Federal Housing Authority or Veterans Administration (FHA/VA), loans held in bank portfolios, and privately securitized loans. Our analysis distinguishes among these four categories.

In addition, these data provide date of origination of the first mortgage, the original loan amount, the original appraised value of the property, the state and county location of the property, borrower FICO at origination, and information on loan type (whether fixed rate, amortizing adjustable rate, or pay-option adjustable rate).

We combine this detailed loan and borrower information with economic data, including the county-level repeat sales house price index (HPI) from CoreLogic and seasonally adjusted unemployment rates by county from the U.S. Bureau of Labor Statistics. Overall, Equifax CRISM allows us to control for a variety of factors associated with the likelihood of being granted a loan modification and the likelihood of redefault subsequent to modification or self-cure.

Identifying mortgage modification. A loan is classified as undergoing modification if: 1) we observe changes made to the principal balance, interest rate, or maturity date yielding a material reduction in the monthly payment, and 2) the mortgage returns from delinquent to nondelinquent (current) status.[10]

Principal reduction modifications are identified by comparing the current principal balance with both the origination balance and the previous month's balance. Similar to Adelino, Gerardi, and Willen (2013), we require that the current principal balance be at least 10 percent less than both the previous month's principal balance and original balance but greater than 50 percent of the original balance. An exception is made for mortgages reported in Equifax CRISM that were assigned to a loss mitigation program, in which case any reduction in principal is equated with a principal reduction modification.[11]

[10] Modifications (as identified by changes in loan terms) that do not return a loan to nondelinquent status appear to be relatively uncommon.

[11] As explained in Adelino, Gerardi, and Willen (2013), the loss mitigation flags included in servicing data are not comprehensive, necessitating the construction of modification indicators using reported changes in loan terms.

Interest rate modifications are identified by comparing the reported interest rate between the current and previous month. In the case of a fixed-rate mortgage, a loan modification is indicated by an interest rate reduction of at least 50 basis points.[12] The same rule is applied to adjustable rate mortgages (ARMs), provided that the current month does not coincide with the original note's contractual reset date. Otherwise, if the ARM is reported in Equifax CRISM to have been assigned to a loss mitigation program, then a rate modification is indicated by a 1 percentage point reduction. Otherwise, rate modification for an ARM is indicated by an interest rate reduction that is no less than 1 percentage point and at least 50 basis points in excess of the decline in the index rate since the previous rate reset (or since origination, in the absence of a prior reset).[13]

One other type of modification, involving combination rate and maturity adjustment, is identified by comparing reported interest rate and maturity date between the current and previous months. A modification is indicated if the maturity has been extended at least 12 months, the interest has been reduced by at least 12.5 basis points, and the required monthly payment has been reduced.[14]

Each modified mortgage is uniquely assigned to a modification category, such that priority is given to principal reduction and term extension. Thus, if the loan is indicated to be a principal reduction modification, it would be assigned to that category regardless of whether an interest rate modification is also indicated. If rate and term modification but not principal reduction is indicated, the loan would be considered a rate and term modification.

Identifying self-cure. A first mortgage is indicated to be self-cured if it returns to current status without the material reduction in monthly payment indicative of loan modification. Note that this definition does not rule out some assistance by mortgage servicers, such as granting a term extension that returns the borrower to current status but increases the monthly payment, or forgiving some accrued interest or penalties.

Sample composition. The bars with cross-hatches in Figure 1 show the composition of the prematch sample with respect to shares of modified versus self-cured mortgages, by year of cure or

[12] Adelino, Gerardi, and Willen (2013) apply a more restrictive criterion (larger rate reduction) for identifying interest rate modifications but do not require that a modification return a loan from serious delinquent to current status.

[13] The index rate, or market rate to which the mortgage note rate is tied, is represented by the three-month Treasury bill rate for this calculation.

[14] In contrast, Adelino, Gerardi, and Willen (2013) identify term extensions that increase monthly payments as loan modifications.

modification and by investor or guarantor category. The dashed lines indicate total modified plus self-cured loan counts by year and category.

The total number of self-cured or modified loans and the share of these that were modified increased markedly between 2008 and 2010, and especially within the Agency and FHA/VA categories. Within the portfolio and privately securitized categories, the share of modifications among all self-cured and modified loans doubled, while within the Agency and FHA/VA categories, it went from under 10 percent to more than 55 percent.

The vast majority of payment-reducing modifications each year provided an interest rate reduction (occasionally combined with a term extension) but no forgiveness of principal. Table 1 reports, for the prematch sample, the share of loan modifications involving principle reduction, by year. Notably, the share of principal write-down modifications increased steadily between 2008 and 2011.

5. Matching Modified with Self-Cured Loans

We seek to compare the redefault behavior of borrowers who receive modifications versus borrowers who self-cure as a means of controlling for the influence on redefault of the changing economic environment and delinquent borrower population. Both groups (modified and self-cured) go through the similar experience of initial delinquency, becoming current, and being at risk of redefault. What distinguishes them is that self-cures did not receive payment-reducing changes in loan terms to facilitate their remaining current and that some (not all) self-cures may have returned to current on their own (without any restructuring of the payment schedule).

To ensure that the comparison is between very similar borrowers (close to being identical given the available information), thus narrowing the scope for selection effects, we apply a two-step matching process. First, we match modified loans (treated) with self-cured loans (nontreated) using the propensity scoring process introduced by Rosenbaum and Rubin (1983).[15] Then, we impose further restrictions based on selected categorical variables: Matched loans must share the same product category, location of the property, delinquency status prior to cure, and year and quarter of cure.

[15] Propensity score matching is a process commonly used to account for observable heterogeneity across "treated" and "nontreated" entities, based on the conditional probability of treatment given observable characteristics, to reduce selection bias in treatment. In our study, the treated loans are modified loans and the nontreated loans are self-cured loans. For a more complete discussion of the origination and motivation for propensity score matching, see Guo, Barth, and Gibbons (2006).

The propensity scoring process involves three steps. First, we regress observable characteristics of the loans on a binary treatment indicator (modified versus self-cured) using a logistic regression specification. Specifically, we estimate the logistic regression model (1) to predict propensity $p(x_i)$ for

borrower i of being selected for modification ($M_i = 1$):

$$p(x_i) = pr(M_i = 1 | X_i = x_i) = \frac{1}{1 + e^{-X_i \beta}} \qquad ((1)$$

where X_i is a vector of covariates, including both point-in-time and original characteristics of the loans or the borrowers.

Second, we match each treated observation (modified) with a similar nontreated observation (self-cured) based on the predicted values (i.e., the propensity score) from the logistic regression in Equation (1). We run separate regressions for the three investor (or guarantor) categories: FHA/VA loans, loans securitized and guaranteed by Fannie Mae and Freddie Mac (GSE), and loans held in bank portfolios or privately securitized.

The explanatory variables in the regressions include dummy indicators for location of the property (state fixed effects), year of origination, year and quarter of cure, and portfolio type (bank portfolio versus privately securitized portfolio). Other explanatory variables include both point-in-time (updated) variables as well as original characteristics of the borrower or loan (from the date of origination), as listed below.

Point-in-time variables include change in local house price index over the year prior to cure, interest rate spread between the mortgage interest rate and 10-year Treasury rate, indicator variables that capture the ranges of delinquency status (days past due) as of the month prior to cure, and indicator variables for ranges of refreshed LTV ratio. Other point-in-time variables are the log of the mortgage principal balance, the borrower's Equifax Risk Score (a credit score assigned by Equifax) and bankruptcy status, and an indicator for multiple first mortgages (more than one active, first mortgage account in the borrower's credit file).[16] Unless otherwise noted, each of these variables is measured as of three months prior to the date of cure. Original characteristics include an indicator for being a subprime borrower (defined as having FICO score at origination no greater than 620 and for jumbo

[16] The refreshed LTV is calculated as the principal balance of the mortgage divided by the current property value. The latter is based on the original appraised value updated using the county-level house price index from CoreLogic. The specified ranges of refreshed LTV are > 80 and ≤ 90; greater than 90 and ≤ 100, and > 100 percent. The specified delinquency status categories are ≥ 120 and < 180, ≥ 180 and < 270, ≥ 270 and < 360, and ≥ 360 days past due.

mortgage) and an indicator for the retail origination channel.[17] Also included are indicators distinguishing ARM categories from fixed-rate mortgages.[18]

Table 2 reports the sample mean values for each of these explanatory variables by year of cure, cure type (modification or self-cure), and investor (or guarantor) category. Results reported in Table 2 indicate that loans that received modification tended to have larger outstanding balances and larger ex-ante interest rate spreads and tended to occur at later stages of delinquency. In addition, the share of modifications occurring at later stages of delinquency increased over time, and refreshed LTV declined over time (with the exception of loans within the FHA and VA categories). Notably, the average Risk Scores also increased over time within all categories, for both modifications and self-cures.

Propensity score model results. Logistic regression results based on the propensity score Equation (1) are presented in Table 3. For each investor (or guarantor) category, loans with refreshed LTV below 90 percent have reduced probability of modification relative to self-cure. For Agency and privately securitized loans and loans held in bank portfolios, more severe financial difficulties (as indicated by a bankruptcy filing or lower Risk Score) are inversely related to likelihood of modification relative to self-cure, while more favorable housing market conditions are positively associated with it.

The coefficients of the delinquency segments indicate that cure is more likely to be associated with a loan modification as the borrower falls more behind in payments. Loans with larger interest rate spreads and loans with larger balances are more likely to cure through modification. For borrowers with multiple first mortgages, their primary residence is less likely to cure through modification.

Matching modifications to self-cures. The matching process is completed in two steps. The first step is to divide all cured loans into broad segments based on geographic location (the state in which the property is located), date of modification or cure, delinquency bucket (same delinquency status in the month prior to being cured), and investor (or guarantor) category. Each of these segments contains both modified and self-cured loans. In the next step, we match modified loans to self-cured loans within the same segment based on the estimated propensity score, which is the predicted value for probability of modification from Equation (1).

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[17] The CRISM data include a jumbo mortgage identifier and a servicer-provided classification of the mortgage as subprime at origination that we use to identify subprime mortgages if the FICO score at origination is missing.

[18] The ARM categories distinguished are pay-option loans allowing negative amortization (Option ARM), mortgages that allow monthly rate adjustment (variable ARM), mortgages with one-year initial fixed-rate periods, those with two- or three-year initial fixed-rate periods, and those with initial fixed-rate period longer than three years (other ARM).

We use the method of nearest-neighbor, caliper matching to identify modified and self-cured loans with sufficiently close propensity scores.[19] We allow multiple self-cured loans to be matched to a unique modified loan (with the same propensity score) in the same segment. To assign the same weight to each matched pair in this one-to-many matching procedure, we assign a weight of 1 to the modified loans (treated) and weigh each of the matched self-cured loans (control) by the reciprocal of the number self-cured loans matched to a specific modified loan.

In the event of no match being found for a modified loan within the caliper, the observation is dropped from the analysis. To minimize loss of observations of modified loans due to a lack of suitable matches, we allow for replacement in the matching process such that a particular self-cured loan may be paired with multiple modified loans in the same segment, up to a limit of 25 uses of the same self-cured loan.[20] If a self-cured loan is used as a match for more than one modified loan, then its sample weight is calculated as the sum of its weights across all modified loans with which it is paired.

The match rate between modified and self-cured loans is affected by our choice of caliper interval. A larger caliper interval would increase the matching rate but would be more likely to result in less-accurate matching (smaller degree of similarity). The choice of caliper interval for matching involves a trade-off between the matching accuracy and the number of matched pairs that could be used for the study. Following Ding et al. (2011), we select a caliper of 0.1 for our analysis.

