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The Effect of Negative Equity on Mortgage Default: Evidence from HAMP PRA*

Therese C. Scharlemann[†] and Stephen H. Shore[‡]

Abstract

The Home Affordable Modification Program’s Principal Reduction Alternative (HAMP PRA) is a government-sponsored program to reduce the principal balances and monthly mortgage payments of borrowers with negative equity (mortgage balances in excess of their home value, or “under water”) who are in danger of default. We use administrative data to examine the impact of principal forgiveness — a permanent mortgage balance reduction — on borrowers’ subsequent mortgage default. The program’s rules imply a kink in the relationship between principal forgiveness and a borrower’s initial equity level *ceteris paribus*. Our identification strategy exploits the quasi-experimental variation in principal forgiveness generated by this kink using a regression kink design (RKD), which compares the relationship between initial equity and default on either side of the kink. The quarterly hazard — the proportion of loans that become more than 90 days delinquent and consequently exit the program — in our sample is 3.1 percent; we estimate that it would have been 3.8 percent absent principal forgiveness, which averaged 28 percent of the initial mortgage balance.

JEL Codes: G21 (Mortgages), R30 (Real Estate Markets, General)

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1 Introduction

Mortgages represent by far the largest liability for U.S. households, with a total balance exceeding \$10 trillion. From the fourth quarter of 2006 through the first quarter of 2009, falling home prices reduced U.S. home equity by nearly \$5 trillion. By the fourth quarter of 2010, an estimated 12 million homes (25.4 percent of mortgages) had negative equity or were ‘underwater’ (CoreLogic, 2013), with mortgage balances exceeding the homes’ values. Researchers have raised concerns that negative equity may be associated with reduced mobility (Ferreira et al., 2010, 2013),¹ an inability to refinance mortgages into a recent low interest rate environment (Keys et al., 2014), and reduced consumption (Mian and Sufi, 2011; Dynan, 2012).

During the same period that home prices fell and negative equity increased, mortgage delinquency rates rose rapidly. The share of active mortgages more than 90 days delinquent or in foreclosure shot from 2.2 percent in the fourth quarter of 2006 to a peak of 9.7 percent in the first quarter of 2010 (Mortgage Bankers Association, 2013). The possible link between negative equity and mortgage delinquency is therefore of natural interest and has attracted considerable attention from both researchers and policymakers in the last several years. (See for example Deng et al. (2000); Foote et al. (2008); Bhutta et al. (2010); Ghent and Kudlyak (2011); Das (2012).)

This paper uses administrative data on the government’s Home Affordable Modification Program’s (HAMP’s) Principal Reduction Alternative (PRA) to examine the impact of principal forgiveness on subsequent mortgage default. HAMP PRA subsidizes mortgage investors and servicers to reduce payments and provide principal forgiveness to borrowers in danger of default who have negative equity. To identify the causal effect of principal forgiveness on mortgage default, we exploit several kinks – discontinuities in the first derivative – in the function that determines the amount of principal forgiveness in HAMP PRA as a function of the borrower’s initial equity level, *ceteris paribus*.

¹This result has been contested in Schulhofer-Wohl (2012) and Demyanyk et al. (2013).

These kinks allow the impact of principal forgiveness to be identified by exploiting the quasi-experimental variation in principal forgiveness from a regression discontinuity design (RDD) (Hahn et al., 2001; Lee and Lemieux, 2010), or more specifically, a regression kink design (RKD) (Florens et al., 2009; Card et al., 2012).

Though we explore several kinks that arise out of variations in servicers' policies, the primary kink is generated by the fact that principal forgiveness in HAMP PRA is generated using a minimum function. Specifically, the amount of principal forgiveness granted in a HAMP PRA modification is the minimum of the amount needed to reach an affordability target (debt-to-income ratio, DTI, of 31 percent) and the amount needed to reach an equity target (loan-to-value ratio, or LTV, of 115 percent or 110 percent).² The location of the kink is jointly determined by the borrower's DTI ratio and LTV ratio at application. For each value of DTI, there is an LTV value such that the principal forgiveness implied by DTI and LTV are the same; this point is the "kink." At pre-modification LTVs below the kink, a higher LTV generates a modification with more principal forgiveness (and less use of the other, less generous modification steps). In this range, every additional dollar of unpaid balance generates an additional dollar of principal forgiveness. However, for pre-modification LTVs above this kink, a higher LTV has no effect on the mortgage modification terms. We estimate the impact of principal forgiveness on mortgage default by comparing the relationship between pre-modification LTV and default on either side of the kink. Because the location of the kink varies from loan to loan and is jointly determined by DTI, LTV, and the servicer's LTV target, the LTV where the slope of the principal reduction function changes varies from loan-to-loan as well.³ The structure of the kinks are illustrated in Figure 1 and described in much

²HAMP PRA uses a series of specified mortgage modification steps to reduce mortgage payments until the borrower reaches a DTI ratio of percent, the "affordability target". The first step uses principal forgiveness to reduce the mortgage balance to achieve the affordability target, without reducing the borrower's LTV below the servicer-specific target. If principal forgiveness to the LTV-target is insufficient to achieve the affordability target, the payment is decreased as needed until the affordability target is reached by lowering the mortgage rate, extending the mortgage term, and forbearing mortgage principal.

³Some loans are subject to a second kink because their servicer caps principal forgiveness at 30 percent of the pre-modification principal balance. Below this 30 percent cap, increasing pre-modification

more detail in Section 2.3.

A number of researchers have examined the relationship between negative equity and mortgage default since the start of the housing crisis (Bajari et al., 2010; Bhutta et al., 2010; Fuster and Willen, 2015; Ghent and Kudlyak, 2011; Tracy and Wright, 2012; Haughwout et al., 2010). One strategy employed in the research is to use loan-level performance data (Bajari et al., 2010; Bhutta et al., 2010; Laufner, 2013) and exploit variation in negative equity arising from changes in state- or ZIP-code-level home price indexes. The major challenge inherited by these research designs is that the level of negative equity may not be exogenous. Variation in negative equity driven by local price changes may be associated with having neighbors who are increasingly underwater, living in an area with increasing vacancy rates, or low levels of home maintenance. Variation in negative equity driven by initial down payment, mortgage terms, cash-out refinancing, or time of purchase may be associated with unobservable borrower characteristics. Moreover, borrowers who have different levels of negative equity because they purchased at different times may be unobservably different.⁴ Lastly, when applied to policy intervention, it is unclear whether borrowers' responses to changes in equity are symmetric — i.e., whether increasing a borrower's equity will induce behavior similar to observably identical borrowers at the same equity level who did not receive principal forgiveness.

A separate line of literature has evaluated the performance of mortgage modifications, some of which carry principal forgiveness. Hembre (2014) estimates a structural model of mortgage default with data from “standard” HAMP, a separate part of the HAMP program we do not study that includes payment reduction but not principal forgiveness. Agarwal et al. (2012) exploit variation in HAMP program eligibility criteria to identify the effect of HAMP modifications, though this research does not focus on principal forgiveness in particular. Haughwout et al. (2010) and Agarwal et al. (2011) look more directly at the

LTV and DTI increases principal forgiveness; above this cap, it does not.

⁴For example, there is evidence that income was less-stringently documented as home prices accelerated (Keys et al., 2010; Jiang et al., 2011), and that second homes comprised over half of the market near the height of the boom in areas with the most dramatic price swings (Haughwout et al., 2011).

role of principal forgiveness in modification performance by comparing the default rates on non-HAMP modifications with and without principal forgiveness. However, in these data, it is not clear what unobservable criteria (including variables like pre-modification DTI and credit score that are observable in our data) affected who received principal forgiveness and how much they received. The impact of these unobservable factors on mortgage default or delinquency may be misidentified as coming from negative equity. This paper aims to overcome the omitted variable bias problems that are unavoidable when using local price variation to measure negative equity, as well as the selection issues inherent in studies of non-random mortgage modifications.

Using the RKD framework in the context of the HAMP PRA program, we find that principal forgiveness reduces subsequent rates of delinquency. The cumulative default rate in our sample (the overall default rate so far, including borrowers who have been in the sample for less than 2.5 years) is 16.4 percent; we estimate that it would have been 19.6 percent (95 percent confidence interval (CI): 18.2 percent to 21.1 percent) absent principal forgiveness. Among HAMP PRA participants in our sample, 3.1 percent become at least 90 days delinquent per quarter on average. (Borrowers are disqualified from the program if they become more than 90 days delinquent.) Our estimates suggest that this default rate would have been 3.8 percent (95 percent CI: 3.5 percent to 4.1 percent) had these borrowers received modifications with no principal forgiveness but the same payment reduction (achieved instead through rate reduction, term extension, and principal forbearance). The average loan in the HAMP PRA sample received a 28 percent reduction in the mortgage balance. The first cohort of PRA modifications in our sample (originated the first quarter of 2011) had a cumulative default rate of 39 percent; we estimate that their default rate would have been 49 percent (95 percent CI: 45 percent to 52 percent) absent principal forgiveness. Given the unpaid balances in our sample (averaging \$292,000) and the principal forgiveness amounts (averaging 28 percent of unpaid principal balance (UPB)), about \$877,000 must be written down to

avoid a single foreclosure during the 2.5 year sample period.⁵ This estimate suggests that principal forgiveness is more effective than is implied by the naive interpretation of the relationship between post-modification LTV and default in our sample (assuming that borrowers with higher LTVs are not unobservably better than borrowers with lower LTVs who require the same payment reduction) but less cost-effective than “standard” HAMP without principal forgiveness, as estimated by the structural model in Hembre (2014).⁶ In this sense our results are consistent with Eberly and Krishnamurthy (2014), who develop a theoretical model demonstrating that principal forgiveness is not the most cost-efficient way to avoid default.

Our results are robust to a variety of specifications and are present in various subsamples. Ganong and Jager (2014) argue that regression kink designs are prone to mistakenly identify an effect when there is none, depending on curvature of the underlying relationship (in our case, between LTV and default). Several features of our setting and approach suggest those concerns are mitigated. The pre-modification LTV of the kink varies from borrower-to-borrower based on pre-modification DTI. As a result, we can control nonparametrically for pre-modification LTV in our kink design. Because servicers differ in their policies, we can use the kink design to obtain separate estimates of the effect of principal forgiveness around each kink. In addition, we can compare otherwise identical borrowers who received different amounts of principal forgiveness because they had different servicers to obtain a “between” estimate of the effect of principal forgiveness, controlling nonparametrically for the interaction of pre-modification LTV and pre-modification DTI. All yield similar estimates. By contrast, estimates using two different “placebo samples” of loans that were ineligible for principal forgiveness shows no such pattern. A “placebo treatment” shows that distance from a hypothetical kink

⁵Note that the true cost of forgiveness will be far less than the forgiven amount, because it costs nothing to write down a mortgage that would otherwise not have been repaid. Note also that this is not the cost of the modification itself; this calculation reflects only the substitution of principal forgiveness for other means of achieving the same payment reduction.

⁶Hembre (2014) estimates a \$41,000 five-year cost per prevented default in standard HAMP.

implied by the policy of a servicer other than the borrower's actual servicer also shows no such pattern.

2 HAMP Structure and Identification

The Home Affordable Modification Program (HAMP) was announced in February 2009 under the authority of the Troubled Asset Relief Program (TARP). HAMP uses TARP funds to subsidize servicers and lenders to modify the terms of mortgage loans according to the rules of the program. At the beginning of the program, participating services were required to sign a Servicer Participation Agreement (SPA) that obligates them to comply with HAMP protocols on all of the loans in their servicing portfolio to the extent permitted by their pre-existing contracts with mortgage investors. Servicers covering nearly 90 percent of the mortgage market elected to participate in the HAMP program, though not all of these services elected to participate in the Principal Reduction Alternative (PRA).

When borrowers become 60 days delinquent, HAMP services are required to send them a letter with information on applying for a HAMP mortgage modification.⁷ To be eligible for the HAMP program, borrowers must have a DTI ratio over 31 percent, live in the home, and have an unpaid balance below \$729,750.⁸ Borrowers must sign a hardship affidavit, under penalty of perjury, stating they have experienced a hardship and are unable to make their current mortgage payments.

When borrowers apply for HAMP, they provide information about their income, used to determine the DTI ratio, the measure of affordability used by HAMP. DTI measures

⁷Non-delinquent borrowers may also apply for HAMP, and are eligible for the program if their default is deemed imminent. Though many servicers use an imminent default calculator similar in structure to the default model embedded in the HAMP net present value (NPV) test, ultimately imminent default is determined by the servicer for its own its investors' portfolios.

