Failure to refinance★

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ABSTRACT

Households that fail to refinance their mortgage when interest rates decline lose out on substantial savings. Using a random sample of outstanding US mortgages in December 2010, we estimate that approximately 20% of unconstrained households for whom refinancing was optimal had not done so. The median household would save $160/month over the remaining life of the loan, for a total present-discounted value of forgone savings of $11,500, a particularly large consumer financial mistake. To shed light on possible mechanisms, we also provide results from a mail campaign targeted at a sample of homeowners who could benefit from refinancing.

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1 Introduction

Buying and financing a house is one of the most important financial decisions a household makes. Housing decisions can have substantial long-term consequences for household wealth accumulation in the US, where housing wealth makes up almost two-thirds of the median households total wealth (Iacoviello, 2011). Given the importance of housing wealth, public policies have been crafted to encourage home ownership and help households finance and refinance home mortgages. However, the effectiveness of these policies hinges on the ability of households to make wise housing decisions.

One housing decision in particular that can have large financial implications is the choice to refinance a home mortgage. Households that fail to refinance when interest rates decline can lose out on tens of thousands of dollars in savings. For example, a household with a 30-year fixed-rate mortgage (FRM) of $200,000 at an interest rate of 6.0% that refinances when rates fall to 4.5% (approximately the average rate decrease between 2008 and 2010 in the US) saves more than $60,000 in interest payments over the life of the loan, even after accounting for refinance transaction costs. Further, when mortgage rates reached all-time lows in late 2012, with rates of roughly 3.35% prevailing for three straight months (Federal Home Loan Mortgage Corporation Primary Mortgage Market Survey, Freddie Mac PMMS), this household with a contract rate of 6.5% would save roughly $130,000 over the life of the loan by refinancing.

Despite the large stakes, anecdotal evidence suggests that many households fail to refinance when they otherwise should. Failing to refinance is puzzling due to the large financial incentives involved. However, certain features of the refinance decision make failing to refinance consistent with recent work in behavioral economics. For example, calculating the financial benefit to refinancing is complex and households have very limited experience with transactions of this type. Furthermore, the benefits of refinancing are not immediate, but rather accrue over time. Finally, there are a number of up-front costs, both financial and nonfinancial, that households must pay to complete a refinance, including a reevaluation of their financial position and the value of their home. All of these features provide a psychological basis, in addition to the opportunity cost of time, for why some households could fail to take up large savings.

In this paper, we provide empirical evidence regarding how many households in the US appear to be suffering from a failure to refinance and approximate the magnitude of their mistakes. Our analysis utilizes a unique, nationally representative sample of approximately one million single-family residential mortgages that were active in December 2010. These data include information about the origination characteristics of each loan, the current balance, second liens, the payment history, and the interest rate being paid. Given these data, we can calculate how many households would save money over the life of the loan if they were to refinance their mortgages at the prevailing interest rate.

A household can very sensibly not refinance their house for many reasons, even when it apparently could save money by doing so. Perhaps the most obvious reason—and one that is especially important after the recent housing bust—is that it is unable to qualify for a new loan due to bad credit or because of decreasing housing values [leading to high loan-to-value (LTV) ratios]. Another reason is if a household plans to move in the near future. Further, some households might not have the cash-on-hand liquidity to pay the up-front refinancing fees. For these reasons, it would be naïve to argue that any household that appears as if it could save money by refinancing is acting suboptimally when it fails to

do so.

The data set that we use contains information that allows us to reasonably distinguish homeowners who could be unable to refinance from those that suboptimally fail to do so. For example, we can restrict the sample to homeowners who have not missed any previous loan payments and whose current combined loan-to-value (CLTV) ratio is below a certain threshold (including information on second liens). In addition, we can take into account reasonable assumptions about the probability of moving and the present-discounted, tax-adjusted benefits of refinancing relative to up-front costs.