Table 4 quantifies the outcomes of the matching process, by year of modification or self-cure, and by investor (or guarantor) category. Panel A reports the percentage of modified loans successfully matched to at least one self-cured loan, Panel B reports the percentage of self-cured loans used for at least one matched modification, and Panel C provides some information on the frequency of multiple matches per modified loan. Excluding loans held in bank portfolios, the majority of modified loans are successfully matched to at least one self-cure, with success rates ranging from 55 percent to 78 percent, depending on the year and investor (or guarantor) grouping. For loans held in bank portfolios, the match success frequency ranges between 43 percent and 54 percent, reflecting the relatively smaller number of loans in this category. The majority of self-cured loans are not employed as a match because the

[19] This method involves selecting pairs of modified and self-cured loans, within the same characteristic segment, with absolute difference in propensity scores less than a specified caliper value (α). Alternative matching algorithms found in the literature include one-to-one matching, kernel matching, local linear matching, and Mahalanobis metric matching (Guo, Barth, and Gibbons, 2006).

[20] In cases in which this limit would be exceeded (a particular self-cured matches to more than 25 loan modifications), we prioritize use in one-to-one matches such that no other matching self-cures are available for the particular loan modification. Beyond that, we prioritize use among fewer total matches for a particular loan modification, and beyond that, the selection is random.

majority of self-cured loans do not have propensity scores sufficiently close to those of modified loans in the same segment.

The solid bars in Figure 1 show composition of the postmatch sample with respect to the weighted share of modified loans by year of self-cure or modification and by investor (or guarantor) category. The solid lines indicate total loan counts by year. Since unmatched loans have been dropped from the sample and there are proportionately more self-cures left unused as matches than modified loans left unmatched, total (postmatch) loan counts are smaller and the share of modifications is somewhat larger compared with the prematch composition, as expected.

Table 5 reports the postmatch, weighted sample mean values for the same set of variables included in Table 2, again by year of cure, cure type, and investor (or guarantor) category. By design, both self-cures and modifications have similar mean values postmatch; the primary exception is that modifications continue to exhibit somewhat larger average loan balances than self-cures within the Agency grouping.

Identifying redefault. The matched sample allows for controlled comparisons of redefault rates between modified and self-cured loans. However, defining redefault is not as straightforward as one might initially surmise. Many borrowers return to delinquency after being modified or self-cured, but the lapse is often temporary (the borrowers quickly cure again), while some borrowers redefault, cure, and fall behind again, ultimately being unable to cure.

We settled upon the following definition of *redefault* as reasonably indicative of a long-term return to delinquency. First, we define a *redefault event at date t* as: 1) the self-cured or modified loan returns to severe delinquency (90 or more days past due, in foreclosure, in real estate owned (REO), or involuntarily liquidated) at date *t*, and 2) delinquent status is confirmed (the loan is observed to be at least 30 days past due, in foreclosure, in REO, or involuntarily liquidated) as of six months after date *t* or as of its last observed performance date, whichever comes first. Next, we only focus on redefault events that occur within 36 months after modification or self-cure, and define redefault as the occurrence of at least one redefault event within this 36-month period. For loans with more than one redefault event within the 36-month period, we take the date of the first redefault as the redefault month.

On occasion, within the 36-month window, a modified or self-cured loan returns to delinquency and, before six months has passed, is granted a modification that resets it to current, precluding a redefault event. If these loans otherwise are not observed to redefault during the 36-month window, we exclude them from the sample, as their redefault status becomes ambiguous because of the (re-)

modification. This exclusion only has a small impact — less than 1 percent of the loans in the sample are affected.

Comparative redefault rates. In Figure 2, we compare the monthly cumulative redefault rates of modified loans to the monthly, weighted cumulative redefault rates of their matched self-cures, by investor (or guarantor) category. We plot these cumulative redefault rates over a 36-month window after the loans had returned to nondelinquent status, separately for the earliest cure cohort in our sample (2008) and the latest (2011). For ease of visualization, we also show cubic polynomial approximations to the monthly data points.

The portfolio, Agency, and private securitized categories exhibit similar patterns, characterized as follows. Redefault rates are much lower for the 2011 cohort compared with the 2008 cohort, for both modified loans and their matched, weighted self-cures. However, the decline in redefault frequency is markedly larger for loan modifications than for self-cures. In 2008, loan modifications have a higher frequency of redefault than self-cured loans, but by 2011, the ordering is reversed.

For example, among Agency loans, the 36-month cumulative redefault rate for the 2008 cohort was around 80 percent for modifications and 70 percent for self-cures. The 36-month cumulative default rate for the 2011 cohort was about 20 percent for modifications and 35 percent for self-cured loans.

Improvement in performance between 2008 and 2011 is much more modest for the FHA/VA category, although again, the decline in redefault rates is larger for modifications than for self-cures. Given the relatively small changes in performance for this category, we focus primarily on Agency, portfolio, and private securitized loans for the remainder of the paper.

Figure 3 presents monthly cumulative redefault rates of modifications and matched, weighted self-cures through a 36-month window after the initial cure, by year of cure; as a set of pairwise comparisons: the 2008 cohort compared with 2009, 2009 with 2010, and 2010 with 2011. These comparisons are presented separately for Agency loans (Panel A), privately securitized loans (Panel B), and portfolio loans (Panel C).

Within each investor (or guarantor) category, most of the improvement in performance is seen for the 2009 cohort compared with 2008 and for 2010 versus 2009. From 2008 to 2009, the decline in redefault rates between 2008 and 2009 is substantially larger for modifications compared with self-cures. In the case of Agency and portfolio loans, the frequency of redefault is higher for modifications compared with self-cured loans in the 2008 cohort, but the ordering is reversed for the 2009 cohort. From 2009 to 2010, the decline in redefault rates is about the same for loan modifications as for self-cures. From 2010 to 2011, the improvement in performance is more modest, and again larger for modified compared with self-cured loans.

Alternative sample constructions and default definitions. Qualitatively similar redefault rate trends are observed if we reverse the matching and weighting procedure, whereby each self-cured loan is assigned a weight of one and potentially matched to multiple modified loans (allowing reuse of modified loans in different pairings), or if we forego matching entirely and use the full (prematch) population. In each case, we find that redefault rates decline over time for both modified and self-cured loans, such that the decline in redefault rates is larger for modifications. However, the differences between modifications and self-cures are somewhat more pronounced for the uncontrolled (full) population.

We also examined redefault rate patterns with a broader definition of redefault, whereby we specify redefault as any reoccurrence of severe delinquency within 36 months of modifications or self-cures, whether or not the reoccurrence is transient. Not surprisingly, redefault rates are generally higher under this definition, and they do not decline as much over time. However, default rate trends are similar to those observed using our original, preferred definition: The decline in redefault rates over time remains substantial and remains larger for modifications compared with self-cures, under the broadened definition. Thus, the results are qualitatively robust to a broader definition of redefault.

Impacts of the economic environment. Improving macroeconomic and housing market conditions was probably one of the key factors driving the improving performance of both self-cured and modified loans between 2008 and 2011. In other words, the stabilization followed by recovery in economic and housing market conditions beginning in 2010 contributed to declining redefault frequencies of both self-cured and modified loans.

Another possible factor driving improved performance of both self-cured and modified loans is that borrowers who became delinquent in the later stages of the mortgage crisis period tended to be less vulnerable to repeat shocks compared with their predecessors. Hence, they were better able to sustain a self-cure or modification.

Learning by doing. Alternatively, over time servicers may have become more effective at helping borrowers stay current following a self-cure or modification, such as through counseling and early intervention. In other words, mortgage servicer learning-by-doing may have taken place in regard to self-cured borrowers as well as with modifications.

Each of these explanations implies a gradual decline in redefault rates over time. Unfortunately, we cannot distinguish among them using our data. We can, however, potentially draw from our data additional insights regarding why the decline in redefault rates was greater for loan modification compared with self-cure. We explore this issue in the next section.

6. Logistic Regression Analysis of Redefault

Building upon our visual analysis of redefault patterns over time, we further explore the decline in redefault rates of modified loans in relation to self-cures. We exclude government-insured (FHA and VA) loans from this additional analysis, since we observe relatively little change in redefault rates between 2008 and 2011 for this category.

Hypothesis 1. Our point of departure is the hypothesis that once a borrower cures from delinquency, whether through self-cure or with servicer intervention via modification, the determinants of redefault are largely independent of this distinction. More specifically, conditional on observable characteristics of the borrower and loan, a borrower who cures via loan modification is similarly situated to one that self-cures, except to the extent that modification provides financial relief that makes the cure more sustainable.

Hypothesis 2. Moreover, we posit that the extent to which modification bestows an advantage depends on not only the generosity of the revised repayment terms but also on the following factors: 1) the economic environment; 2) the length of delinquency (number of days past due) at the time of modification, and 3) modification vintage (calendar year and quarter). Intuitively, the modification is expected to be more likely to succeed when combined with improving economic conditions. A borrower in longer-term delinquency when the modification is granted is expected to be in a more precarious financial condition, making the modification less effective. The effectiveness of loan modifications is also expected to have improved over time during the course of the downturn and recovery through learning-by-doing.

To test these hypotheses, we first estimate a logistic regression model that predicts redefault probability for self-cures, as shown in Equation (2).

$$rederedefault\ flag_i = \alpha + \beta_0 selfcure_{2009Q2_i} + \cdots \beta_4 selfcure_{2011_i} + \gamma \cdot Z_{it} + \eta \cdot X_i \quad (2)$$

The dependent variable $redefault\ flag_i$ is a binary indicator that is equal to 1 if the self-cured loan *i* redefaults and equal to zero otherwise. We use the postmatch sample of self-cured loans, weighting each observation as described earlier.

The “vintage” dummy variables $selfcure_{t_i}$ indicate the specific year and quarter when the self-cured loan *i* returned to current, leaving the peak of the crisis period (all quarters in 2008 and 2009:Q1) as the baseline period. The vector Z_{it} represents a set of independent variables that measure local economic conditions that could impact the repayment performance of loan *i* subsequent to the modification period *t*. Specifically, we include in Z_{it} change in the county unemployment rate and percentage change in the county house price index during the 18 months following the cure date, each splined at 0.

The vector X_i represents a set of independent variables that measure risk characteristics of the loan *i* and the associated borrower. These include most of the loan- and borrower-specific characteristics previously used in the propensity scoring model in Equation (1), as these are potentially related to likelihood of redefault. [21]

In addition, X_i includes a new variable (derived from the borrower credit record) — whether the borrower was delinquent on other unsecured consumer loans such as credit cards within six months before or six months after the initial mortgage default.[22] Delinquency on these accounts may be indicative of a more severe adverse liquidity event for the borrower, making redefault more likely. Table 6, Panel A reports the postmatch sample, weighted mean values of this new variable, by year of cure; cure type; and investor (or guarantor) category. The proportion of borrowers who remained current on cards and other unsecured personal loans around the cure date rose over time as economic conditions improved.