⁸However, larger balances are allowed for multifamily properties if the borrower lives in one of the units. In June 2012, HAMP eligibility was expanded to nonowner occupiers, borrowers with lower DTI ratios, and borrowers who could not achieve a 31 percent DTI ratio using the standard HAMP modification steps. The modification granted by the expanded program (HAMP Tier 2) is different than in the original program and does not generate the kink employed in our identification strategy, even when principal forgiveness is included. We exclude PRA recipients in Tier 2 from our sample.

the fraction of the borrower's pre-tax income that goes to monthly first-lien mortgage payments, real estate taxes, homeowner's insurance, and condominium or homeowner's association dues. Temporary income — such as from unemployment insurance — is excluded from the gross income calculation. An automatic appraisal system calculates the borrower's home value, which is used to determine the LTV ratio. The LTV ratio is the balance on the first mortgage divided by the home value, the measure of home equity used by HAMP. Updated credit scores are pulled from credit bureaus. Second liens are not considered when borrowers are evaluated.

Two modifications are commonly offered under HAMP: standard HAMP and HAMP PRA. Servicers use a net present value (NPV) model to compare the expected discounted cash flows lenders would receive with and without a modification. The NPV model estimates a default probability, prepayment rate, and recovery rate based on the borrowers' pre- and post-modification DTI and LTV, their credit score and delinquency at the time of modification, their geography, and other variables. To encourage participation in HAMP, the government provides subsidies to participating lenders. Those subsidies are included in lenders' NPV calculations. Servicers typically offer borrowers the option that yields the highest NPV to the lender, though they may use other objective criteria. For example, the servicers may offer a HAMP PRA modification if it is better than no modification even if standard HAMP yields an even higher NPV.⁹ Not all HAMP-participating servicers participate in HAMP PRA, and some loans serviced by HAMP PRA-participating servicers are ineligible for HAMP PRA (such as loans guaranteed by Fannie Mae and Freddie Mac, and mortgage investors whose contracts specifically forbid or limit principal forgiveness).

Once borrowers are offered and accept the modification, they are given a three-month

⁹While there will be selection into 'standard' HAMP, HAMP PRA, and no modification based on the NPV model, the structure of the model is known to the econometricians (and is publicly available at www.hmpadmin.com) as are the loan-level variables used to calculate the NPV for each borrower who receives a HAMP PRA modification. As a result, any selection stemming from the NPV model can be corrected for explicitly.

trial period during which they must stay current on their new, lower mortgage payments and produce any required documentation (for example, occasionally certain income documents are not collected up front).¹⁰ The mortgage modification becomes permanent after the trial period, and delinquency or foreclosure proceedings are terminated. If borrowers become more than 90 days delinquent on a permanent modification, they are dropped from the program and delinquency or foreclosure proceedings can be re-initiated; mortgage terms will remain as specified in HAMP unless the servicer elects to further modify the loan terms.

2.1 Standard HAMP

The standard HAMP modification is designed to bring the borrower's mortgage payment to an affordable level, defined in this program as a post-modification DTI of 31 percent. Borrowers with a pre-modification DTI below 31 percent are ineligible for the standard HAMP modification. Borrowers with a pre-modification DTI above 31 percent have their post-modification DTI reduced to 31 percent through a series of specified adjustments to the mortgage's terms. Past-due fees are waived and past-due interest is capitalized into the unpaid mortgage balance. The standard modification does not permanently reduce the mortgage balance and is not the focus of this paper.

The standard HAMP modification is summarized in Table 1. The payment reduction in the standard modification is achieved first by reducing the mortgage interest rate until the payment hits the affordability target of 31 percent DTI or the rate hits the 2 percent floor. If further payment reduction is needed to reach 31 percent DTI, the mortgage term is extended in monthly increments until the payment reaches 31 percent DTI or the term reaches 40 years. If further payment reduction is needed to reach 31 percent DTI, then principal forbearance is used as needed to reach 31 percent DTI. (Forbearance is

¹⁰If borrowers fail to produce this documentation or go delinquent during this period, they fail out of the trial modification. At this point, the mortgage reverts to its pre-modification terms and delinquency or foreclosure proceedings can continue; the borrower may also be evaluated for a non-HAMP modification.

held at 0 percent interest. Increasing the amount of principal forbearance is equivalent to reducing the interest rate proportionately to the share of the balance that has been forborne).¹¹

2.2 HAMP PRA

The HAMP Principal Reduction Alternative modification is designed to bring the borrower’s mortgage payment to an affordable level — to a post-modification DTI of 31 percent, like standard HAMP — in a way that prioritizes principal forgiveness. The steps used to calculate the HAMP PRA modification are summarized in Table 1. Standard HAMP and HAMP PRA involve the same payment reduction, though PRA modifications achieve at least some of that payment reduction by forgiving a portion of the principal balance. Servicers set their own LTV targets for HAMP PRA. Servicers covering roughly 85 percent of loans in our sample use a 115 percent target. The rest use a 100 percent target.¹²

Payment reduction is achieved by forgiving mortgage principal by the minimum amount necessary to achieve either the affordability target (31 percent DTI) or the servicer’s LTV target. Servicers with an LTV target of 100 percent have also chosen to apply a 30 percent cap on the amount of principal forgiven as a share of the principal balance. If the affordability target of 31 percent DTI is reached using principal forgiveness alone, the borrower’s LTV remains at or above the servicer’s LTV target, and the borrower’s mortgage rate and amortization term are unchanged. In the LTV range where

¹¹Servicers may cap principal forbearance at 30 percent of the borrower’s principal balance. If the payment target cannot be met using 30 percent principal forbearance, the borrower can be rejected for a modification. The mortgage terms remain unchanged for five years. After five years, if the modified mortgage rate is below the Primary Mortgage Market Survey (PMMS) 30-year fixed-rate-mortgage rate that prevailed at the time of the modification (the rate cap), the mortgage rate rises one percentage-point per year until it reaches the rate cap and then becomes a fixed rate. Borrowers with modification rates over the rate cap retain their modification rate for the duration of the modified mortgage term.

¹²Although many servicers did not participate in PRA initially, most HAMP modifications not related to the government-sponsored enterprises are done by servicers who now participate in PRA. We have excluded several PRA-participating servicers with volume so low we could not ascertain their LTV target with certainty, and two large servicers who use principal-reduction allocation methods that do not generate the kink we exploit for identification.

principal reduction alone achieves the payment target, increasing pre-modification LTV on the margin has no effect on the structure of the mortgage modification. However, if the affordability target of 31 percent DTI is not achieved by reducing the borrower's LTV to its target level, then the modification achieves further payment reduction using the steps from the 'standard' HAMP modification. The interest rate is reduced as needed to reach 31 percent DTI or to 2 percent, whichever comes first. Next, the mortgage term is lengthened as needed to reach 31 percent DTI or 40 years, whichever comes first; then, principal is forgiven as needed to reach 31 percent DTI. In the range where principal forgiveness alone is insufficient to achieve the servicer's LTV target, increasing pre-modification LTV on the margin would lead to more principal forgiveness (a larger percent change in LTV) and correspondingly less of the benefit — temporary rate reduction, term extension, or forbearance — in the last step in the modification reached by that borrower.

Nominally, the principal forgiveness is phased in over three years in three equal increments. However, if the borrower wishes to sell or refinance the house at any time, they need repay only the post-modification loan balance, which reflects the full forgiveness amount. If the borrower becomes more than 90 days delinquent and is disqualified from the HAMP program, the balance reflects only the portion of the principal forgiveness realized before the default date. Any remaining principal forgiveness that has not been vested is converted to forbearance.

2.3 Identification

The structure of the HAMP PRA modification generates kinks in the relationship between pre-modification LTV and principal forgiveness. We exploit these kinks for identification. On one side of each kink, the principal forgiveness amount varies with the borrower's pre-modification LTV (and post-modification LTV is invariant to pre-modification LTV),

Table 1: ‘Standard’ HAMP and HAMP PRA Modifications

Standard HAMP	HAMP PRA
<i>No reduction in mortgage balance</i>	<i>Reduce mortgage balance</i> as needed to reach the lesser of underwater target (typically 115 percent LTV) and affordability target (31 percent DTI)
If previous step insufficient to reach 31 percent DTI, then <i>reduce interest rate</i> down to 2 percent as needed to reach 31 percent DTI.	
If previous step insufficient to reach 31 percent DTI, then <i>extend loan term</i> to up to 40 years as needed to reach 31 percent DTI.	
If previous step insufficient to reach 31 percent DTI, then <i>forbear principal</i> as needed to reach 31 percent DTI. (equivalent to zero rate)	

Source: Authors’ analysis of Making Home Affordable documentation.

while on the other side, the modification structure is invariant to pre-modification LTV (and post-modification LTV varies with pre-modification LTV).

While HAMP PRA loans differ in their pre-modification affordability (as measured by DTI), all HAMP PRA modifications have the same post-modification DTI.¹³ Post-modification LTV, as well as the amount of principal forgiveness, will depend on pre-modification LTV, the servicer’s LTV target, the pre-modification mortgage DTI (pre-modification MDTI), and the mortgage DTI target (MDTI target). We define principal

¹³The total DTI target is 31 percent on all loans. Borrowers may differ in their ability to pay 31 percent of income for housing based on other credit card debts, student loan payments, health expenditures, or other obligations.

forgiveness (PF) as:¹⁴

$$\begin{aligned} \text{PF} &\equiv \frac{\text{pre-modification LTV}}{\text{post-modification LTV}} - 1 \\ &= \max \left(0, \min \left(\frac{\text{pre-modification LTV}}{\text{target LTV}}, \frac{\text{pre-modification MDTI}}{\text{target MDTI}} \right) - 1 \right). \end{aligned} \quad (1)$$

Limiting the sample to loans with a pre-modification LTV above their servicer's target and taking logs yields:

$$\begin{aligned} \ln(1 + \text{PF}) &= \min(\ln \text{pre-modification LTV} - \ln \text{target LTV}, \\ &\quad \ln \text{pre-modification MDTI} - \ln \text{target MDTI}). \end{aligned} \quad (2)$$

PF is a kinked function of the borrower's pre-modification LTV. The location of the kink depends on the pre-modification MDTI, the servicer's target LTV and the borrower's target MDTI. The kink occurs where the amount of forgiveness implied by the borrower's LTV (the first term in Equation 2) is equal to the amount of forgiveness implied by the borrower's payment reduction (the second term in Equation 2). In other words, the pre-modification LTV at the kink (which we call LTV*) equates the two arguments of the min function in equation (1):

$$\text{LTV}^* = \text{target LTV} \times \frac{\text{pre-modification MDTI}}{\text{target MDTI}} \quad (3)$$

For pre-modification LTVs below LTV*, forgiveness is increasing in pre-modification LTV (and the amount of temporary rate reduction or term extension is decreasing in pre-

¹⁴The servicer LTV target is 115 percent for 85 percent of loans and 100 percent for the remaining 15 percent. DTI is the proportion of income needed for the mortgage payment and other fixed housing expenses such as real estate taxes, homeowner association fees and insurance. DTI is the sum of the mortgage DTI (MDTI) and the fixed DTI (FDTI), where the former is the proportion of income needed to make the mortgage payment and the latter is the proportion of income needed to pay real estate taxes, insurance, and other fixed housing expenses, which do not vary with the mortgage terms. Since the mortgage modification does not change the fixed portion of the borrower's monthly payments, the 31 percent DTI target must be achieved exclusively by reducing the mortgage DTI. As a result, the mortgage DTI target is 31 percent minus the pre-modification fixed DTI.

modification LTV). For pre-modification LTVs above LTV^* , the mortgage modification terms do not depend on the pre-modification LTV:

$$\begin{aligned} \frac{d \ln(1 + PF)}{d \ln(\text{pre-modification LTV})} &= 1 && \text{if pre-modification LTV} < LTV^* \\ &= 0 && \text{if pre-modification LTV} > LTV^* \end{aligned} \quad (4)$$

A second kink is present at the 30 percent principal forgiveness cap for servicers that apply this cap.¹⁵ The cap lowers LTV^* in equation (5) for borrowers whose MDTI and pre-modification LTV both exceed their target by more than 30% - in other words, for high-DTI, high-LTV borrowers. Below the LTV^* implied by this cap, increasing pre-modification LTV increases principal forgiveness. Above this point, the modification is unchanged by increasing pre-modification LTV.