Next, we apply the estimated, self-cure redefault (logistic) model (2), (2) to the sample of postmatch modified loans — as shown in Equation (3).

$$redefault\ flag_i = \mu + \delta_0 * \left(\alpha + \beta_0 mod_{2009Q2_i} + \cdots \beta_4 mod_{2011_i} + \gamma \cdot Z_{it} + \eta X_i\right) + \lambda \cdot Z_{it}$$

$$+ \theta \cdot Y_i + \varphi_0 mod_{2009Q2_i} + \cdots + \varphi_4 mod_{2011_i} \qquad (3)$$

The term $\left(\alpha + \beta_0 mod_{2009Q2_i} + \cdots \beta_4 mod_{2011_i} + \gamma \cdot Z_{it} + \eta X_i\right)$ in Equation (3) represents the imputed redefault probability of the modified loan based on the redefault behavior for self-cures from Equation (2). An estimated coefficient δ_0 close to 1 on this term would be consistent with Hypothesis 1.

[21] We reduce the number of delinquency categories to two: ≥ 180 and < 270 and ≥ 270 days past due.

The "vintage" dummy variables mod_{t_i} indicate specific year and quarter of the modification of loan *i*, and the terms Z_{it} and Y_i in (3) represent factors influencing the effectiveness of modifications. Inclusion of these terms tests Hypothesis 2.

In particular, the local economic variables Z_{it} are reincluded separately (apart from their presence in the imputation term) to account for the possibility that the repayment advantage bestowed by a modification is most effective when combined with improving economic conditions. We include in Y_i an indicator for principal forgiveness modification and a piecewise-linear spline term measuring percentage reduction in the mortgage payment due to the modification (with a single knot point at 15 percent) to capture the financial benefit accruing to the borrower as a consequence of the modification. In addition, we include indicators for delinquency (days past due) segment as of the month prior to modification.

We estimate a pair of equations for Agency and non-Agency (portfolio and private securitized) loans, respectively. In the non-Agency equation, we add a dummy variable to distinguish portfolios from privately securitized loans.

Empirical results: self-cures. Table 7 presents the estimated redefault model for the postmatch self-cured samples based on Equation (2). The results are as expected. The sustainability of self-cure is related to the local house price and unemployment trends; that is, rising unemployment increases redefault likelihood while rising house prices mitigate it. Moreover, borrowers who have lower refreshed LTV prior to self-curing are more likely to sustain the cure. In addition, self-cured borrowers with higher Risk Scores are less likely to redefault, while those who are more than 270 days delinquent at the time of cure are more likely to redefault.

The results also show that while the economic variables and risk measures exhibit the expected associations to redefault risk, they do not explain the entire improvement in self-cure redefault rates between 2008 and 2011. Much of the improving performance of self-cures is captured by the vintage dummy variables. The vintage indicators may capture more general improvement in macroeconomic and housing market conditions, or increasing resiliency of the self-cure population tied to unobservable factors (those not captured in the independent variables in X_i and Z_{it}). In addition, the vintage indicators may capture mortgage servicer learning-by-doing for their ability to sustain self-cured borrowers' performance.

Empirical results: modified loans. Table 6, Panels B and C*,* report the postmatch sample, weighted mean values of the principal forgiveness indicator variable and the payment reduction from loan modification, by year of modification and by investor (or guarantor) category. Both the share of principal forgiveness modifications and the size of payment reductions increased over time, which we expect would be reflected in improving repayment performance of modified loans.

Table 8, columns 1 and 3 present the regression results for Agency loans and private securitized (or portfolio) loans, respectively. In each case, the estimated coefficient on the imputed redefault probability is close to one. Indeed, as shown in columns 2 and 4 of Table 8, if we reestimate these equations with the imputed redefault (from self-cure model) being fixed at one, the other estimated coefficients would remain pretty much unchanged except for the coefficients of the modification vintage terms. Thus, the redefault behavior of modified loans closely resembles that of similarly situated self-cured loans with respect to all the relevant determinants of redefault, except for the additional impact captured by the modification vintage variables and modification terms, consistent with Hypothesis 1.

Impact of modification terms. The likelihood of redefault of a modified loan exhibits statistically significant, inverse relationships to the principal modification indicator and to the size of the payment reduction. In addition, the estimated coefficient on declining unemployment rate is positive and statistically significant. Thus, increasingly generous payment terms on modifications and improving economic conditions over the course of the study period contributed to the larger decline in the redefault rate of modified loans compared with self-cured loans. We also find that loan modifications at later stages of delinquency have higher probability of redefault. These findings are consistent with Hypothesis 2.

Net impact of modification vintages. Even after accounting for all of the relevant factors discussed previously, much of the improvement in performance of modified loans (relative self-cures) is captured by the modification vintage terms. The results indicate a large decline in the redefault rate of modifications after the first quarter of 2009 and another more moderate decline after 2010, consistent with the matched-pair, visual comparisons in Figure 3.

Odds ratios associated with the estimated coefficients of the modification vintage terms from model (1) are shown in Table 9. The odds of redefault in the second through fourth quarters of 2009, relative to the 2008 and early 2009 baseline are 0.72 for Agency loans and 0.65 for privately securitized and portfolio loans, respectively. These odds rise slightly in 2010 (where the difference is not statistically significant), and then drop to 0.62 and 0.56, respectively, in 2011.

Robustness check. These results are robust to including more variables in Y_i and thus controlling for other factors that may be associated with differences in performance of modified versus self-cured loans. Risk Score, in particular, provides an updated measure of a borrower's creditworthiness and is an obvious candidate to control for systematic differences in the likelihood of default across the two subpopulations. As shown in Table 10, columns 1 and 3, the results are robust to adding Risk Score as a covariate in Equation (3).[23] Results likewise were also robust to inclusion of refreshed LTV and the subprime indicator; in each case, we found no important impact on the other estimated coefficients or on the model's goodness-of-fit.

Testing for a potential role of "strategic default." The modification vintage terms capture improvement in performance of loan modifications relative to self-cures because factors we cannot specifically identify. One conceivable such factor could be an increasing frequency of borrowers opting to become delinquent on their mortgages to become eligible for a loan modification, such as in Mayer et al. (2014) and Jagtiani and Lang (2011). If the frequency of borrowers engaging in such strategic behavior increased as modification activity expanded, then that could explain declining redefault rates on modifications, as such borrowers would have little incentive to redefault after receiving their sought-after modification.

We believe the likelihood of such strategic behavior is small overall and is greatest when borrowers perceive modifications to be quickly obtainable.[24] That is, the likelihood of strategic default declines the longer the wait for a modification because of greater harm to the borrower's credit score, accumulating late fees, and increasing risk of foreclosure. Thus, one way to mitigate any impact of strategic default is to restrict the sample to borrowers who became at least 120 days past due prior to receiving their loan modification.

The results from reestimating the baseline specification (model 1) using the restricted sample of modified loans (which were deep in delinquency status prior to receiving modification) are presented in Table 10, columns 2 and 4. There are no material differences from the full sample results of Table 8, suggesting that strategic default was not an important factor driving the improvement in redefault performance after 2008.[25]

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[23] In the private securitized or portfolio equation, Risk Score is not statistically significant, and other estimated coefficients are essentially unchanged. In the Agency equation, Risk Score is statistically significant, the estimated coefficient on the imputed likelihood of default is marginally smaller, and estimated coefficients of the vintage terms indicate greater decline in redefault frequency over time. However, the overall goodness-of-fit of the equation is unchanged, and other estimated relationships are qualitatively the same as without Risk Score included.

[24] The specific Countrywide Mortgage program studied by Mayer et al. (2014) likely encouraged strategic default, as it became widely publicized that borrowers were eligible for modification as early as 60 days or more past due.

[25] We also tried including the indicator for whether the borrower was delinquent on a credit card or on an unsecured consumer loan other than a student loan around the time of the initial mortgage default, as a control for strategic default behavior. (A borrower who is severely liquidity constrained as indicated by such small balance

Summary. Overall, our analysis has highlighted key factors contributing to the larger decline in redefault frequency of modified compared with self-cured loans between 2008 and 2011. First, consistent with Goodman et al. (2012), we can in part attribute the improving, relative performance of loan modifications to an increased share of principal modifications, which on average perform better than other types of modifications. Second, improving relative performance is attributable to larger payment reductions associated with modifications in general after 2008. Third, the favorable impacts of principal and payment reductions were enhanced by improving economic conditions, with modifications becoming more effective as unemployment rates declined.

Our analysis has also provided additional insights that have not been explained in the mortgage modification literature. Goodman, Ashworth, Landy, and Yang (2012) and Goodman, Yang, Ashworth, and Landy (2013) argue that the decline in redefault rate after 2008 reflects modifications occurring at earlier stages of delinquency in the later vintages. Our analysis confirms that earlier intervention is associated with reduced redefault probability of modified loans relative to that of self-cured loans. However, we also find that time in delinquency prior to modification was actually lengthening after 2008. Therefore, we cannot attribute the improving performance of modifications relative to self-cures to earlier interventions.[26] There must be some unspecified factors that explain this phenomenon — consistent with our learning-by-doing hypothesis.

Learning-by-doing is our preferred explanation for the significant vintage effect during the last three quarters of 2009 (relative to 2008 through first quarter of 2009 baseline), as it is intuitively plausible that loan modifications became more successful because servicers performed a large number of mortgage modifications and observed and learned from the outcomes. Early in the crisis, many servicers had limited experience designing modification programs. As modification activity ramped up, particularly during 2008 and into early 2009, servicers may have learned how to design and implement the programs more successfully.

We note that there might be a borrower-side explanation as well. Improving performance of loan modifications may be potentially attributable in part to changes in the characteristics of borrowers

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delinquencies is an unlikely candidate for strategic defaulter.) Inclusion of this variable (before or after excluding borrowers less than 120 days past due) had no important impact on other estimated coefficients.

[26] Goodman et al. (2011) suggest that declining redefault rates on loan modifications during 2008–2011 may reflect an increasing number of loans experiencing a remodification. Since we exclude remodifications from our sample ex ante, this explanation is not applicable here. However, the frequency of remodification was very low (as noted earlier, less than 1 percent of loans were excluded due to a modification subsequent to the initial modification or cure). Therefore, incidence of remodification is unlikely to have had a significant impact on redefault rates of modified loans.

receiving them, with these changes being unrelated to (evolving independently of) servicers' modification strategies. As indicated in Table 5, compared with later years, 2008 defaulters in the Agency category had relatively high, refreshed LTV, and especially in the privately securitized (or portfolio) category, they were more likely to have subprime characteristics. However, our estimated vintage relationships are robust to controlling for these factors, and the 2008 defaulters otherwise were not observably much different from 2009 defaulters. Thus, the learning-by doing explanation seems most consistent with the fact that the improvement in performance followed upon the initial ramping up of modification activity.[27]

Learning-by-doing in regard to loan modification might be reflected in servicers becoming more adept at screening borrowers for eligibility. Based on the repayment performance associated with previous modification decisions, servicers may be updating the criteria or net present-value calculations applied to assess whether a modification is preferable to inaction or foreclosure to lead to better outcomes. Alternatively, servicers may have learned how to tailor modification terms to individual borrower circumstances. Again, servicers could be updating their intuition or models for what modification terms are likely to be successful for a given borrower based on their accumulated experience. Another potential form of learning-by-doing may be through enhancing default prevention activities, such as postmodification financial counseling.

7. Concluding Remarks

A payment-reducing loan modification is intended to provide borrowers with an opportunity to sustainably cure their mortgage delinquency, although for some borrowers, mortgage modification only delays the inevitable redefault. Early during the mortgage crisis that developed during 2007 and 2008, redefault rates of modified loans were quite high, validating the common perception that loan modifications are not cost effective. However, over the course of the downturn and early recovery periods, loan modifications increasingly achieved their goals.

Our study examines redefault rates of loans selected for modification during 2008–2011, using similarly situated, self-curing borrowers as a control group. We find that while the performance of

[27] We are somewhat more agnostic in regard to the further improvement in performance indicated by the estimated 2011 vintage effect. On the one hand, as the economy and housing prices had begun to stabilize by 2011, these later defaulters, who had survived the worst of the downturn, may have been systematically different along unobservable dimensions than earlier cohorts. On the other hand, additional learning-by-doing might have occurred as the economic context evolved.

modified and self-cured loans both improved dramatically after 2008, the improvement of modified loans was substantially greater than that of similarly situated self-cures.

We identify key factors that potentially contribute to the larger decline in redefault frequency of modified compared with self-cured loans over the study period via estimation of logistic regression models of redefault for modified loans in conjunction with models of self-cured loans. First, the improving, relative performance of loan modifications in part reflected an increasing share of principal modifications, which on average perform better than other types of modifications. Second, improving relative performance is attributable to larger payment reductions associated with modifications in general after 2008. Third, the favorable impacts of principal and payment reductions were enhanced by improving economic conditions, with modifications becoming more effective as unemployment rates declined.

Fourth, much of the improvement in performance of modified loans relative self-cures is captured by modification vintage terms, which suggest that the improvement in part has been driven by changing behavior on the servicer side. That is, as servicers gained experience via expanded loan modification activity in the early stages of the mortgage crisis, they changed the criteria for modification selection. We believe that this learning-by-doing process, wherein servicers learned from past mistakes and successes, contributed to declining redefault rates.

This moderation in redefault rates on loan modifications suggests that encouragement of loan modification may, in fact, have been optimal public policy. However, further research incorporating a full cost and benefit quantification is needed to establish whether mortgage modifications were worth it from the lenders' and borrowers' perspectives as well as from the perspectives of overall social welfare. Further research might also provide additional insights into specific policy questions around the design for effective loan modification — for example, whether servicers should receive subsidies for modification, whether and to whom subsidies should be targeted, and what strategies might further enhance the effectiveness of mortgage loan modifications.

Finally, our findings imply that public policies associated with housing finance or home ownership support should be evaluated in part on their ability to promote or facilitate the learning-by-doing process. Encouraging mortgage loan modification proved to be effective public policy despite historical evidence of high redefault rates, because as modification activity expanded, repayment performance of modifications improved dramatically. Information dissemination by government agencies may have facilitated this learning-by-doing process.

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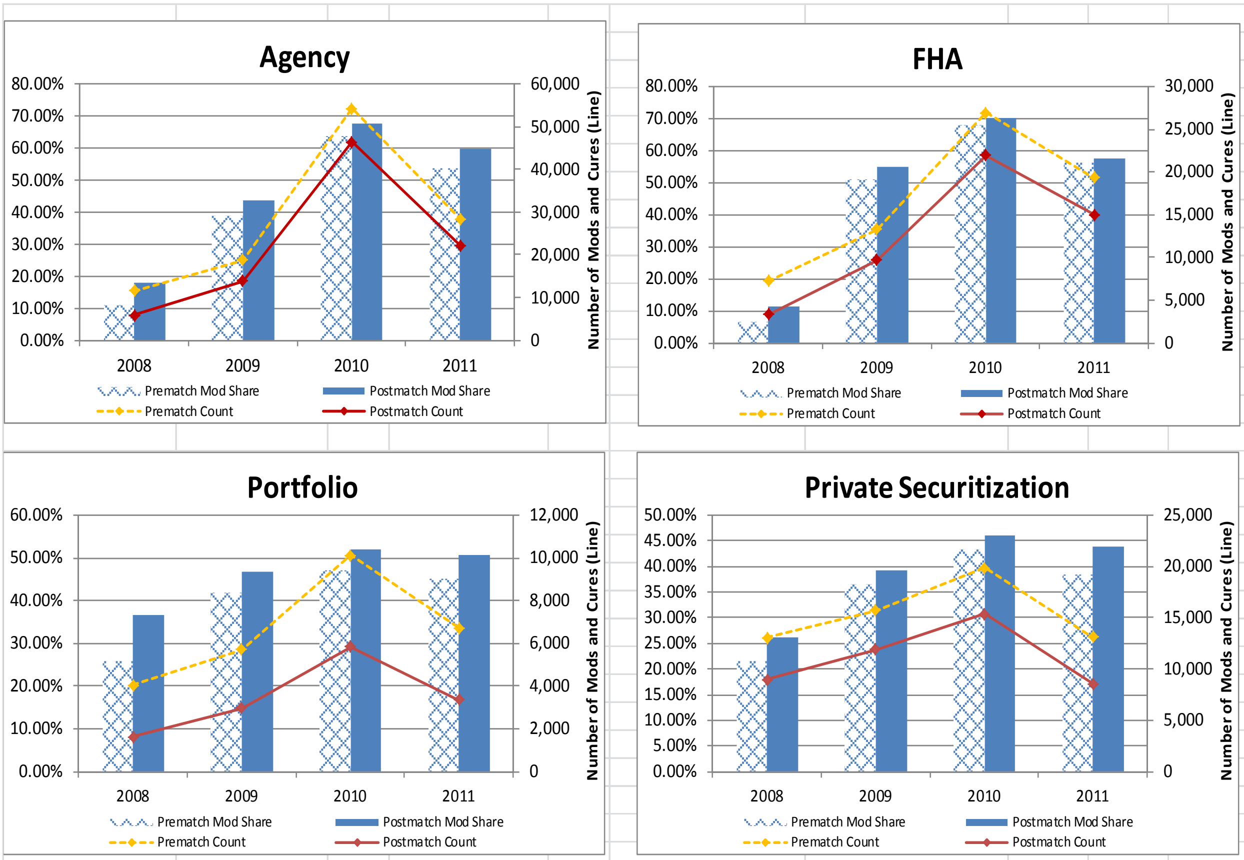
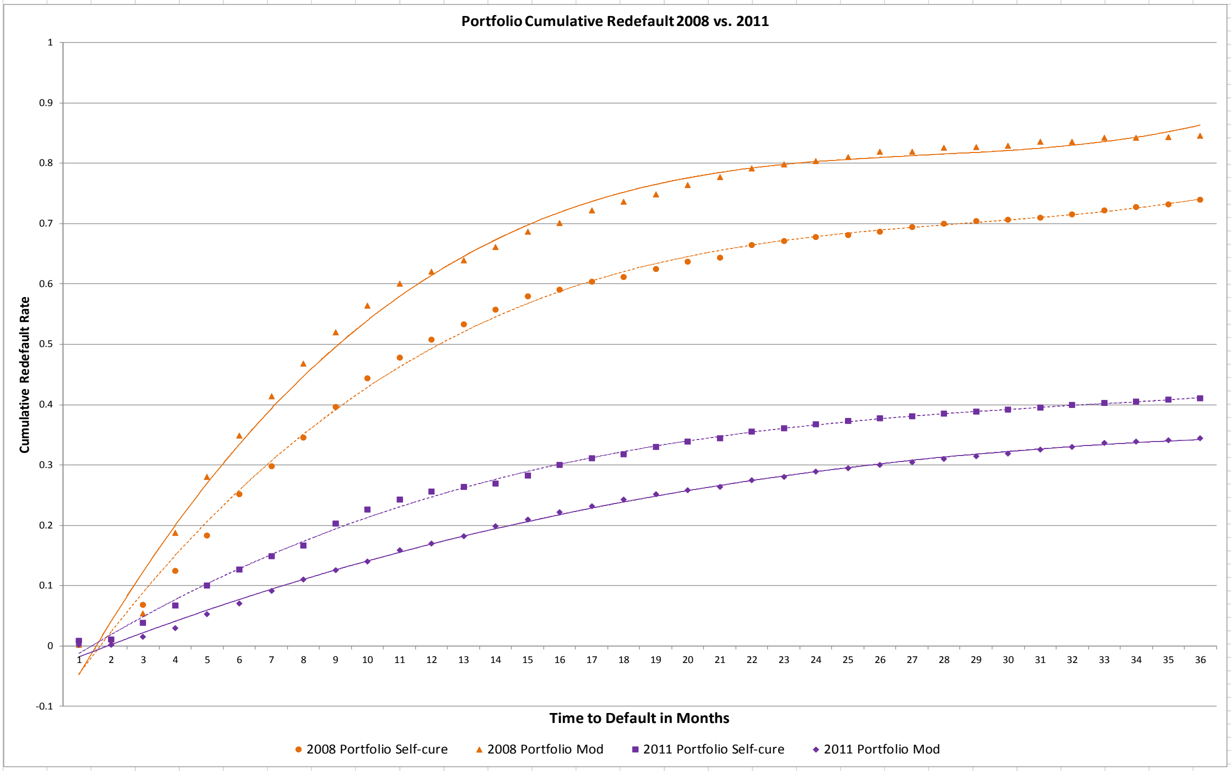
Figure 1: Cure Type by Year of Cure/Modification (Prematch Sample)

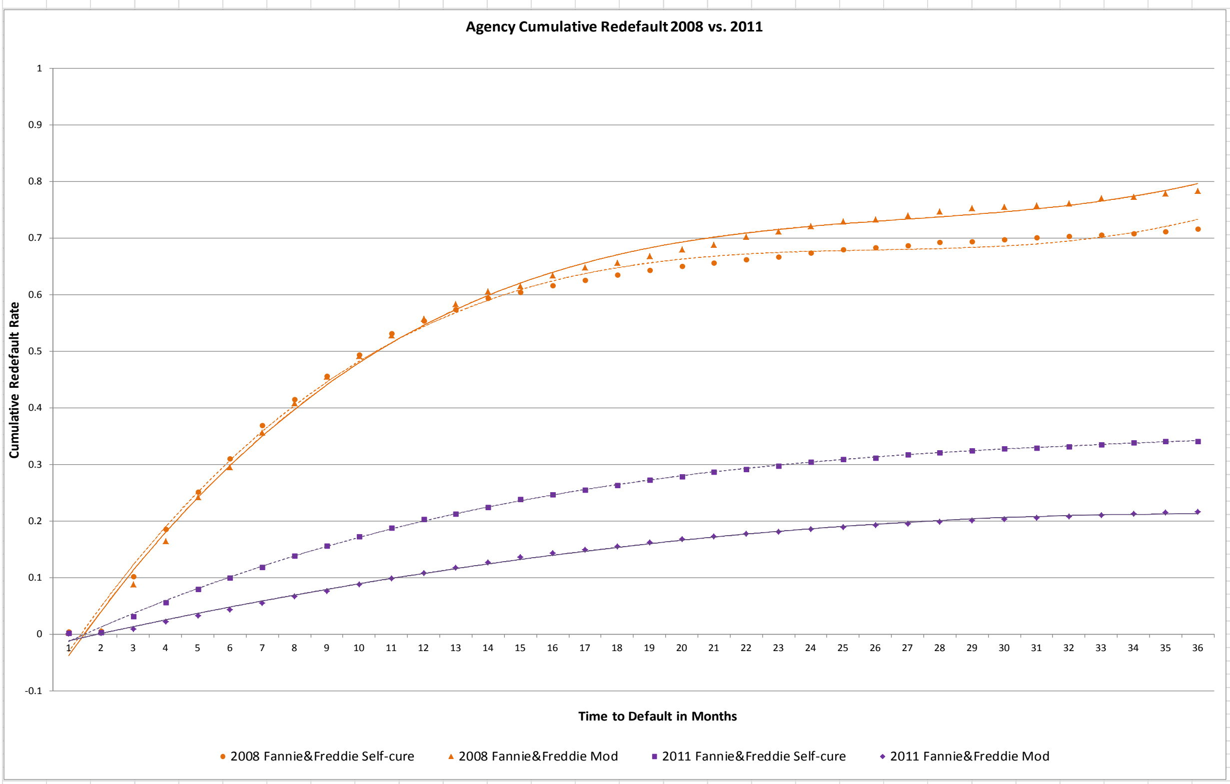
Share of Modifications and Total Counts of Modifications and Self-Cures



Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

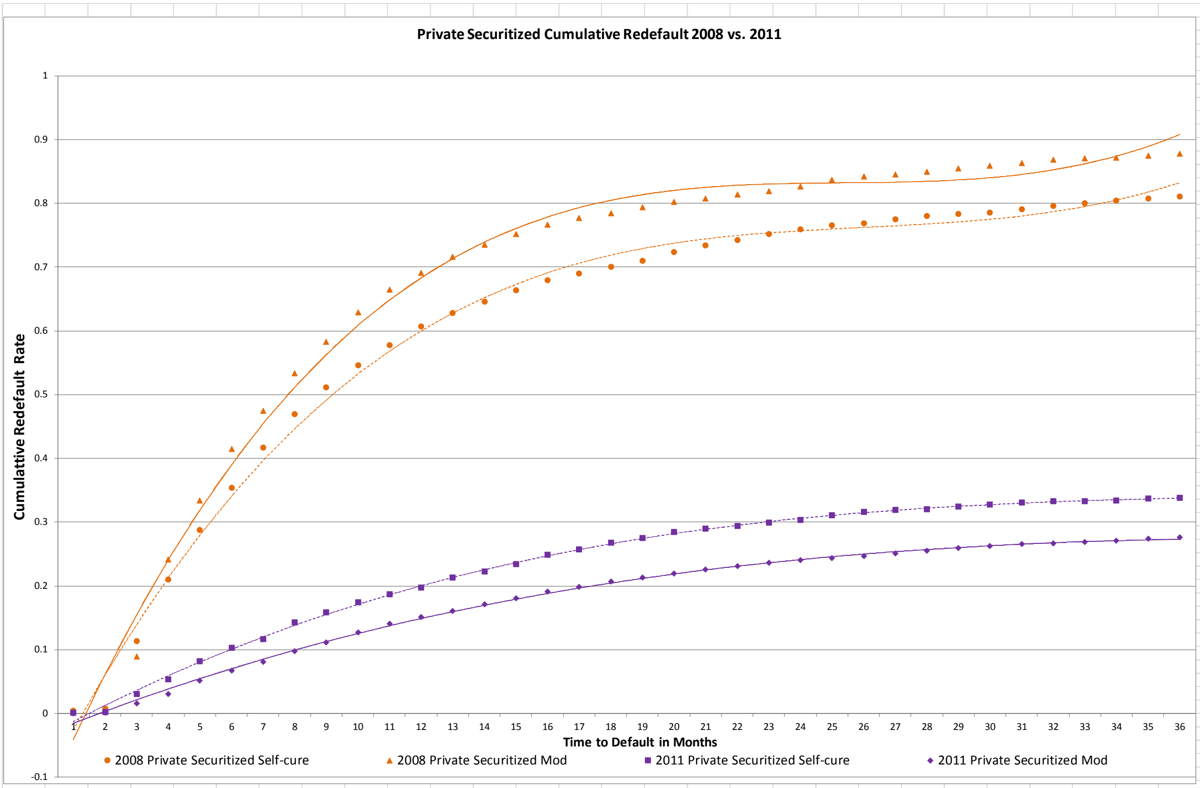
Figure 2: Redefault Rate Comparisons by Investor or Guarantor Category

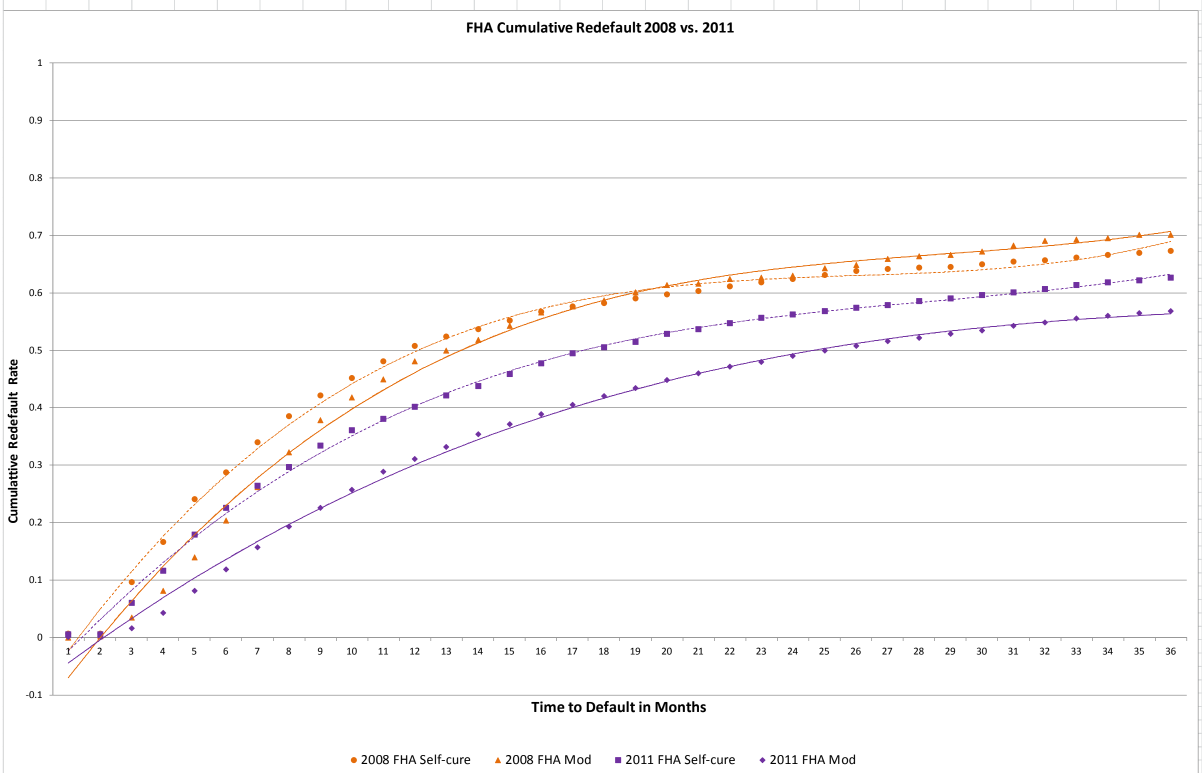




Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Figure 2 (continued): Redefault Rate Comparisons by Investor or Guarantor Category

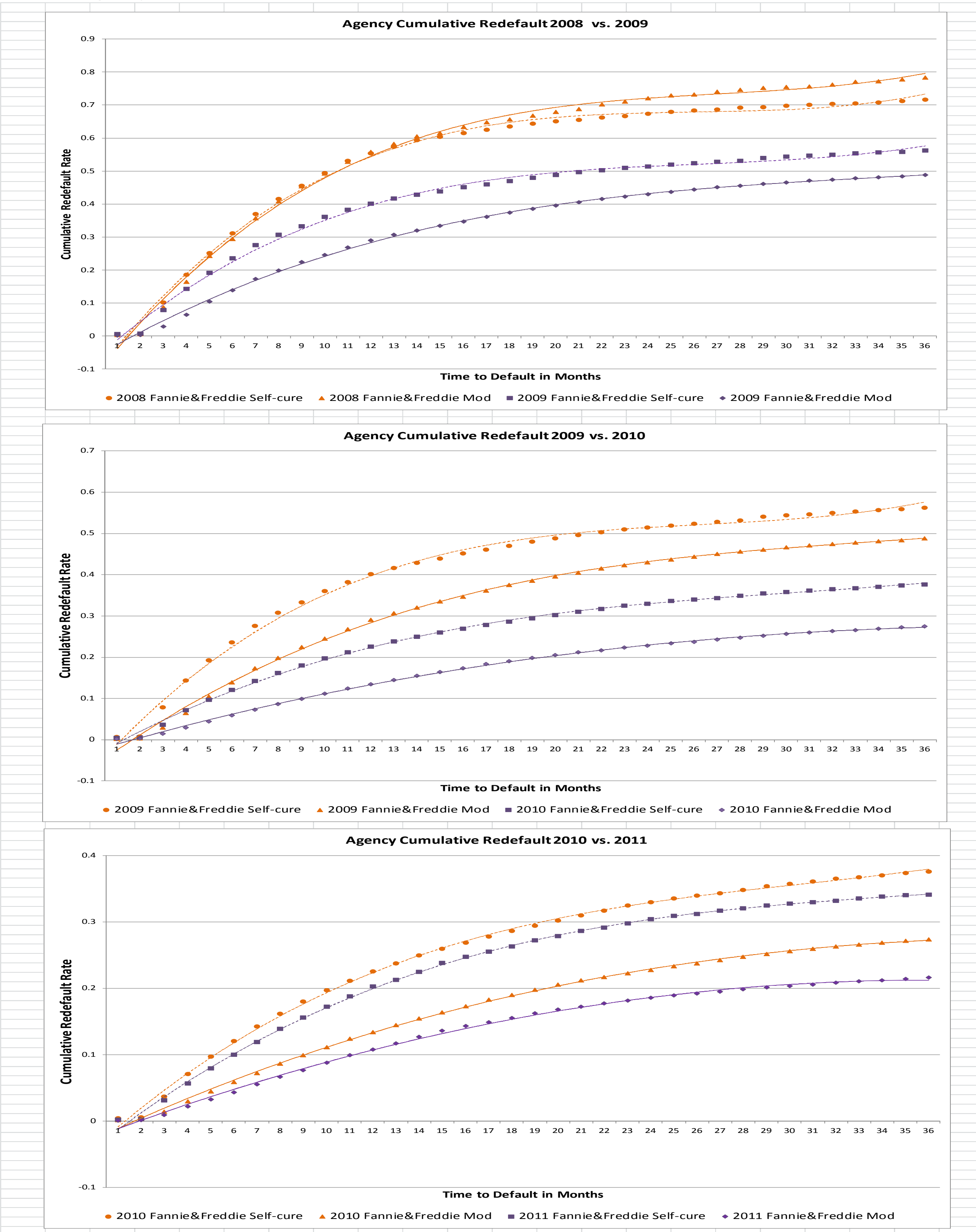




Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Figure 3: Redefault Rate Comparisons by Year of Cure