The kinked structure of the problem allows us to examine the impact of principal forgiveness — or equivalently, post-modification LTV¹⁶ — while controlling separately (and even nonparametrically) for pre-modification LTV, pre-modification MDTI, target LTV, and target MDTI. This suggests the following basic regression to predict

¹⁵For loans with servicers who have a LTV target of 100 percent, principal forgiveness is limited to 30 percent of the initial mortgage balance. In this case, $PF \equiv 1/(1 - 30\%) - 1 = 10/7 - 1 = 3/7$. For this sample, the principal forgiveness amount is determined as follows:

$$\begin{aligned} PF &\equiv \frac{\text{pre-modification LTV}}{\text{post-modification LTV}} - 1 \\ &= \max\left(0, \min\left(\frac{\text{pre-modification LTV}}{\text{target LTV}}, \frac{\text{pre-modification MDTI}}{\text{target MDTI}}, 10/7\right) - 1\right). \end{aligned} \quad (5)$$

Limiting the sample to loans with LTV above their servicer's target and taking logs yields:

$$\ln(1 + PF) = \min(\ln 10 - \ln 7, \ln \text{pre-modification LTV} - \ln \text{target LTV}, \ln \text{pre-modification MDTI} - \ln \text{target MDTI}). \quad (6)$$

¹⁶Our identification strategy does not allow us to separate the effects of principal forgiveness from negative equity because principal forgiveness and post-modification LTV are perfectly (negatively) correlated in our setting, conditional on our other controls.

re-default:

$$\begin{aligned}
\Pr(\text{Default}) = f(\alpha &+ \beta_F \ln(1 + \text{PF}) \\
&+ \beta_{\text{LTV}}(\ln \text{pre-modification LTV} - \ln \text{LTV target}) \\
&+ \beta_{\text{DTI}}(\ln \text{pre-modification MDTI} - \ln \text{MDTI target}) \\
&+ \beta_X X + \varepsilon)
\end{aligned} \tag{7}$$

The forgiveness term in the first row of equation (7) is the minimum of the terms found in the second (forgiveness implied by LTV) and third rows (forgiveness implied by DTI). The regression examines the impact of principal forgiveness while controlling separately for the two terms in the min function that determine it.¹⁷ The identifying assumption here is that this minimum of the affordability term and the negative equity term has no independent impact on default except to determine the amount of principal forgiveness the borrower receives. It is straightforward to allow for an interaction of the LTV and DTI, so long as this interaction doesn't take the kinked form of a minimum. Nonparametric controls for DTI and LTV are also straightforward. Furthermore, we can perform the analysis in the neighborhood around the kink:

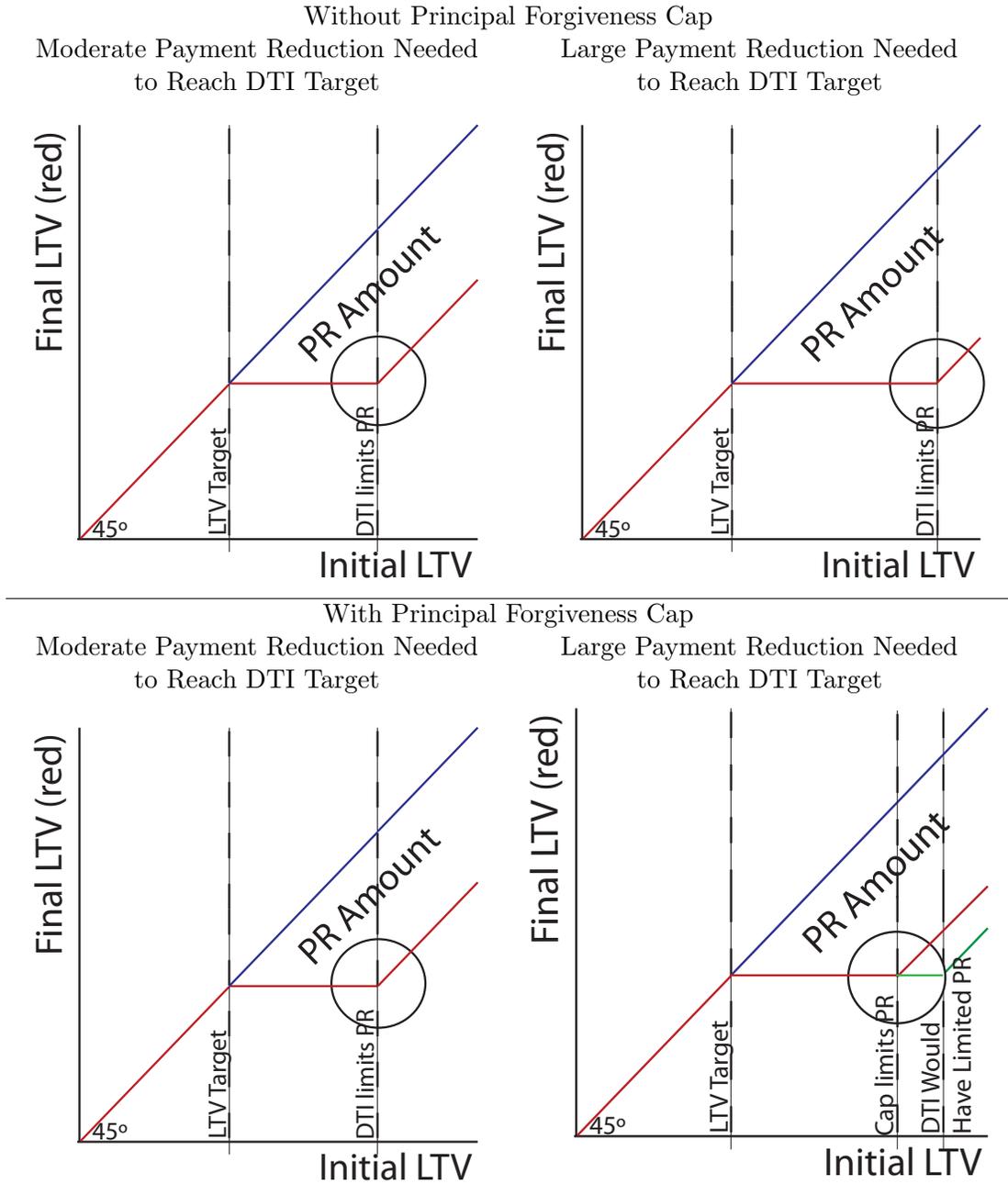
$$\text{abs} \ln \left(\frac{\text{pre-modification LTV}}{\text{pre-modification LTV}^*} \right) < k \tag{8}$$

where k specifies the size of the neighborhood around the kink used in the analysis.

To provide further intuition for our identification strategy, the structure of the kink is illustrated in Figure 1. This series of panels shows the relationship between pre-modification LTV and the amount of principal forgiveness under several different DTI scenarios and servicer policies. Each panel shows this relationship for borrowers with

¹⁷Equivalently in the kink framework, β_{LTV} and β_{DTI} control for the borrower's position relative to the kink, and β_{PR} gives the change in the slope at the kink point. The change in the reaction function at the kink point must be divided by the change in the derivative of the treatment function at the kink point, which in this case is 1.

Figure 1: HAMP PRA Identification



Source: Authors' analysis.

the same given pre-modification DTI and servicer. DTI and servicer policy assumptions change across panels. The red line plots post-modification LTV as a function of pre-modification LTV. The amount of principal forgiveness is represented by the vertical distance between the red line and the 45-degree line in blue.

The top-left panel in Figure 1 shows the relationship between pre-modification LTV and post-modification LTV for borrowers with a specific, moderate pre-modification DTI¹⁸ and a servicer with a specific post-modification target (such as 115 percent) but without a principal forgiveness cap. To the left the circled kink at LTV*, increasing pre-modification LTV leads to increased principal forgiveness and does not increase post-modification LTV. To the right the circled kink, increasing pre-modification LTV leads to increased post-modification LTV and does not change the mortgage modification.

The top-right panel in Figure 1 shows borrowers with a specific, high pre-modification DTI and a servicer with a specific post-modification target (e.g., 115%) but without a principal forgiveness cap. Note that the panels on the top-left and top-right are identical except that the panels differ in the location of LTV* at the kink.

The bottom panels of Figure 1 show how the location of the kink adjusts for servicers with a cap on the amount of forgiveness they permit. For lower-DTI borrowers, the cap does not bind, and the location of the kink is unaffected (lower left). For higher LTV borrowers, the cap alters the location of the kink (lower right).

These figures can be used to visualize a sequence of increasingly flexible identification strategies. The most restrictive identification strategy can be visualized with a single panel, such as the one in the top left. This strategy uses borrowers with the same pre-modification DTI and servicer policy and compares the relationship between pre-modification LTV and default on either side of the kink. The problem with using borrowers who require identical payment and LTV reductions is that LTV* is the same for all borrowers; a borrower's location relative to the kink maps directly into pre-modification

¹⁸For example, DTI=40 percent. More specifically, this refers to borrowers whose pre-modification MDTI exceeds their MDTI target by a specific, moderate amount, such as 9 percentage points.

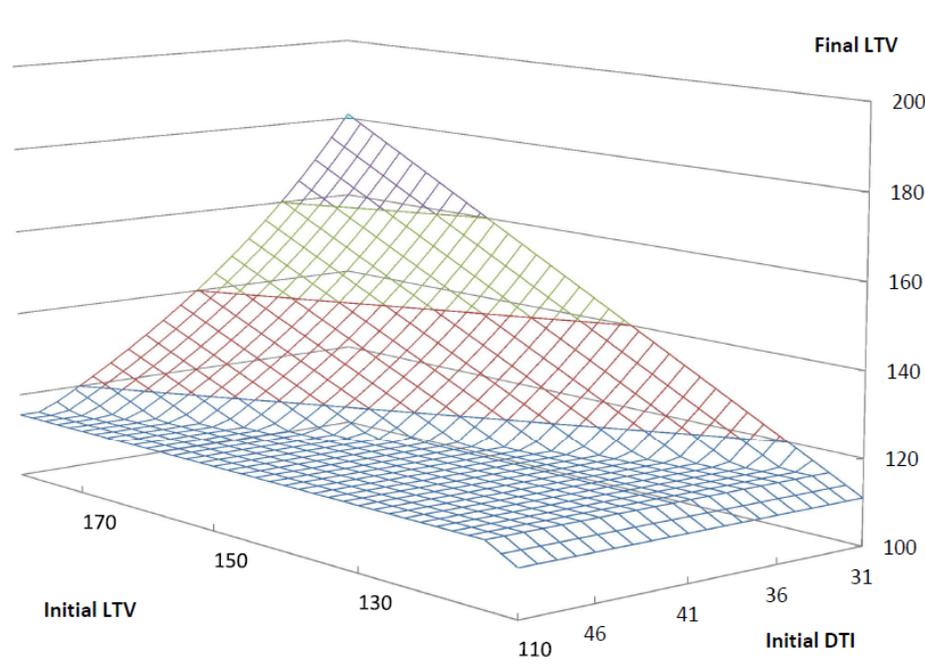
LTV. Pre-modification LTV may have an independent, nonlinear effect on default. With this identification framework, there is no way to nonparametrically separate the effects of pre-modification LTV from principal forgiveness.

A more flexible identification strategy combines the top-left and top-right panels of Figure 1. This identification strategy includes all borrowers with the same servicer LTV target (and no servicer forgiveness cap), regardless of pre-modification DTI. Combining borrowers with many different DTIs requires a three-dimensional understanding of the kink. Two such illustrations are provided. First, we envision the top two panels of Figure 1 as cross-sections of a three-dimensional mapping of post-modification LTV as a function of pre-modification LTV and DTI. This is shown in Figure 2. As we can see from this illustration, the location of LTV* changes with pre-modification LTV and pre-modification DTI. The principal reduction amount can be visualized in Figure 3, which shows the amount of principal forgiveness (z-axis) as a function of pre-modification LTV (x-axis) and affordability (y-axis, pre-modification MDTI relative to target). Since the amount of forgiveness is a nonlinear (pyramid-shaped) function of pre-modification LTV and pre-modification MDTI relative to target, the relationship between forgiveness and default can be estimated while controlling (potentially nonparametrically) for the pre-modification LTV (location along the width of pyramid) and pre-modification MDTI relative to target (location along the depth of pyramid). This “within” (within-servicer) identification strategy is employed in the third column of Table 5 for servicers with a 115 percent LTV target, and in the fourth column of Table 5 for servicers with a 100 percent LTV target and a 30 percent forgiveness cap.

An even more flexible identification strategy exploits the fact that servicers with different LTV targets differ in the shape of their forgiveness pyramids in Figure 3. When including borrowers with servicers with multiple servicer LTV targets, it is possible to estimate the relationship between forgiveness and default while controlling nonparametrically for the X-Y coordinates of the pyramid (the interaction of pre-modification LTV

and pre-modification MDTI relative to target). This "between-servicer" identification strategy is employed in the second column of Table 5.