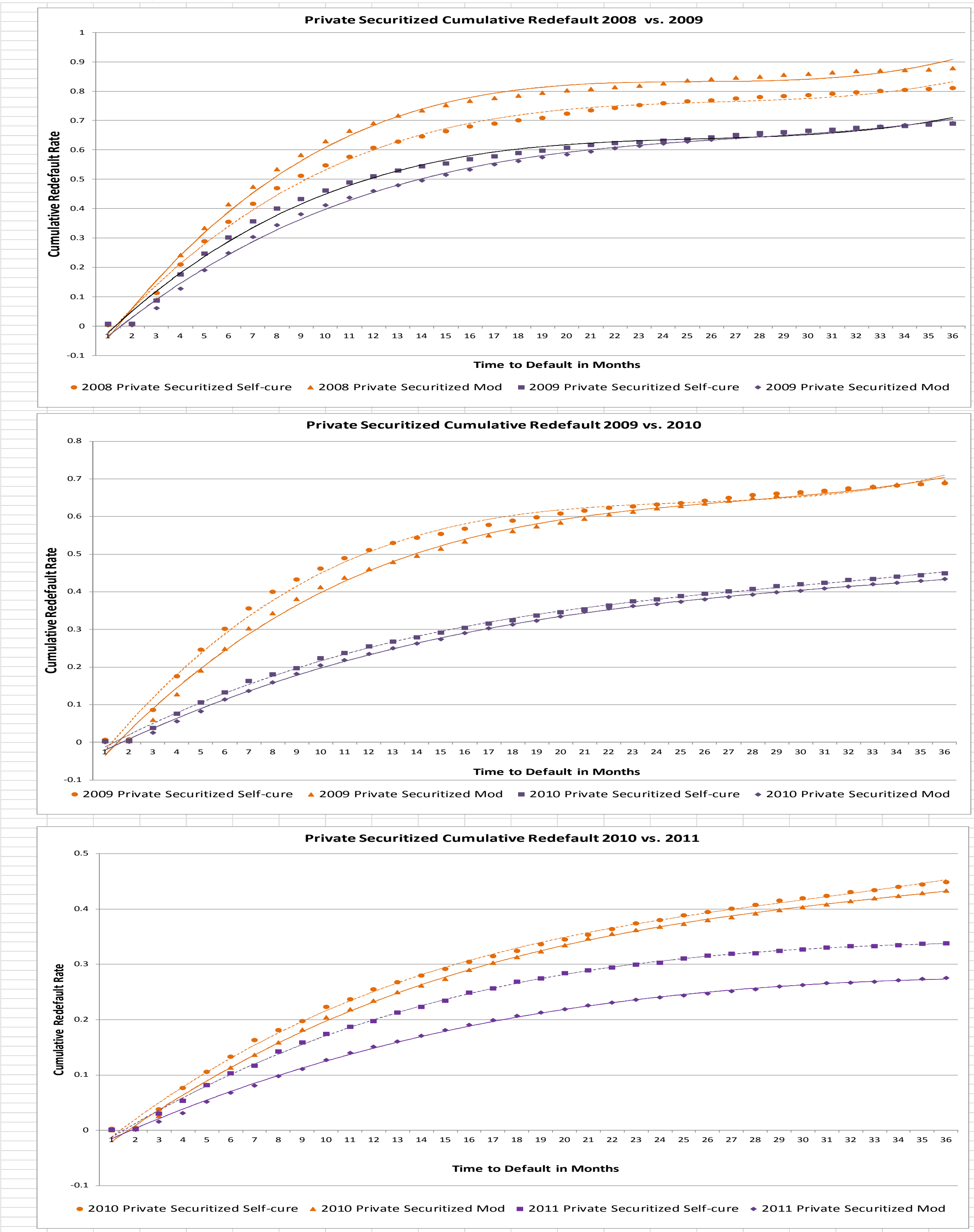
Panel A. Agency Loans



Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Figure 3: Redefault Rate Comparisons by Year of Cure

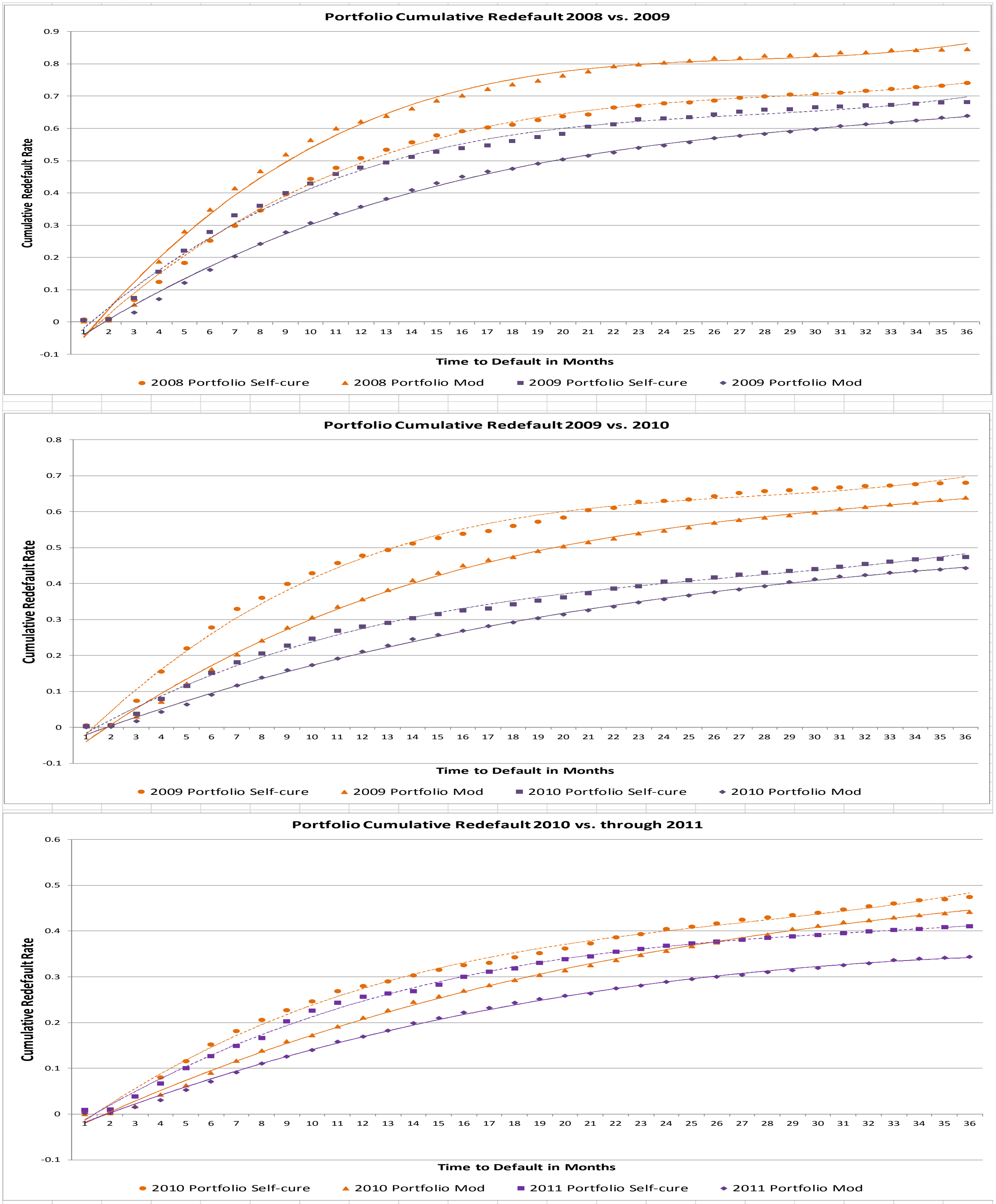
Panel B. Privately Securitized Loans



Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Figure 3: Redefault Rate Comparisons by Year of Cure

Panel C: Portfolio Loans



Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 1: Percent of Modifications with Principal Reduction, by Year of Modification and Investor or Guarantor Category (Prematch Sample)

	Agency	FHA	Portfolio	Private Securitized
2008	1.5	2.7	2.4	1.7
2009	2.8	0.4	4.6	4.1
2010	6.1	1.6	4.7	7.3
2011	10.4	4.0	11.7	17.8

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 2. Prematch Sample Mean Values

Year of Cure	Cure Type	Bankruptcy indicator	Indicator for CLTV > 80 and ≤ 90	Indicator for CLTV > 90 and ≤ 100	Indicator for CLTV > 100	Principal Balance	Indicator for Cure from ≥ 120 and < 180	Indicator for Cure from ≥ 180 and < 270	Indicator for Cure from ≥ 270 and < 360	Indicator for Cure from ≥ 360
FHA/VA										
2008	Self-cured	3.7%	21.2%	46.4%	4.5%	92,825	25.7%	16.5%	5.4%	2.9%
2008	Modified	0.0%	18.8%	55.5%	8.4%	109,000	42.2%	30.9%	9.2%	2.5%
2009	Self-cured	4.1%	23.2%	47.1%	4.1%	99,255	21.1%	14.5%	5.4%	2.8%
2009	Modified	0.7%	20.4%	56.5%	5.9%	124,264	34.8%	33.1%	12.1%	7.5%
2010	Self-cured	4.1%	24.5%	45.5%	3.3%	110,415	19.6%	13.7%	6.8%	5.2%
2010	Modified	1.2%	22.2%	54.2%	5.0%	129,591	24.6%	27.6%	18.5%	16.2%
2011	Self-cured	4.3%	23.6%	46.4%	3.6%	116,368	19.6%	11.6%	5.7%	4.9%
2011	Modified	1.7%	23.9%	52.8%	3.4%	133,875	23.8%	25.2%	18.0%	19.1%
Agency										
2008	Self-cured	2.6%	16.2%	14.7%	2.2%	117,672	31.0%	16.4%	4.1%	1.6%
2008	Modified	0.2%	24.9%	25.0%	4.7%	167,140	38.9%	26.8%	7.7%	4.9%
2009	Self-cured	3.3%	15.6%	11.8%	1.5%	126,295	28.9%	17.9%	5.8%	2.5%
2009	Modified	0.6%	18.2%	18.3%	2.0%	174,714	32.4%	31.3%	14.5%	7.7%
2010	Self-cured	2.9%	14.7%	8.8%	0.6%	148,275	25.9%	18.7%	9.4%	7.7%
2010	Modified	1.0%	16.1%	15.1%	0.9%	186,811	26.9%	29.4%	16.3%	14.9%
2011	Self-cured	4.1%	13.0%	6.2%	0.7%	136,164	24.9%	16.4%	8.6%	9.9%
2011	Modified	2.2%	15.8%	10.2%	0.8%	181,075	22.3%	25.9%	18.6%	23.4%
Portfolio or Private Securitized										
2008	Self-cured	2.0%	33.5%	14.4%	1.9%	163,971	28.3%	19.7%	7.6%	3.7%
2008	Modified	0.6%	36.3%	18.0%	2.2%	181,463	30.4%	26.9%	12.5%	8.3%
2009	Self-cured	2.9%	31.8%	12.6%	2.1%	187,462	27.5%	19.6%	9.2%	5.8%
2009	Modified	1.1%	30.2%	17.9%	3.3%	198,539	30.5%	27.4%	14.0%	9.8%
2010	Self-cured	3.0%	27.3%	9.5%	2.0%	214,014	21.7%	20.3%	13.0%	13.8%
2010	Modified	1.3%	23.0%	14.6%	3.8%	204,708	23.2%	27.3%	18.0%	20.3%
2011	Self-cured	4.5%	23.9%	9.5%	3.6%	191,598	21.6%	18.1%	11.6%	15.3%
2011	Modified	2.6%	19.8%	13.2%	5.3%	200,911	21.8%	24.6%	17.8%	24.2%

Year of Cure	Cure Type	Indicator for 2 or More First-Lien Mortgages	Indicator for Originated Via Retail Channel	Consumer Credit Score	Current Interest Rate Spread	Subprime Indicator	Indicator For 1-, 2-, or 3-Year ARM	1-year % Change County HPI	Jumbo Mortgage Indicator
FHA/VA									
2008	Self-cured	5.8%	25.5%	507	2.67	40.7%		-8.0%	
2008	Modified	4.1%	23.6%	488	3.04	61.5%		-8.4%	
2009	Self-cured	6.2%	26.4%	519	3.20	40.1%		-7.7%	
2009	Modified	4.5%	23.6%	499	3.36	56.5%		-7.2%	
2010	Self-cured	6.0%	26.6%	527	2.72	35.6%		-2.4%	
2010	Modified	4.6%	20.8%	512	3.03	43.7%		-2.7%	
2011	Self-cured	5.3%	26.9%	531	2.79	27.2%		-3.6%	
2011	Modified	3.9%	23.5%	521	3.14	36.0%		-3.9%	
Agency									
2008	Self-cured	17.6%	30.7%	539	2.69	18.7%	16.8%	-9.9%	
2008	Modified	20.0%	32.8%	520	2.96	20.3%	11.8%	-13.7%	
2009	Self-cured	18.7%	33.9%	551	3.23	16.0%	12.8%	-9.3%	
2009	Modified	17.8%	29.4%	548	3.33	17.8%	7.0%	-9.7%	
2010	Self-cured	17.9%	35.7%	574	2.80	11.4%	8.4%	-2.4%	
2010	Modified	15.0%	29.0%	581	3.05	12.5%	12.0%	-2.7%	
2011	Self-cured	17.4%	37.9%	569	3.04	11.6%	6.4%	-3.7%	
2011	Modified	14.8%	34.8%	580	3.35	10.1%	6.1%	-3.9%	
Portfolio or Private Securitized									
2008	Self-cured	23.5%	23.6%	525	4.45	50.4%	69.5%	-12.6%	13.4%
2008	Modified	24.4%	14.9%	516	4.98	59.2%	76.1%	-14.2%	13.2%
2009	Self-cured	25.5%	26.5%	542	4.31	35.5%	52.4%	-11.7%	19.4%
2009	Modified	21.3%	25.9%	535	4.78	41.5%	67.5%	-12.2%	16.0%
2010	Self-cured	22.0%	26.2%	560	3.35	29.3%	42.4%	-1.6%	26.5%
2010	Modified	17.0%	29.0%	553	3.95	35.5%	60.7%	-2.2%	18.6%
2011	Self-cured	18.7%	26.1%	562	3.37	32.1%	35.5%	-3.5%	23.9%
2011	Modified	14.4%	29.9%	564	3.92	34.0%	52.1%	-3.8%	19.8%

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 3. Logistic Regression Model Predicting Propensity Scores

Dependent variable	**FHA**		**Agency**		**Private Securitized or Portfolio**	
Modification						
Independent variables	*Coefficient*		*Coefficient*		*Coefficient*	
Refreshed LTV 80-90 (3 months prior to cure)	0.21091***	(0.03046)	0.21187***	(0.01786)	0.16943***	(0.01928)
Refreshed LTV 90-100 (3 months prior to cure)	0.37825***	(0.02890)	0.45085***	(0.02081)	0.29584***	(0.02366)
Refreshed LTV 100+ (3 months prior to cure)	0.29693***	(0.05026)	0.42638***	(0.05796)	0.42913***	(0.03895)
% Change in HPI over prior 12 months	0.55536**	(0.22169)	-0.67036***	(0.15503)	-0.89372***	(0.15286)
Subprime	0.18078***	(0.01996)	-0.05268***	(0.01996)	0.00933	(0.01826)
Retail origination channel	-0.10580***	(0.02063)	-0.13448***	(0.01408)	-0.07835***	(0.01866)
Bankruptcy status (3 months prior to cure)	-0.94695***	(0.06182)	-0.59724***	(0.04462)	-0.53463***	(0.05260)
Multiple first mortgage	-0.29027***	(0.04375)	-0.20774***	(0.01849)	-0.09683***	(0.02186)
Other ARM			-0.5229***	(0.0337)	-2.78290***	(0.02974)
Option ARM			-0.0495	(0.0873)	-2.76772***	(0.03610)
One-year ARM			0.4070*	(0.2408)	1.37773***	(0.12917)
Two- or three-year ARM			0.4272***	(0.1001)	0.61600***	(0.03211)
log balance (3 months prior to cure)	0.82222***	(0.02373)	0.54452***	(0.01528)	0.58349***	(0.02041)
Jumbo					8.50866***	(0.97222)
Portfolio loan					0.12445***	(0.01916)
Jumbo * Log balance amount (3 months prior to cure)					-0.67121***	(0.07429)
10-year treasury interest rate spread (3 months prior to cure)	0.63235***	(0.01725)	0.42532***	(0.00898)	0.21443***	(0.00553)
Risk score (3 months prior to cure)	-0.00054***	(0.00011)	0.00079***	(0.00007)	0.00031***	(0.00009)
120 to 180 DPD (month prior to cure)	1.12233***	(0.02443)	0.69108***	(0.02006)	0.51485***	(0.02496)
180 to 270 DPD (month prior to cure)	1.53104***	(0.02603)	1.14171***	(0.02096)	0.85391***	(0.02581)
270 to 360 DPD (month prior to cure)	1.80901***	(0.03166)	1.30212***	(0.02441)	1.01635***	(0.02911)
360 to 540 DPD (month prior to cure)	1.81684***	(0.03326)	1.39490***	(0.02469)	1.13165***	(0.02861)
N	75,970		123,565		97,888	
C Statistic	0.81		0.769		0.818	
Pseudo R-squared	0.3768		0.3013		0.3681	
Models include state fixed effects, year of origination controls, and year-quarter of cure controls. Additional controls include quarter of cure indicators. The ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.						

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc. DPD = days past due

Table 4. Match Statistics

Panel A: Percent of Modifications with at Least One Matched Self-Cure

	GSEs	FHA	Portfolio	Private Securitized
2008	61.4%	73.8%	43.1%	59.7%
2009	60.9%	72.5%	46.4%	59.3%
2010	67.3%	77.8%	53.5%	60.9%
2011	64.5%	73.7%	46.9%	55.2%

Panel B: Percent of Self-Cures with at Least One Matched Modification

	GSEs	FHA	Portfolio	Private Securitized
2008	26.8%	29.6%	19.4%	37.5%
2009	38.0%	43.1%	26.4%	40.5%
2010	41.7%	49.7%	31.6%	42.7%
2011	37.8%	48.5%	26.6%	34.7%

Panel C: Frequency Distribution for Multiple Matches

Investor/Guarantor	Number of Matches	2008	2009	2010	2011
GSEs	1	9.9%	10.8%	5.0%	9.6%
	2 or 3	13.6%	18.2%	17.8%	20.9%
	4 or 5	10.3%	14.5%	24.9%	21.6%
	6 or More	66.2%	56.5%	52.2%	47.9%
FHA	1	4.6%	14.8%	10.7%	17.8%
	2 or 3	10.3%	27.4%	28.4%	27.2%
	4 or 5	7.5%	19.7%	28.1%	20.3%
	6 or More	77.6%	38.1%	32.8%	34.6%
Portfolio or Private Securitized	1	15.2%	18.56%	19.35%	22.08%
	2 or 3	20.5%	24.4%	27.5%	25.0%
	4 or 5	14.4%	14.7%	19.0%	15.0%
	6 or More	49.9%	42.4%	34.1%	37.9%

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 5: Postmatch Sample Mean Values

Year of Cure	Cure Type	Bankruptcy indicator	Indicator for CLTV > 80 and ≤ 90	Indicator for CLTV > 90 and ≤ 100	Indicator for CLTV > 100	Principal Balance	Indicator for Cure from ≥ 120 and < 180	Indicator for Cure from ≥ 180 and < 270	Indicator for Cure from ≥ 270 and < 360	Indicator for Cure from ≥ 360
FHA/VA										
2008	Self-cured	1.4%	21.1%	61.2%	6.5%	106,778	41.4%	30.9%	7.8%	1.3%
2008	Modified	0.0%	21.2%	60.3%	9.0%	108,609	41.5%	31.2%	7.9%	1.3%
2009	Self-cured	1.0%	22.8%	63.8%	4.1%	126,933	36.5%	33.9%	10.5%	5.6%
2009	Modified	0.6%	22.0%	62.1%	6.6%	126,300	36.4%	33.6%	10.6%	6.0%
2010	Self-cured	1.2%	23.0%	60.1%	4.6%	135,129	25.3%	27.8%	17.9%	15.1%
2010	Modified	1.1%	23.2%	60.2%	5.6%	133,819	25.2%	27.7%	18.0%	15.6%
2011	Self-cured	1.3%	23.6%	60.8%	4.5%	141,690	25.7%	25.1%	17.3%	16.8%
2011	Modified	1.5%	25.0%	58.1%	3.7%	136,227	25.8%	25.0%	17.3%	17.2%
Agency										
2008	Self-cured	1.2%	19.8%	26.7%	4.2%	146,771	42.6%	24.2%	6.4%	2.8%
2008	Modified	0.2%	26.3%	31.6%	5.9%	164,775	42.6%	24.6%	6.3%	3.1%
2009	Self-cured	1.2%	17.9%	18.5%	2.4%	162,711	34.9%	32.1%	12.9%	4.9%
2009	Modified	0.6%	19.9%	21.8%	2.5%	175,567	34.8%	32.1%	13.1%	4.8%
2010	Self-cured	1.2%	17.2%	15.3%	0.8%	171,557	27.4%	29.4%	16.2%	14.4%
2010	Modified	1.0%	18.9%	18.9%	1.1%	189,073	27.3%	29.6%	16.1%	14.7%
2011	Self-cured	1.5%	15.8%	10.0%	0.9%	169,547	22.4%	26.3%	17.8%	23.4%
2011	Modified	2.3%	18.5%	12.1%	0.9%	183,924	22.4%	26.2%	17.9%	23.5%
Portfolio or Private Securitized										
2008	Self-cured	1.0%	35.8%	18.8%	2.6%	184,756	31.4%	26.5%	11.5%	6.6%
2008	Modified	0.4%	38.6%	20.9%	2.1%	185,190	31.6%	26.6%	11.5%	6.4%
2009	Self-cured	1.1%	28.8%	18.3%	4.1%	201,190	32.1%	28.5%	12.2%	8.0%
2009	Modified	1.0%	31.7%	19.2%	3.5%	204,658	32.3%	28.4%	12.2%	8.3%
2010	Self-cured	1.4%	25.9%	14.4%	2.6%	205,913	25.7%	27.2%	15.6%	19.9%
2010	Modified	1.2%	24.9%	15.5%	3.8%	208,533	25.5%	27.3%	15.7%	19.9%
2011	Self-cured	1.8%	22.8%	13.7%	5.6%	194,797	22.7%	24.2%	16.2%	25.0%
2011	Modified	2.5%	23.0%	15.1%	5.7%	207,010	22.6%	24.1%	16.2%	24.8%