Figure 2: Post-Modification LTV



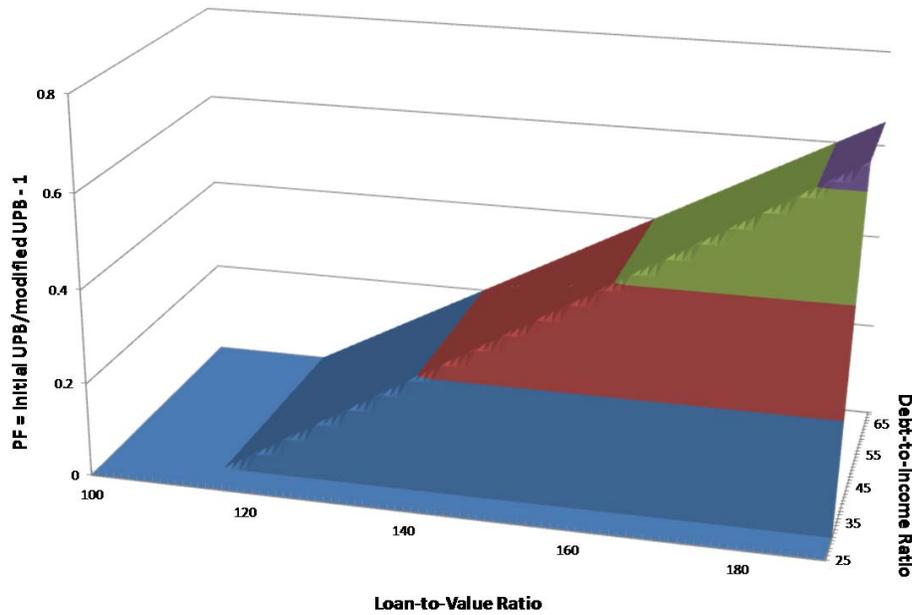
Source: Authors' analysis.

3 Data

Data come primarily from HAMP administrative "loan setup" files, which record modification characteristics and performance. Additional data come from "NPV run" files, which record variables used when evaluating the net present value of modifications to the lender.¹⁹ We examine new permanent HAMP modifications on non-GSE loans enrolled in 2011, 2012, and part of 2013. (GSE stands for government-sponsored enterprises. GSE loans are mortgages backed by Fannie Mae or Freddie Mac, and they are ineligible for HAMP PRA) .

¹⁹Not all records in the loan setup files have matching NPV run files; when we include variables from the loan set-up file in our regressions, some observations are dropped.

Figure 3: Principal Forgiveness Amount



Source: Authors' analysis.

HAMP PRA officially launched in October 2010, but borrowers must complete a three month trial period before becoming eligible for a “permanent” modification that entitles the borrower, servicer, and investor to government subsidies and permanently alters the borrower’s mortgage terms. We begin our sample in January 2011. We focus on modifications that have completed the trial period and become permanent because these data have been checked for internal consistency and randomly audited as the subsidy payments are set up. Data on loans that have failed out of the trial period are not subject to this level of scrutiny, and can be unreliable. About 10 percent of the trial modifications originated during our sample period failed to become permanent; roughly two-thirds of this fall-out can be attributed to nonpayment. Because we cannot consistently determine whether the failure to submit documentation reflects ineligibility or default, we do not consider the impact of principal forgiveness on re-default in the first three months of a modification; results are conditional on the modification’s survival to three months.

Loans that become 90 days (or more) delinquent and are disqualified from HAMP are considered “defaulted” for the purpose of this analysis.²⁰ This is similar to the default measure used by Bhutta et al. (2010). We have no subsequent performance data on borrowers who drop out of HAMP.

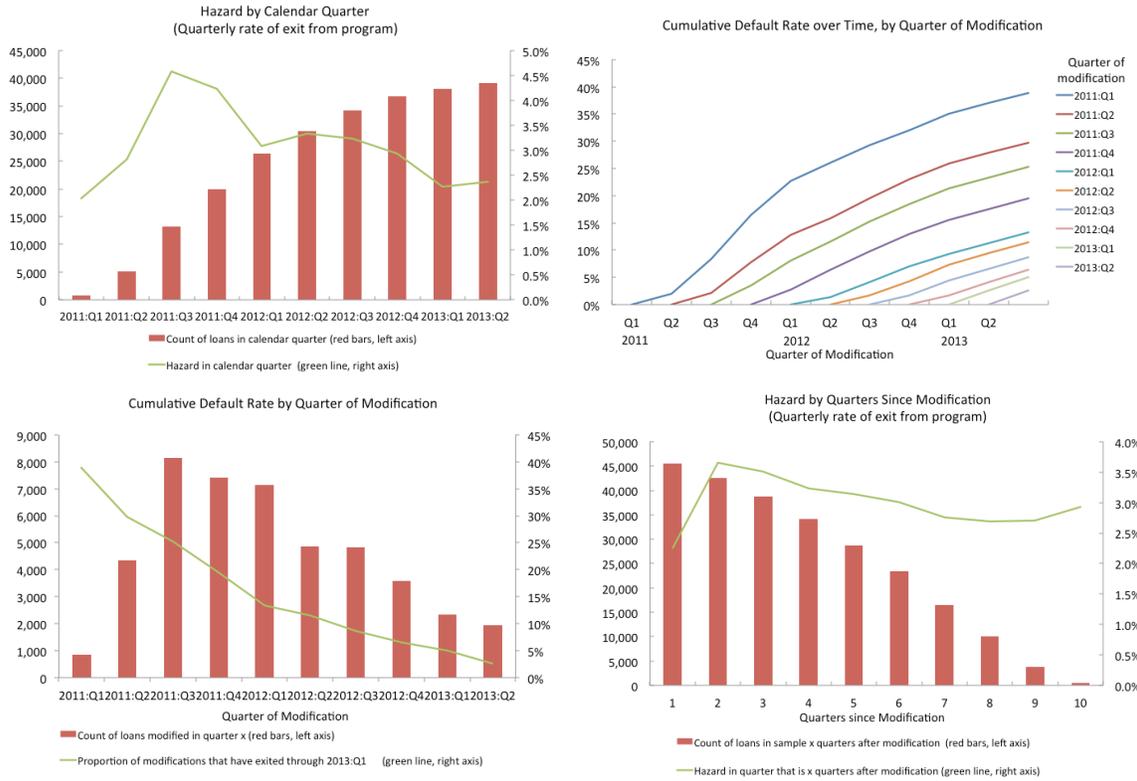
Our analysis is performed at a quarterly frequency, examining the default hazard in each calendar quarter for cohorts of loans that became permanent in each calendar quarter.²¹ Because at least 90 days must elapse for a borrower to become 90 days delinquent and disqualified from HAMP, it is virtually impossible to exit HAMP in the same quarter that a permanent modification begins. As a result, we include default data from the second quarter of 2011 through the third quarter of 2013, and we begin monitoring performance in the second quarter of each borrower’s HAMP tenure HAMP. The first cohort of modifications (those that became permanent in the first quarter of 2011) has 10 quarters of default data, from the second quarter of 2011 through the third quarter of 2013. The most recent cohort of modifications (those that became permanent in the second quarter of 2013) has only one quarter of default data, the third quarter of 2013.

We encounter extreme values in the data, some of which likely reflect data entry errors rather than true mortgage characteristics. On these grounds, we exclude borrowers with initial DTI ratios (including taxes, homeowners’ association or other fees, and insurance) over 100 percent and initial LTV ratios over 240 percent. We drop loans if any of the mortgage rate, term, or unpaid balance is recorded as zero, or the servicers’ PRA policies could not be determined because they had very few PRA loans. We also drop

²⁰After being disqualified from HAMP, the borrower may be evaluated for an additional non-HAMP modification, or foreclosure proceedings may be initiated. We do not have loan-level performance data following disqualification, so the eventual disposition of disqualified PRA HAMP modifications is unobserved. We refer to falling out of the program as “default” or “redefault”, but borrowers falling out of HAMP do not necessarily permanently default. Their mortgage could be repaid in full outside of HAMP. However, falling out of HAMP PRA is punitive — the borrower loses any principal forgiveness that has not yet been earned. Because of the earned principal forgiveness feature, HAMP PRA is more generous than nearly all modifications available to borrowers, so a borrower who fails out of HAMP PRA is unlikely to remain in their home as a homeowner without a material improvement in their financial position.

²¹Default is recorded in the quarter when the loan first becomes 90 days delinquent, namely 90 days after the last payment the borrower was scheduled to make but did not.

Figure 4: Loan Count Statistics



Source: Authors' analysis.

loans that received principal forgiveness through a program other than HAMP PRA. We drop one large and one medium-sized servicer who use principal forgiveness allocation methods that do not generate the kink we exploit for identification; loans from these two servicers comprise the majority of dropped loans. The dropped loans comprised about 60 percent of the full sample of PRA recipients who enrolled during the sample period. For these reasons, our total loan counts will not match publicly-available information on the HAMP PRA program. During the enrollment period in our sample, 634,135 new permanent modifications were started in HAMP. Of these, 110,480 included HAMP PRA principal forgiveness amounting to more than \$8 billion. Our sample consists of 45,513 loans, and \$3.8 billion in principal forgiveness.

Figures 4 presents information about counts, rates of HAMP exit following 90 days of delinquency, and sample attributes. Table 2 describes the borrowers and their loans

Table 2: Summary Statistics About Loans and Borrowers

	N	Median	Mean	St. Dev.	Min	Max
Balance pre-mod ('000s)	45,513	\$292	\$324	\$173	\$18	\$1,279
Home value ('000s)	45,513	\$180	\$205	\$118	\$10	\$856
Gross monthly income ('000s)	45,513	\$4.5	\$4.9	\$2.4	\$0.6	\$22.2
Total Mortgage Payment ('000s)	45,513	\$2.0	\$2.2	\$1.1	\$0.3	\$9.5
Principal & Interest Payment ('000s)	45,513	\$1.6	\$1.8	\$0.9	\$0.2	\$9.0
Credit score	41,833	559	568	69	250	839

The mortgage balance includes accrued past unpaid interest. The home value is the assessed home value from the servicer's automated valuation model (AVM) at time of modification or a broker's price opinion (BPO) or appraisal when an AVM is unavailable. Monthly mortgage payment includes mortgage principal and interest. Monthly total payment includes mortgage principal and interest, as well as homeowners' insurance premiums and property taxes. Gross income is the borrower's monthly pre-tax eligible income, excluding temporary sources such as unemployment insurance benefits or self-employment income from an irregular source. The sample excludes borrowers who received only unsubsidized principal forgiveness (which may be allocated under a different framework than PRA) and borrowers whose servicers' PRA policies either could not be imputed or did not generate the kink exploited for this analysis.

Source: Authors' analysis.

before modification. Table 3 describes summary statistics about the modification terms.

Table 2 shows that the median home value in the sample is \$180,000 and the median pre-modification mortgage balance is \$292,000, though there is substantial variation. Table 3 shows that HAMP PRA reduces the median DTI from 44 percent to 31 percent and reduces median LTV from 159 percent to 115 percent, roughly 30 percent principal forgiveness on average. Figure 4 (lower left corner) shows that the number of new modifications in our sample peaked in the third quarter of 2011 at a little more than 8,000 for the quarter and has fallen consistently since then to fewer than 2,000 in the most recent quarter.

Roughly 85 percent of loans in the sample have servicers with a 115 percent LTV target; none of these servicers have elected to place a cap on the total allowable amount of principal forgiveness. Servicers for the remaining 15 percent of loans have a 100 percent LTV target; all of these servicers have elected to place a 30 percent cap on the principal forgiveness amount. Slightly more loans in the data have fixed rates than adjustable

Table 3: Summary Statistics About Modification

	N	Median	Mean	St. Dev.	Min	Max
Total DTI pre-mod	45,513	44.2%	47.0%	12.3%	24.0%	100.0%
Total DTI post-mod	45,513	31.0%	31.0%	0.4%	12.4%	33.0%
Total payment reduction	45,513	29.8%	30.0%	16.0%	0.0%	69.0%
LTV before modification	45,513	158.8%	164.2%	33.5%	109.8%	240.0%
LTV after modification	45,513	115.0%	121.2%	16.1%	100.0%	237.7%
Principal forgiveness	45,513	28.2%	28.9%	17.4%	0.0%	73.5%
Rate pre-mod	45,513	6.375%	6.3%	2.0%	0.8%	15.1%
Rate post-mod	45,513	3.0%	3.9%	2.1%	1.0%	15.0%
Term pre-mod (months)	45,513	305	317	60	1	541
Term post-mod (months)	45,513	301	333	76	12	541

Mortgage DTI is the ratio of the borrower’s monthly mortgage payment (principal and interest) to gross income. Total DTI is the ratio of the total monthly payment (principal, interest, homeowners insurance, and property taxes) to gross income. Loan-to-value (LTV) is the ratio of the mortgage balance to the home value.

Source: Authors’ analysis

rates, and the majority of loans are held in mortgage-backed securities and not on bank balance sheets. In roughly two-thirds of all cases, the LTV target is the limiting factor determining the amount of principal forgiveness received; reducing the mortgage balance until the LTV target is met is insufficient to reach the affordability target. Rate reduction as well as possibly term extension and forbearance are needed to reach the affordability target.

Figure 4 shows that default rates have been relatively constant as modifications age, with a hazard of about 3 percent per quarter between the fourth and 10th quarters after modification. There is some indication that default rates have fallen with calendar time, from a peak in the quarterly default hazard in the fourth quarter of 2011 at 4.6 percent to 2.4 percent in the third quarter of 2013, though the relationship is not monotonic.

Because the identification strategy relies on a kink in the principal forgiveness formula, it is critical that the amount of principal forgiveness received actually adhere to that formula. PRA participants receive almost exactly the amount of principal forgiveness predicted by the formulas we use. A regression to predict the natural log of actual

principal forgiveness with the natural log of predicted principal forgiveness and no other covariates has a precisely-estimated coefficient of 0.99 and an R^2 of 0.99. Although the analyses that follow examine the relationship between predicted principal forgiveness (given the program design outlined in Section 2) and default, results are nearly identical when actual principal forgiveness is used instead.

Figure 5 illustrates the change in treatment at the kink, with the y-axis measuring the amount of principal forgiveness (denoted as PF) as the difference between actual $\ln(\text{post-modification LTV})$ and $\ln(\text{pre-modification LTV})$. The x-axis shows the $\ln(\text{pre-modification LTV})$ relative to the kink ($\ln(\text{LTV}^*)$ in equation 3).²² At the kink (x-axis equals zero), the borrower’s pre-modification LTV is such that the amount of PF needed to reach the borrower’s LTV target equals the amount of principal forgiveness needed to reach the DTI target. To the left of the kink, the amount of PF needed to meet the LTV target is less than the amount needed to meet the DTI target; because the borrower receives the lesser of these two amounts, the borrower receives the amount PF implied by the LTV target. In this range, increasing pre-modification LTV increases the amount of PF dollar-for-dollar so that the post-modification LTV remains unchanged. To the right of the kink, the amount of PF needed to meet the LTV target is greater than the amount needed to meet the DTI target. Because the borrower receives the lesser of these two amounts, the borrower receives the amount PF implied by the DTI target. In this range, increasing pre-modification LTV does not change the mortgage modification so the post-modification LTV increases dollar-for-dollar.

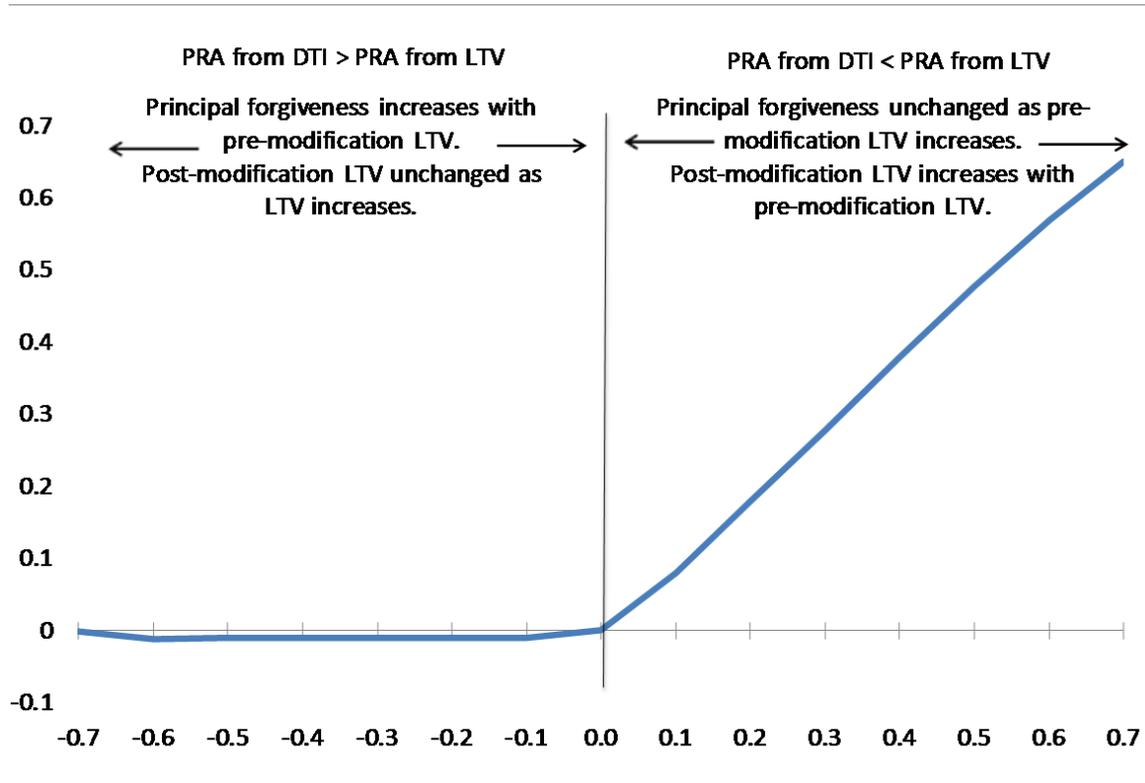
The identifying assumption of the kink design is that the unobservable propensity to default is smooth around the kink. Absent any reason to believe that being near the kink

²²More formally, the figure shows estimates of coefficients for 10 percentage-point bins for $\ln(\text{pre-modification LTV}) - \ln(\text{LTV}^*)$ from the following regression:

$$\begin{aligned} \ln(\text{post-mod LTV}) = & \alpha + \beta_{\text{DTI}}(\ln \text{pre-modification MDTI} - \ln \text{MDTI target}) \\ & + \beta_{\text{kink}}(\text{distance from kink}) + \beta_X X + \varepsilon \end{aligned} \quad (9)$$

Additional controls include fixed effects for servicer, cohort, and the number of quarters since modification.

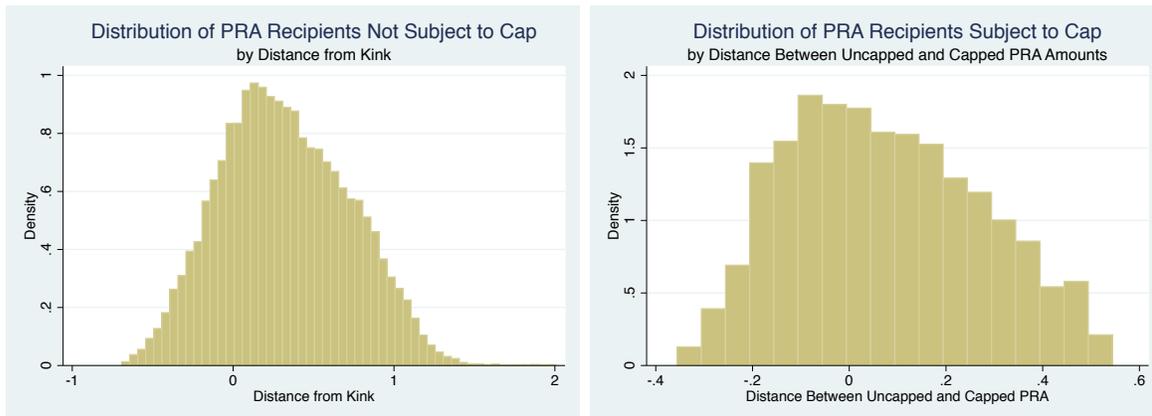
Figure 5: Treatment at Kink



The horizontal axis represents the distance from the kink, measured as $\ln(\text{PF from LTV}) - \ln(\text{PF from DTI})$. The plotted line reflects the coefficients from a regression of $\ln(\text{post-modification LTV})$ on the distance from the kink (in 10 ppt bins). To the left of the kink, the slope of the line implied by the coefficients is 0, because in this range, principal forgiveness increases dollar for dollar with pre-modification unpaid balance. To the right of the kink, the slope implied by the coefficients is 1, because principal forgiveness does not increase with pre-modification unpaid balance over this range. Source: Authors' analysis.

would affect default rates per se, there are scenarios in which this assumption might be violated. First, some people may try to manipulate their location relative to the kink. Second, individuals may selectively apply for (or prematurely drop out of) HAMP based on their location relative to the kink. These behaviors will show up as “bunching”, or counts of loans that are uneven around the kink. (Card et al., 2012) For either of these concerns to arise, individuals would have to have precise information about where they would lie relative to the kink. This may be difficult because servicers' LTV targets are

Figure 6: Evidence on Bunching Around the Kink



Source: Authors' analysis.

not generally known to the public. Furthermore, servicers are required to use regulator-approved automated valuation models to determine the value of the home. Borrowers generally do not know the algorithms used in these models. Figure 6 shows that there is no evidence of bunching around the kink.

4 Results

4.1 Basic Results

Table 4 shows the results of a hazard regression to predict quarterly entry into default using a logit functional form, as shown in equation (7). Our independent variable of interest is the natural log of the amount of principal forgiveness (PF, predicted by equations 1 and 5). The first column includes linear controls for the natural log of the principal forgiveness amount predicted by the borrower's LTV and the natural log of the principal forgiveness amount predicted by DTI (together, these two variables control for the location of the kink), an indicator variable for whether the servicer uses an LTV target of 115 percent (as opposed to 100 percent), and 10 dummy variables indi-

Table 4: Quarterly Hazard: Impact of Principal Forgiveness on Program Exit

Dep. Var.	Dep Var: Program exit, or 90-plus day delinquency (quarterly)				
ln(predicted PF)	-0.851*** (0.129)	-0.538*** (0.129)	-0.611*** (0.136)	-0.653*** (0.155)	-0.874*** (0.249)
ln(PF from LTV)	0.38*** (0.0886)	0.225** (0.0899)	0.107 (0.11)	0.551*** (0.127)	-0.159 (0.67)
ln(PF from DTI)	-1.072*** (0.0454)	0.418*** (0.0453)	0.313*** (0.075)	0.255** (0.101)	1.771** (0.728)
Dummy for LTV target = 115 percent	YES	YES	YES	YES	YES
Quarters of observation controls	YES	YES	YES	YES	YES
Quarter cohort and servicer dummies	NO	YES	YES	YES	YES
DTI before modification	NO	YES	YES	YES	YES
Interaction variable	NO	NO	YES	YES	YES
Other controls	NO	NO	NO	YES	YES
10-ppt LTV and DTI bins	NO	NO	NO	NO	YES
Observations	244,132	244,132	244,132	211,409	211,409
Loans	45,513	45,513	45,513	39,310	39,310
R^2	0.0289	0.0520	0.0520	0.0808	0.0826

Each observation refers to a loan in a calendar quarter. Observations are included on loans that have not exited from the program to date and for which data is available for the entire quarter. Because program exit is nearly impossible in the quarter in which a loan was modified, observations begin in the quarter following the quarter of modification. The regression shows results from a hazard for quarterly program exit, where the hazard is specified as a logit; coefficients are shown. “Quarter since modification controls” indicate dummy variables for the number of quarters since the modification; “Quarter of modification controls” are dummy variables for the calendar quarter in which the loan was modified. Total DTI controls for the natural log of the pre-modification total DTI ratio. The interaction control is a control for the interaction of the natural logs of pre-modification total DTI and pre-modification LTV. “Other Controls” includes credit score, adjustable rate mortgage dummy, investor-owned mortgage dummy, ln income, ln pre-modification mortgage balance, length of trial modification (linear and squared), ln NPV of HAMP modification over no modification, ln NPV of HAMP PRA modification over no modification, and a dummy for whether the standard HAMP modification had a higher NPV than the HAMP PRA modification.

Source: Authors’ analysis.

cating the number of quarters since modification. The second column adds 10 dummy variables indicating the modification’s cohort quarter, servicer dummies, and borrower’s pre-modification total DTI. The third column adds an interaction between the natural log of pre-modification LTV and the natural log of pre-modification mortgage DTI. The fourth column adds additional controls, including state dummies, the borrower’s credit score, NPV test results (for standard HAMP and PRA, in natural logs), the natural log of gross monthly income, the natural log of pre-modification principal balance, the trial length (in months), the square of the trial length, and dummy variables indicating ARM and investor-owned loans. The final column adds 10-percentage-point bins for each of the principal forgiveness predicted by LTV (in logs) and the principal forgiveness predicted by DTI (in logs).

The coefficient on principal forgiveness varies between -0.54 and -0.87 and is statistically significant. On a baseline re-default hazard of 3.1 percent, a 10 percent principal forgiveness would reduce the re-default hazard by 0.2 to 0.3 percentage points (from 3.1 percent to 2.8 percent or 2.9 percent).