Year of Cure	Cure Type	Indicator for 2 or More First-Lien Mortgages	Indicator for Originated Via Retail Channel	Consumer Credit Score	Current Interest Rate Spread	Subprime Indicator	Indicator For 1-, 2-, or 3-Year ARM	1-year % Change County HPI	Jumbo Mortgage Indicator	
FHA/VA										
2008	Self-cured	4.4%	25.3%	499	2.64	51.1%		-8.1%		
2008	Modified	3.4%	23.0%	485	3.02	63.8%		-8.3%		
2009	Self-cured	3.9%	22.0%	507	3.28	48.4%		-7.2%		
2009	Modified	3.8%	22.7%	500	3.34	57.7%		-7.2%		
2010	Self-cured	3.9%	22.8%	514	2.89	41.4%		-2.6%		
2010	Modified	4.1%	20.2%	513	3.03	44.2%		-2.7%		
2011	Self-cured	3.9%	24.1%	522	2.95	34.1%		-3.7%		
2011	Modified	3.5%	23.3%	523	3.11	35.8%		-3.9%		
Agency										
2008	Self-cured	14.4%	25.2%	541	2.85	21.9%	5.9%	-12.6%		
2008	Modified	16.8%	31.7%	520	2.99	24.1%	7.4%	-12.7%		
2009	Self-cured	15.6%	30.8%	556	3.32	21.0%	11.8%	-9.5%		
2009	Modified	16.1%	28.1%	552	3.35	20.1%	6.2%	-9.6%		
2010	Self-cured	13.8%	31.7%	578	3.05	14.5%	7.4%	-2.7%		
2010	Modified	13.7%	27.9%	583	3.09	13.5%	11.7%	-2.7%		
2011	Self-cured	13.8%	32.9%	580	3.38	13.7%	2.9%	-3.9%		
2011	Modified	13.7%	33.8%	586	3.37	10.9%	4.0%	-3.9%		
Portfolio or Private Securitized										
2008	Self-cured	20.8%	22.2%	524	4.69	59.2%	78.5%	-14.9%	11.9%	
2008	Modified	23.0%	14.2%	519	5.05	62.9%	78.6%	-14.9%	12.6%	
2009	Self-cured	21.8%	30.7%	538	4.58	43.6%	68.1%	-12.9%	16.2%	
2009	Modified	19.4%	27.2%	539	4.75	44.7%	70.8%	-12.9%	15.7%	
2010	Self-cured	18.3%	26.3%	554	3.78	35.4%	63.7%	-2.2%	18.2%	
2010	Modified	16.2%	29.4%	557	3.93	36.9%	65.2%	-2.2%	18.1%	
2011	Self-cured	14.8%	24.8%	561	3.82	37.8%	46.2%	-3.8%	16.9%	
2011	Modified	14.2%	31.2%	569	3.87	32.7%	50.5%	-3.8%	20.2%	

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 6: Postmatch Sample Mean Values

Panel A: Indicator of no delinquent unsecured, nonstudent credit in the borrower's credit record (around the date of the original mortgage default)

Year of Cure	FHA/VA Modification	FHA/VA Cure	Agency Modification	Agency Cure	Private Securitized or Portfolio Modification	Private Securitized or Portfolio Cure
2008	3.44%	2.48%	8.28%	5.17%	3.92%	2.85%
2009	5.00%	3.02%	14.34%	9.17%	8.79%	5.63%
2010	5.27%	3.35%	19.48%	11.62%	11.88%	8.36%
2011	7.23%	3.32%	17.38%	12.13%	11.57%	8.27%

Panel B: Principal reduction dummy indicator

Year of Modification	FHA/VA	Agency	Private Securitized or Portfolio
2008	2.12%	1.40%	1.94%
2009	0.30%	3.13%	4.32%
2010	1.63%	6.38%	6.61%
2011	4.43%	11.10%	16.69%

Panel C-: Mean values for size of payment reduction

Year of modification	FHA/VA	Agency	Private Securitized or Portfolio
2008	6.47%	23.73%	24.26%
2009	10.79%	31.92%	30.02%
2010	14.07%	40.99%	37.20%
2011	17.65%	38.44%	39.55%

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 7. Logistic Regression Model for Redefault of Self-Cured Loans

Dependent Variable	Agency		Portfolio	
Redefault within 36 months of cure				
Independent Variables	*Coefficient*		*Coefficient*	
Cured 2009Q2-Q4	-0.57975***	(0.06286)	-0.40825***	(0.05957)
Cured 2010	-1.16760***	(0.05862)	-1.13624***	(0.05769)
Cured 2011	-1.14910***	(0.06139)	-1.31057***	(0.06301)
Portfolio loan			0.0356	(0.03003)
Change in unemployment rate 1-18 months after cure (+)	0.03154**	(0.01560)	0.04379**	(0.01793)
Change in unemployment rate 1-18 months after cure (-)	0.00793	(0.00899)	0.02470*	(0.01471)
% Change in HPI 1-18 months after cure (+)	-2.10537***	(0.18454)	-1.51671***	(0.27615)
% Change in HPI 1-18 months after cure (-)	-1.54280***	(0.27331)	-2.61356***	(0.38027)
Refreshed LTV 80-90 (3 months prior to cure)	0.16167***	(0.02348)	0.19430***	(0.03059)
Refreshed LTV 90-100 (3 months prior to cure)	0.29877***	(0.02583)	0.42129***	(0.03876)
Refreshed LTV > 100 (3 months prior to cure)	0.45300***	(0.08135)	0.85897***	(0.06695)
Log balance (3 months prior to cure)	0.02989*	(0.01675)	0.01087	(0.02152)
Risk score (3 months prior to cure)	-0.00258***	(0.00010)	-0.00342***	(0.00016)
Subprime	0.35906***	(0.02428)	0.19790***	(0.02826)
Multiple first mortgage	0.11366***	(0.02530)	0.07626**	(0.03457)
Bankruptcy status (3 months prior to cure)	-0.16897**	(0.07324)	0.01758	(0.10090)
Cure from 180-269 DPD	0.06019***	(0.02186)	-0.04646	(0.03275)
Cure from 270+ DPD	0.18537***	(0.02124)	0.02555	(0.03142)
No delinquent unsecured, nonstudent credit (coincident with the original mortgage default)	-0.05826*	(0.03237)	-0.04021	(0.05490)
N	416938		205878	
C Statistic	0.649		0.742	
Pseudo R^2	0.0512		0.1145	
Observations are weighted using the matched-sample weights. The ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.				

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc. DPD = days past due

Table 8. Logistic Regression Model for Redefault of Modified Loans

	Agency: Model 1		Agency: Model 2		Private Securitized or Portfolio: Model 1		Private Securitized or Portfolio: Model 2	
Dependent Variable								
Redefault within 36 months of modification								
Independent Variables	*Coefficient*		*Coefficient*		*Coefficient*		*Coefficient*	
Self-cure redefault probability	1.13266***	(0.02904)	1		0.98909***	(0.03244)	1	
Modified 2009Q2-Q4	-0.32337***	(0.07055)	-0.41803***	(0.06723)	-0.42714***	(0.06821)	-0.42168***	(0.06627)
Modified 2010	-0.27468***	(0.07511)	-0.45613***	(0.06364)	-0.37325***	(0.07675)	-0.35956***	(0.06507)
Modified 2011	-0.47763***	(0.07799)	-0.66044***	(0.06684)	-0.58678***	(0.08338)	-0.57205***	(0.07094)
Portfolio loan					-0.09725***	(0.03137)	-0.09884***	(0.03103)
Change in unemployment rate 1-18 months after cure (+)	0.03767*	(0.02031)	0.04016**	(0.02022)	0.04539**	(0.02080)	0.04499**	(0.02078)
Change in unemployment rate 1-18 months after cure (-)	0.02469**	(0.01047)	0.02626**	(0.01044)	0.01439	(0.01498)	0.01416	(0.01497)
% Change in HPI 1-18 months after cure (+)	0.14335	(0.23250)	-0.19342	(0.22011)	-1.24919***	(0.32026)	-1.22570***	(0.31264)
% Change in HPI 1-18 months after cure (-)	-0.25784	(0.30679)	-0.45072	(0.30286)	0.71532*	(0.41620)	0.74564*	(0.40647)
Principal modification	-0.34240***	(0.04168)	-0.34240***	(0.04160)	-0.26325***	(0.04831)	-0.26416***	(0.04825)
Payment change spline (<15%)	-5.15932***	(0.40676)	-5.15686***	(0.40558)	-3.11546***	(0.48472)	-3.11260***	(0.48482)
Payment change spline (>15%)	3.59760***	(0.43283)	3.59244***	(0.43168)	1.04164**	(0.52771)	1.03814**	(0.52778)
Modified from 180-269 DPD	0.26256***	(0.02537)	0.28324***	(0.02490)	0.38165***	(0.03536)	0.38125***	(0.03536)
Modified from 270+ DPD	0.42436***	(0.02566)	0.46446***	(0.02407)	0.64691***	(0.03403)	0.64594***	(0.03392)
N	60926		60926		28330		28330	
C Statistic	0.723				0.791			
Pseudo R^2	0.179				0.3243			

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc. DPD = days past due

Table 9: Odds Ratios Associated with Modification Vintage Dummies (Model 1)

Modification Vintage	Agency	Private Securitized or Portfolio
2009 Q2-Q4	0.724	0.652
2010	0.760	0.688
2011	0.620	0.556

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc.

Table 10. Logistic Regression Model for Redefault of Modified Loans — Additional Specifications

	Agency: Model 3		Agency: Model 4		Private Securitized or Portfolio: Model 3		Private Securitized or Portfolio: Model 4	
Dependent Variable			Restricted to 120+ DPD at Modification				Restricted to 120+ DPD at Modification	
Redefault within 36 months of modification								
Independent Variables	*Coefficient*		*Coefficient*		*Coefficient*		*Coefficient*	
Self-cure redefault probability	0.82150***	(0.05540)	1.11160***	(0.03066)	1.05384***	(0.05808)	0.93127***	(0.03412)
Modified 2009Q2-Q4	-0.51482***	(0.07638)	-0.31193***	(0.07914)	-0.39867***	(0.07141)	-0.53743***	(0.07904)
Modified 2010	-0.64482***	(0.09397)	-0.27283***	(0.08397)	-0.29744***	(0.09522)	-0.48611***	(0.08777)
Modified 2011	-0.84465***	(0.09603)	-0.48488***	(0.08668)	-0.50355***	(0.10383)	-0.70594***	(0.09456)
Portfolio loan					-0.10451***	(0.03184)	-0.12385***	(0.03373)
Change in unemployment rate 1-18 months after cure (+)	0.04634**	(0.02037)	0.0341	(0.02165)	0.04247**	(0.02092)	0.04264*	(0.02424)
Change in unemployment rate 1-18 months after cure (-)	0.02813***	(0.01049)	0.03387***	(0.01095)	0.01328	(0.01500)	0.01717	(0.01580)
% Change in HPI 1-18 months after cure (+)	-0.55750**	(0.25584)	0.23079	(0.23997)	-1.14348***	(0.32976)	-1.27149***	(0.33372)
% Change in HPI 1-18 months after cure (-)	-0.77815**	(0.31698)	-0.17784	(0.32355)	0.89438**	(0.43693)	0.66361	(0.45752)
Principal modification	-0.33964***	(0.04171)	-0.35135***	(0.04256)	-0.26935***	(0.04854)	-0.29505***	(0.05040)
Payment change spline (<15%)	-5.13183***	(0.40702)	-5.11806***	(0.42951)	-3.12516***	(0.48478)	-2.84344***	(0.51861)
Payment change spline (>15%)	3.56651***	(0.43314)	3.58476***	(0.45595)	1.05129**	(0.52775)	0.76878	(0.56366)
Modified from 180-269 DPD	0.26866***	(0.02540)	0.18289***	(0.02715)	0.38836***	(0.03572)	0.30800***	(0.03835)
Modified from 270+ DPD	0.46692***	(0.02649)	0.34647***	(0.02749)	0.65021***	(0.03412)	0.57382***	(0.03707)
Risk Score 3 months prior to mod	-0.00128***	(0.00019)			0.00037	(0.00027)		
N	60926		54961		28330		24864	
C Statistic	0.723		0.718		0.791		0.788	
Pseudo R^2	0.18		0.172		0.3244		0.3192	
Observations are weighted using the matched-sample weights. The ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.								

Sources: Equifax Credit Risk Insight Servicing and McDash Analytics, LLC, a wholly owned subsidiary of Black Knight Inc. DPD = days past due