Table 5 exploits three kinks — sources of quasi-experimental variation — in the program to provide four separate estimates of the impact of principal forgiveness on mortgage default. The first column repeats column 1 from Table 4. Column 2 (labeled “between”) relies on a between-servicer identification; it controls linearly for the borrower’s initial LTV and interacts principal forgiveness from DTI (in 10 ppt bins) with the borrower’s initial LTV (also in 10 ppt bins). The coefficient on principal forgiveness is identified entirely from between-servicer differences in LTV targets servicer, comparing the experiences of borrowers with the same pre-modification LTV and DTI who received different amounts of principal forgiveness because their servicers had different LTV targets (115 percent or 100 percent). Column 3 limits the sample to borrowers whose servicer targets a 115 percent post-modification LTV, providing a “within” estimate (within the group whose servicers have a 115 percent LTV target). Column 4 limits the sample to borrowers

whose servicer targets a 100 percent post-modification LTV, providing a “within” estimate (within the group whose servicers have a 100 percent LTV target). These servicers also cap principal forgiveness at 30 percent of the pre-modification unpaid balance. This column evaluates the impact of PR separately at each of the two kinks, the kink where the PR amount implied by DTI and LTV are equal and the kink where PR exceeds its cap. To identify the two kinks separately, we break the predicted PR amount into two pieces: the natural log of the amount predicted without the cap, and the difference in the natural logs of the capped and uncapped PR amounts. We find that the point estimates on the two kinks are similar (the difference between the estimates is statistically indistinguishable from zero), though the coefficient on the second kink is not statistically significantly different from zero due to its large standard error.

4.2 Counterfactual Estimates

The results from the estimates in table 4 can be used to construct a counterfactual where borrowers receive no principal forgiveness, assuming the same payment reduction had been achieved through rate reduction, term extension, and forbearance.²³ Figure 7 illustrates the observed and counterfactual default rates for the sample population in several different ways. The first panel shows the cumulative default rate, by modification quarter, for loans that received principal forgiveness through HAMP PRA and the estimated cumulative default rate absent principal forgiveness. The second panel shows the quarterly exit rate in each calendar quarter. The final panel shows by loan duration, the number of quarters the loan has remained in the program. In each panel, the error bars encompass the predicted default rates within two standard deviations from the point estimate.

²³The counterfactuals are estimated using the regression shown in the first column of Table 4 with additional controls for the quarter of modification (linear), and interactions between $\ln(\text{predicted PF})$ and the number of quarters since modification and the quarter of modification. For each mortgage in our sample, we calculate the counterfactual likelihood of survival to date and the default hazard; these are calculated in each quarter that mortgage would have been in the sample had it not defaulted.

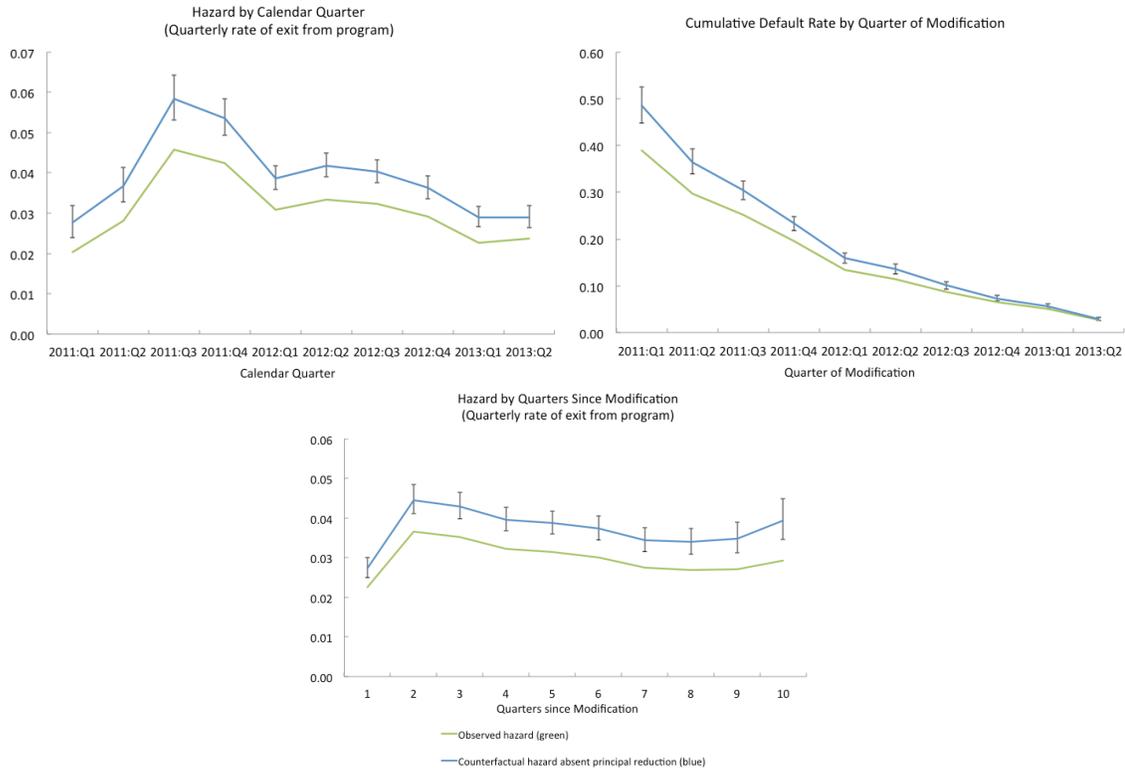
Table 5: Separate Estimates from DTI-LTV and 30 Percent Principal Forgiveness Cap Kink

Dep. Var. Sample	Dep Var: Program exit, or 90-plus day delinquency (quarterly)			
	Full Sample		LTV Target of Sample	
Identification	Full	Between	115% Within	100% Within
ln(predicted PF)	-0.851*** (0.129)	-1.130*** (0.224)	-0.615*** (0.163)	
ln(pred PF uncapped)				-0.925** (0.387)
ln(uncapped PF) - ln capped PF)				-0.486 (0.481)
ln(PF from LTV)	0.380*** (0.089)		0.182 (0.124)	0.688*** (0.183)
ln(PF from DTI)	-1.072*** (0.045)	0.577 (0.659)	-1.184*** (0.058)	-0.777*** (0.115)
ln(LTV initial)		0.502 (0.670)		
LTV bin x PF from DTI bin	No	Yes	No	No
Observations	244,132	244,132	200,146	43,876
Loan count	45,513	45,513	38,513	7,000
R^2	0.0289	0.0332	0.0261	0.0209

The first column of Table 5 repeats the baseline regression from the first column of Table 4. The second column includes controls for the interaction of the borrower's LTV (in 10 ppt bins) and DTI (in 10 ppt bins); the coefficient reflects the difference in post-modification LTV arising from differences in the servicers' LTV target. The third column repeats column 1 for loans whose servicers target 115 percent LTV. The final column limits the sample to servicers who target 100 percent LTV, and decomposes ln (predicted PF) into ln (predicted PF uncapped) and ln (predicted PF capped) - ln(predicted PF capped). This final column provides two estimates for the impact of principal forgiveness on program exit for the 100 percent LTV target sample, one from the DTI-LTV kink (the coefficient from ln (predicted PF uncapped)) and one from the 30 percent cap kink (the coefficient from ln (capped PF) - ln(uncapped PF)).

Source: Authors' analysis.

Figure 7: Counterfactual: Estimated Default Rates Absent Principal Forgiveness



The counterfactuals are estimated using the regression shown in the first column of Table 4 with additional controls for the quarter of modification (linear), an interaction between $\ln(\text{predicted PF})$ and the number of quarters since modification, and an interaction between $\ln(\text{predicted PF})$ and the calendar quarter of modification. This regression is also the last column in Table 9. For each mortgage in our sample, we calculate the counterfactual likelihood of survival to date and the default hazard; these are calculated in each quarter where that mortgage would have been in the sample had it never defaulted. These are used to compute an average hazard weighted by the predicted probability of survival to date. The error bars encompass the predicted default rates within two standard deviations of the point estimate.

Source: Authors' analysis.

Had these borrowers not received principal forgiveness, which averaged 28.2 percent of the pre-modification unpaid balance, we estimate that the quarterly hazard rate would have been 3.8 percent (95 percent confidence interval (CI) : 3.5 percent to 4.1 percent), compared to the 3.1 percent hazard observed in the data. The first cohort of PRA modifications in our sample (originated 2011:Q1) had a cumulative default rate of 39 percent during the 10 quarters of observed performance. We estimate that their default rate would have been 49 percent absent principal forgiveness (95 percent CI: 45 percent to 52 percent). The cumulative default rate in the sample (overall default rate thus far) is 16.3 percent; we estimate that it would have been 19.6 percent (95 percent CI: 18.3 percent to 21.1 percent) had these loans not received principal forgiveness. These results do not change when we cluster errors by loan identifier, clustering all quarters of data from the same loan.

4.3 Regression Kink Design

Figure 8 provides a graphical representation of the relationship between pre-modification LTV and default around the kink. The horizontal axis is the same as in Figure 5, representing the distance from the kink (in logs), or equivalently, the difference between pre-modification LTV and LTV*. The plotted points reflect the coefficients of a logistic regression to predict default with the controls in Equation 9, normalized so that the omitted category is the 10-percentage-point bin that includes pre-modification LTV = LTV* (where the horizontal axis equals zero).

We see a marked change in the relationship between pre-modification LTV and default around the kink. To the left of the kink, default is falling with pre-modification LTV. In this range, increasing pre-modification LTV has no effect on post-modification LTV as increasing pre-modification LTV leads to one-for-one increases in the generosity of principal forgiveness. The negative slope to the left of the kink suggests a role for unobservables; borrowers with higher pre-modification LTV must be unobservably more

stable (i.e., have lower baseline default rates), holding payment reduction constant, because loans to the left of the kink have uniform post-modification LTVs but default rates that are decreasing in pre-modification LTV. To the right of the kink, default is increasing with pre-modification LTV, as expected, because higher pre-modification LTV implies higher post-modification LTV in this range (though the positive correlation between LTV and default is attenuated by the selection identified to the left of the kink). The true effect of principal forgiveness on default can be measured as the difference between the slopes to the left and right of the kink. The slope to the right of the kink reflects both selection and the effect of higher LTV, while the slope to the left of the kink reflects only selection. The slope to the right of the kink, a naive measure of the relationship between LTV and default, is an underestimate of the true effect of LTV on default.

Table 6 repeats results from the first column of Table 4, with samples that sequentially (moving from left to right) zoom in closer around the identifying kink in equation (3). Limiting the regression to observations near the kink implements a regression kink design (RKD) (Florens et al., 2009; Card et al., 2012). Provided the region around the kink is small enough and assignment on either side of the kink is quasi-random, observable and unobservable variables should be the same for observations on either side of the kink. As a result, additional controls are unnecessary and concerns about omitted variables are lessened.

The first column includes the full sample; the second excludes loans that are bound by the principal forgiveness cap (i.e., whose PF would be greater than 30 percent of their principal balance before modification, and whose servicers employ a cap). The third column includes uncapped loans with $k < 0.5$ in equation 8, and the fourth column includes uncapped loans with $k \geq 0.25$ in equation 8; standard errors become extremely large for k substantially below 0.25. Note that results are roughly unchanged when the regression is limited to the neighborhood around the identifying kink; although standard errors grow as the neighborhood shrinks, point estimates change little.

Table 6: Quarterly Hazard: Impact of Principal Forgiveness Near Kink

Dep. Var.: Program exit, or 90-plus day delinquency (quarterly)				
Sample	Full	Uncapped	Distance from Kink ≤ 0.5	Distance from Kink ≤ 0.25
ln PF (predicted)	-0.851*** (0.129)	-0.748*** (0.145)	-0.566** (0.225)	-0.421 (0.519)
ln PF (predicted by LTV)	0.380*** (0.089)	0.308*** (0.105)	0.112 (0.138)	-0.242 (0.307)
ln PF (predicted by DTI)	-0.539*** (0.031)	-0.479*** (0.039)	-0.451*** (0.043)	-0.448*** (0.056)
LTV target = 115 percent?	YES	YES	YES	YES
Quarters since modification	YES	YES	YES	YES
Observations	244,132	216,407	143,851	83,913
Loan count	45,513	41,339	27,641	16,200
R^2	0.029	0.0308	0.0213	0.0182

This table repeats results from the first column of Table 4, with the sample restricted to those observations sufficiently close to the kink from equation (3). The first column is identical to the first column from Table 4; the second column restricts the sample to observations not bound by the restriction that principal forgiveness not exceed 30 percent of the mortgage balance; the third column additionally restricts the sample to observations with log LTV within 0.5 (in logs) of the kink from equation (3); the final column restricts the sample to observations within 0.25 of the kink.

Source: Authors' analysis.

It should not be surprising that we lose power in the region near the kink. Borrowers who are near but on opposite sides of the kink receive nearly identical treatments. One must look relatively far from the kink to find borrowers with substantial differences in principal forgiveness, and consequently different default rates. It is worth noting that the kink occurs at different LTV values depending on the borrower's DTI and servicer PRA policy. As a result, identification from borrowers who are substantially far from the kink does not rely on borrowers with outlier DTI or LTV values or require any assumptions about the independent impact of LTV or DTI on default.

4.4 Placebo Evidence

Ganong and Jager (2014) have argued that results identified from kink designs may simply capture a nonlinear relationship in the data that happens to have an inflection point close

to the kink. This concern seems unlikely to explain the results in this paper, because the location of the kink in this paper varies from borrower-to-borrower based on their pre-modification DTI and the LTV target of their servicer. This variation in the location of the kink allows us to control nonparametrically for any nonlinear relationship between pre-modification LTV and default that may be present in the data. As additional checks, we also perform two placebo tests to confirm the results that we attribute to principal forgiveness are not spurious. Table 7 presents the results of these exercises.

In the first placebo test (shown in columns 2 and 3), we consider a “placebo treatment”. In particular, this is the amount of principal forgiveness the borrower would have received had they had a servicer with a different LTV target.²⁴ The first column shows our baseline regression, repeating the first column from Table 4. Column 2 adds the placebo treatment variable; column 3 adds the full set of controls (as in column 4 of Table 4) to the specification in column 3. We can see that a marginally statistically-significant positive coefficient on this variable comes negative and statistically indistinguishable from zero when the full set of controls is added; the coefficient on the actual principal forgiveness is nearly unaffected by the addition of this placebo treatment.

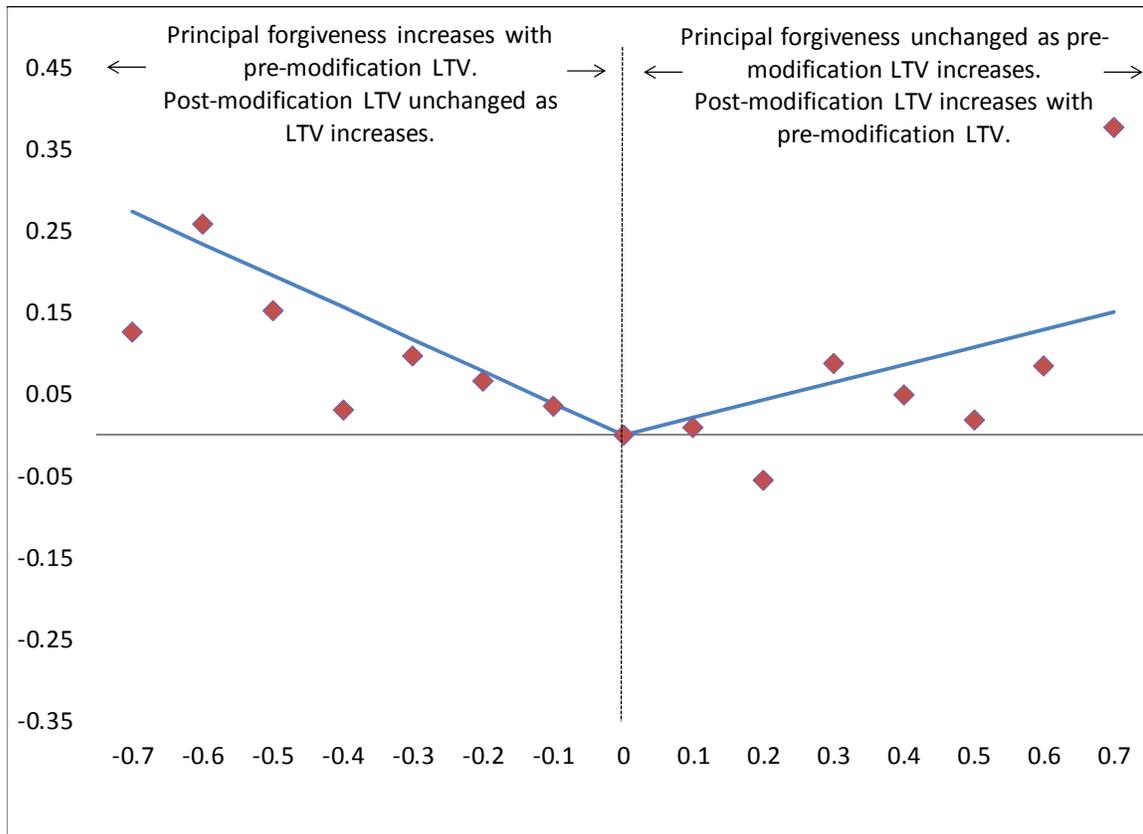
In the second test (shown in columns 4 and 5 from Table 7), we show the results of regressions using the first of two placebo samples. The same regressions are performed on a sample of Fannie Mae and Freddie Mac loans with pre-modification LTVs higher than the loan servicer’s LTV target. Fannie Mae and Freddie Mac do not participate in the principal forgiveness program, so these loans are categorically ineligible for principal forgiveness. We calculate the principal forgiveness these borrowers would have received had they been eligible for HAMP PRA. The results in columns 4 and 5 show the amount of principal forgiveness that these borrowers would have received had they been eligible

²⁴For borrowers whose servicers have a 115 percent LTV target, this variable reflects the principal forgiveness amount they would have received had their servicer instead used a 100 percent LTV target and a 30 percent cap; for borrowers whose servicers have a 100 percent LTV target and a 30 percent cap, this variable reflects the principal forgiveness amount they would have received had their servicer instead used a 115 percent LTV target.

has no effect on their probability of default; the coefficient on $\ln(\text{predicted PF})$ is close to zero and statistically insignificant. These results are apparent in column 4 (which includes only the baseline regression, replicating column 1 from Table 4) and in column 5 (which adds the full set of controls).

In the third test (shown in columns 6 and 7 from Table 7), we show the second placebo sample. The baseline regression and a regression with the full set of controls are performed on a sample of investor-owned loans modified during the sample period that did not receive principal forgiveness. Because HAMP PRA allows investor restrictions to supercede HAMP rules, securitized non-GSE loans occasionally face investor restrictions that prohibit principal forgiveness. We cannot directly identify loans that face these restrictions; the loans in this sample have been denied principal forgiveness either because investor restrictions prohibit it, or because the NPV of a modification without principal forgiveness was calculated to be higher. In column 6 of Table 7, we make no attempt to distinguish between loans denied principal forgiveness for legal versus economic reasons. In column 7, we introduce the full set of controls, which include the variables most important for determining a borrower's NPV outcome. Without the controls, the coefficient of interest is statistically insignificant and reasonably close to zero. With the controls, the coefficient switches sign, the result is statistically indistinguishable from zero, and the standard error is large. Together, these results suggest no evidence of a change in behavior around the kink on the two samples of borrowers who do not receive the treatment and for whom we should not expect any differences in default rates around the kink.

Figure 8: Graphical Evidence of Kink
 Effect of Pre-Modification LTV (Relative to Kink) on Default Hazard



The x-axis represents the distance from the kink in logs, or $\ln(\text{PF from LTV}) - \ln(\text{PF from DTI})$. The y-axis is normalized to zero at the kink (x-axis of zero). The y-axis values of the diamond-shaped red dots indicate, for the baseline sample, the coefficients on the distance from the kink (in logs), in 10 point bins, in a logistic quarterly hazard regression to predict default. A coefficient of 0.1 represents a 10 percent higher log-odds ratio than in the reference bin (corresponding roughly to a 10 percent higher default hazard). The blue line illustrates the coefficients on continuous variables measuring positive and negative distances from the kink in logs.

Source: Authors' analysis.

Table 7: Quarterly Hazard: Placebo Tests

Dep. Var.	Dep. Var.: Program exit, or 90-plus day delinquency (quarterly)			
	Full	Placebo (GSE)	Placebo (investor)	Sample
ln(predicted PF)	-0.851*** (0.129)	-0.920*** (0.264)	0.084 (0.128)	-0.130 (0.143)
ln(PF from LTV)	0.380*** (0.089)	-0.121 (0.675)	0.343*** (0.085)	0.592*** (0.095)
ln(PF from DTI)	-1.072*** (0.045)	1.828** (0.737)	-1.658*** (0.044)	-1.164*** (0.047)
ln(placebo PF)	0.282* (0.144)	-0.124 (0.252)		0.356 (0.318)
Dummy for LTV target = 115	YES	YES	YES	YES
Quarters of observation controls?	YES	YES	YES	YES
Full set of controls?	NO	YES	NO	NO
Observations	244,132	210,712	293,962	277,394
Loan count	45,513	39,172	52,862	42,209
R ²	0.029	0.083	0.042	0.019

(Column 1 reproduces column 1 from Table 4. Column 2 uses the same sample and adds a variable ln(Placebo PF) which is the logarithm of the amount of principal forgiveness a borrower would receive if their servicer were following the alternative PF policy; for borrowers with servicers targeting 115 percent LTV, this value is the amount of PF necessary to achieve a 100 percent LTV target with a 30 percent cap, and vice versa. Column 3 adds the full set of controls. Column 4 replicates column 1 using only data for borrowers with GSE mortgages. Column 5 adds the full set of control variables. Column 6 replicates column 1 using only data for borrowers with loans serviced on behalf of third-party investors. Column 6 repeats column 7 and adds the full set of controls. “Full controls” includes cohort and servicer dummies, DTI before modification, 2-percentage-point pre-modification DTI and LTV bins, credit score, ARM dummy, investor-owned mortgage dummy, log income, log pre-mod mortgage balance, trial modification length (linear and squared), log NPV of standard HAMP modification relative to no modification, log NPV of HAMP PRA modification relative to no modification, and a dummy indicating a standard HAMP mod had a higher NPV than a HAMP PRA mod. Because GSE mortgages are ineligible for PRA, data for GSE borrowers typically do not include results from PRA NPV tests; variables calculated from PRA NPV results were omitted from the specification in column 5 to maintain sample size

Source: Authors’ analysis.

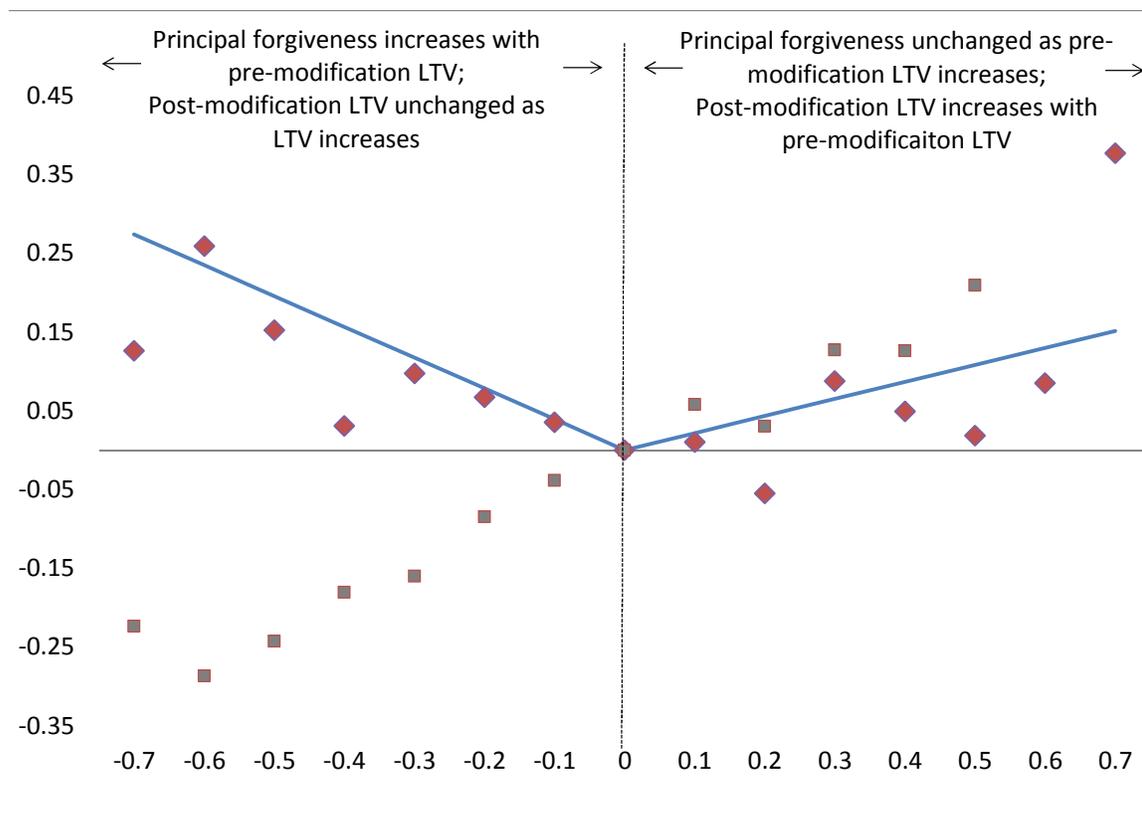
Figure 9 replicates Figure 8 and adds the coefficients from the same regression on the first placebo sample (Fannie Mae and Freddie Mac loans). The difference between the behavior of the treated and placebo samples is remarkable. The placebo sample shows no change in behavior at the kink, and the default probability increases steadily in pre-modification LTV (for this sample, the same as post-modification LTV).

4.5 Variation in Estimates

Table 8 shows the results are robust to choice of sample, including ARM-only, FRM-only, private-investor-held, and portfolio-held. Table 9 allows the impact of principal forgiveness to vary with observables. We find no statistically significant variation in the default-reducing benefits of principal forgiveness by pre-modification LTV. However, principal forgiveness yields significantly larger reductions in default when pre-modification total DTI is lower.

Our estimate does not have a clear interaction with either the borrower's initial loan to value ratio (see column 3 of Table 9) or pre-modification mortgage affordability (TDTI, column 4). The impact of principal forgiveness does not appear increase or decrease monotonically with modification age, and there does not appear to be a significant time trend to the performance of successive cohorts.

Figure 9: Graphical Evidence of Kink, with Placebo Sample
 Effect of Pre-Modification LTV (Relative to Kink) on Default Hazard



The x-axis represents the distance from the kink in logs, or $\ln(\text{PF from LTV}) - \ln(\text{PF from DTI})$. The y-axis is normalized to zero at the kink (x-axis of zero). The y-axis values of the diamond-shaped red dots indicate, for the baseline sample, the coefficients on the distance from the kink (in logs), in 10 percentage-point bins, in a logistic quarterly hazard regression to predict default. The grey squares indicate those same coefficients for the placebo sample. The blue line illustrates the coefficients on continuous variables measuring positive and negative distances from the kink in logs.

Source: Authors' analysis.

Table 8: Quarterly Hazard in Sub-samples

Dep. Var. Sample	Dep Var: Program exit: 90-plus-day delinquency (quarterly)						
	Full	ARM	FRM	PLS	Portfolio	LTV \geq 180	LTV \leq 180
ln(predicted PF)	-0.851*** (0.129)	-0.945*** (0.210)	-0.771*** (0.167)	-0.796*** (0.165)	-0.728*** (0.218)	-0.500** (0.240)	-1.371*** (0.215)
ln (PF from LTV)	0.380*** (0.089)	0.504*** (0.145)	0.352*** (0.115)	0.518*** (0.108)	0.144 (0.161)	0.272 (0.198)	0.597** (0.273)
ln (PF from DTI)	-1.072*** (0.045)	-0.842*** (0.071)	-1.146*** (0.063)	-1.053*** (0.056)	-1.099*** (0.079)	-1.180*** (0.056)	-0.788*** (0.093)
LTV target equal to 115?	YES	YES	YES	YES	YES	YES	YES
Quarters since modification	YES	YES	YES	YES	YES	YES	YES
Observations	244,132	105,265	138,867	146,271	97,861	165,902	78,230
Loan count	45,513	18,867	26,646	29,412	16,101	31,053	14,460
R^2	0.0289	0.0225	0.0322	0.0336	0.0247	0.0262	0.0354

This table repeats the results from the first column of Table 4, with columns differing in the sub-sample used for the regression. Results are shown for adjustable rate mortgages only (ARMs, column 2), fixed rate mortgages only (FRMs, column 3), private-label securities (mortgages that have been securitized, column 4), portfolio loans (mortgages held on bank balance sheets, column 5), loans with a pre-modification LTV < 180 percent (column 6) and loans with a pre-modification LTV > 180 percent (column 7).
Source: Authors' analysis.

Table 9: Variation in Impact of Principal Forgiveness

Dep. Var.	Dep Var: Program exit: 90-plus-day delinquency (quarterly)					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(predicted PF)	-0.851*** (0.129)	-0.62** (0.264)	-0.228 (0.325)	-0.817*** (0.187)	-0.924*** (0.203)	-0.950*** (0.284)
ln(predicted PF) x ln(initial LTV)		-0.409 (0.405)				
ln(predicted PF) x ln(initial TDTI)			0.487 (0.349)			
ln(predicted PF) x quarters since mod quarter of mod				-0.010 (0.039)		0.006 (0.041)
				-0.095*** (0.013)	-0.096*** (0.014)	
ln(predicted PF) x quarter of mod				0.039 (0.045)	0.041 (0.047)	
Observations	244,132	244,132	244,132	244,132	244,132	244,132
Loan count	45,513	45,513	45,513	45,513	45,513	45,513
R ²	0.0289	0.0289	0.0385	0.0289	0.031	0.031

This table repeats the results from the first column of Table 4, allowing additional interaction effects.

Source: Authors' analysis.

4.6 Earned Forgiveness Interpretation

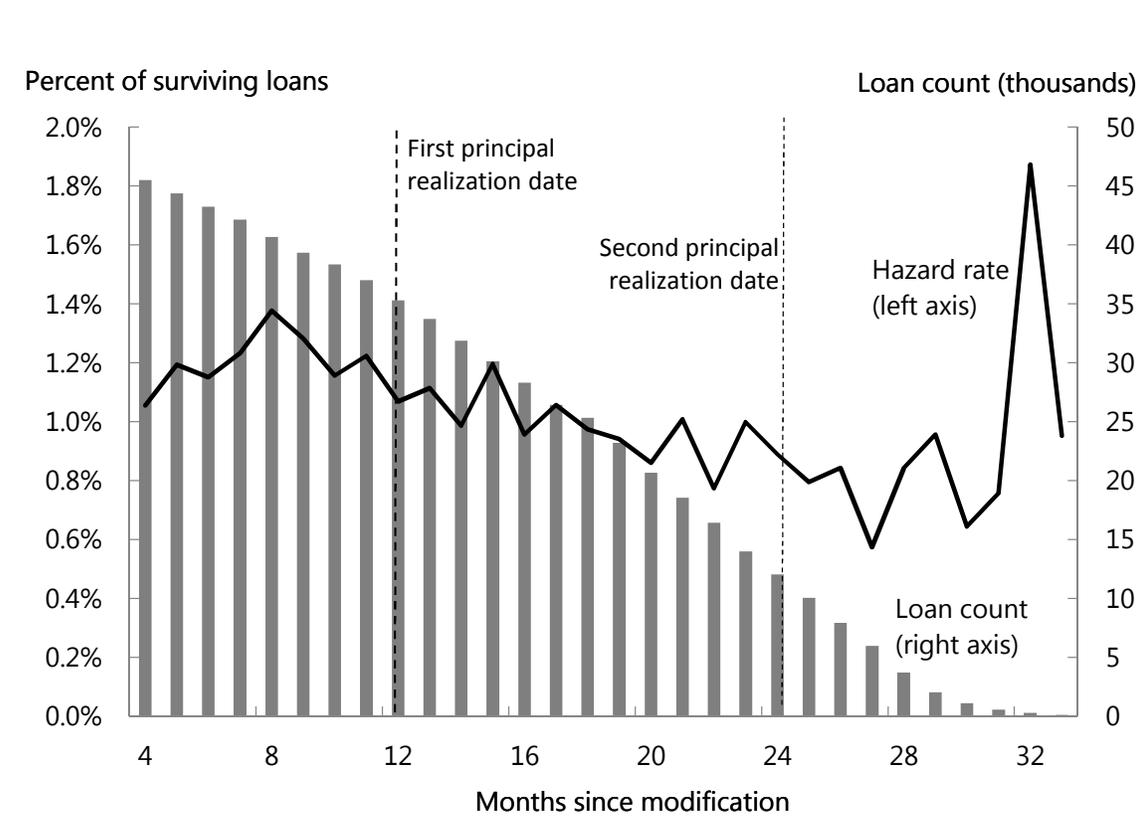
In HAMP PRA, principal forgiveness is nominally granted in three equal installments after staying in the program for 12 months, 24 months, and 36 months. For borrowers who do not default on their loans, this “earned forgiveness” is irrelevant because borrowers receive the full amount of the principal forgiveness if they prepay their loan at any time. For borrowers who default within 36 months of receiving a HAMP PRA modification, the unearned portion of the principal forgiveness is converted to forbearance and the lender may demand repayment of this amount as part of a future foreclosure, short-sale, or other legal proceeding.

One alternative to the hypothesis that lower mortgage balances (and the principal forgiveness that leads to them) reduce mortgage default *per se* is that borrowers who plan to default may want principal forgiveness in order to negotiate a better short sale or, in recourse states, relieve themselves of legal claims. In this case, borrowers may delay default until principal forgiveness is earned. It is the prospect of earning principal forgiveness in the future that reduces default. If this were the case, one might see elevated default rates immediately following the months in which principal forgiveness is earned, namely at 12 months, 24 months, and 36 months after the modification date. In fact, there is no evidence of this; default rates do not spike at these dates in our sample (see Figure 10). To probe this point further, we interacted dummies for the PF realization month with the borrower’s predicted forgiveness amount, and we observed no statistically significant change in default probability (results not shown).

5 Conclusion

Principal forgiveness has gained wide use in residential mortgage modifications only in the last few years, and many policymakers and academics have argued that it should have played a more central role in mitigating the broader economic effects of the recent

Figure 10: Monthly Default Hazard



:Source: Authors' analysis.

housing crisis. Principal forgiveness certainly carries many benefits for mortgage borrowers, because it transfers some of the decline in housing wealth to lenders and improves households' balance sheets. Our research suggests that for liquidity-constrained borrowers likely to enroll in mortgage modification programs, increasing the wealth of borrowers by reducing their mortgage balances also modestly reduces default probability.

The quarterly hazard (the proportion of loans that become more than 90 days delinquent and consequently exit the program) is 3.1 percent in our sample. We estimate it would have been 3.8 percent absent principal forgiveness, which averaged 28 percent of the initial mortgage balance. The first cohort of PRA modifications in our sample (originated in the first quarter of 2011) had a cumulative default rate of 39 percent. We

estimate that their default rate would have been 49 percent (95 percent CI: 45 percent to 52 percent) absent principal forgiveness. In the first cohort of loans, about \$877,000 was forgiven per avoided default during the 2.5 year sample period. For such a large write-down per avoided foreclosure to be cost effective, one would have to believe some combination of three things. First, the vast majority of forgiven principal would never have been repaid absent principal forgiveness.²⁵ Second, much of the default-reducing benefits of the program will come after the observed 2.5 year window.²⁶ Third, the costs of foreclosure are extremely large.

Our results require several caveats. First, they may lack external validity or generalizability. The estimates in this paper are for a sample of mostly-delinquent borrowers with mortgages deemed unaffordable based on DTI criteria who undertook the substantial task of applying for a mortgage modification program. Principal forgiveness may have a different impact among lower-risk borrowers who were not delinquent or whose initial mortgage payments were affordable; or, given documentation required for the HAMP program, successful applicants may have a substantially different baseline default rate than the general delinquent population. Second, estimates are local in the range of the data; all HAMP PRA modifications bring monthly payments to a level deemed affordable, but not lower. We cannot directly test the “dual-trigger” hypothesis (e.g., Foote et al. (2008)), which suggests that the impact of negative equity on default decreases with affordability. Third, our counterfactual estimates measure the impact of principal

²⁵The cost of providing principal forgiveness is lower when the lifetime default rate absent principal forgiveness is high. With only 10 quarters of post-modification data now available, that lifetime default rate is difficult to predict. The cumulative counterfactual default hazard among principal-recipients is nearly 50 percent after 10 quarters among borrowers whose HAMP PRA modifications became permanent in the first quarter of 2011, and the quarterly hazard has not dropped substantially over time. This suggests that the lifetime default rate might be quite high.

²⁶There is reason to believe that the default-reducing benefit to principal forgiveness may not remain constant over time. Following 5 years of participation in HAMP, borrowers who received rate reductions will begin to see their mortgage rates step up to the Freddie Mac Primary Mortgage Market Survey (PMMS) rate that prevailed at the time of modification. If a substantial share of borrowers remain underwater at that point, it is possible that principal forgiveness recipients will be better positioned to weather those payment shocks. On the other hand, we might expect the impact of principal forgiveness to decline as both recipients and non-recipients regain their equity positions.

forgiveness on default only for borrowers who participate in the program. They do not measure the impact of principal forgiveness in HAMP on borrowers' propensity to apply to the program – either because they would have proceeded to foreclosure absent the potential for principal forgiveness, or because they became delinquent to receive principal forgiveness. Fourth, HAMP PRA modifications are relatively new. As a result, redefault rates are available for, at most, 10 quarters from modification. These caveats make principal forgiveness an important topic for ongoing observation and analysis.

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