Based on a conservative set of assumptions, we estimate that approximately 20% of households in December 2010 had not refinanced their mortgage when it appeared profitable to do so given the interest rate environment at the time. That is, the monthly savings in reduced debt servicing costs would cover the up-front costs of refinancing sufficiently fast [as determined by the closed-form threshold of Agarwal, Driscoll, and Laibson (2013)]. We calculate that the median household that is holding on to a mortgage with too high an interest rate would have saved approximately $160 per month, or $45,000 (unadjusted) over the remaining life of the loan, by refinancing or approximately $11,500 when adjusting for the probability of moving, tax incentives, up-front costs, and discounting over time. When calculating the $11,500 number, the implied counterfactual is that a household that fails to refinance will never refinance for the remainder of the loan (with the exception of some households that move, which our estimate takes into consideration). This counterfactual is more realistic in some scenarios than others. For example, if interest rates immediately rise from the time of our calculation and remain high for the remainder of the loan period, our counterfactual is probably fairly accurate. However, in the scenario that interest rates decline further or remain low, the households that fail to refinance in our study window could eventually do so. In this case, our counterfactual of households never refinancing in the future is not as useful as simply thinking about the monthly savings that accrue until the household finally decides to refinance.

In addition, our data allow us to see whether these loans continue to be active in December 2012 when interest rates reached historic lows. We find that approximately 40% of the households that we identify as those that could have benefited from refinancing in December 2010 had not moved from their homes and still had not refinanced their mortgage, despite interest rates dropping even further between 2010 and 2012.

To be clear, refinancing behavior requires a lender willing to take on the risk of a new mortgage. Over the period 2010—2012, lenders were especially reluctant to lend to borrowers whose credit, income, or home values deteriorated substantially following the financial crisis. Although we use updated CLTV measures at the time of refinancing and restrict the sample to households that never missed a housing payment, we do not observe updated credit scores or income for mortgage-holding households in our data. In Subsection 3.3, using auxiliary data, we show that a pristine mortgage repayment record is in fact a strong predictor of subsequent creditworthiness. We also provide a series of heterogeneity analyses to explore whether factors such as becoming unemployed can be a primary driver of the failure to refinance that we show.

As a complement to our results using a nationally representative sample, we analyze microdata from a nonprofit

lender in one major city. In an attempt to help households refinance, this nonprofit lender participated in several waves of mail offers to its clients that would allow them to refinance. By working directly with the lender, we were able to identify in the data which households were eligible (preapproved) to refinance. Consistent with the results from the nationally representative data, we find that a large fraction of the households that received an offer to refinance did not take up this offer despite large savings, no up-front out-of-pocket costs, and certain eligibility. We estimate factors that correlate with failure to take up and provide survey evidence from households that chose not to refinance to better understand the behavioral mechanisms at play.

Overall, these results suggest that the size and scope of the problem of failing to refinance is large. While much of the savings a household can receive by refinancing represents a transfer of wealth from investors to households (as opposed to a welfare loss), the foregone savings is clearly significant for each individual household. Failing to refinance can also have important macroeconomic implications for which policy options are available. We find that during the aftermath of the Great Recession, the Federal Reserve's efforts to reduce households' debt servicing costs by lowering interest rates were constrained by the extent to which homeowners failed to take advantage of their option to refinance. In Section 5, we discuss reasons that failing to refinance could be important from a total welfare perspective and policies such as automatically refinancing mortgages that can combat this failure.

Broadly, our paper contributes to a growing body of literature that shows important financial household mistakes, including mistakes associated with savings and investments (Madrian and Shea, 2001; Thaler and Bernartzi, 2004; Choi, Madrian, and Laibson, 2011), failure to smooth consumption (Stephens, 2003; Shapiro, 2005), failure to accurately respond to taxation (Chetty, Looney, and Kroft, 2009; Finkelstein, 2009), mistakes associated with the purchase of durable goods (Conlin, O'Donoghue, and Vogelsang, 2007; Busse, Pope, Pope, and Silva-Risso, 2015), and mistakes with credit cards and payday lending (Agarwal, Driscoll, Gabaix, and Laibson, 2008; Bertrand and Morse, 2011; Agarwal, Chomsisengphet, Liu, and Souleles, 2015). Lusardi and Mitchell (2014) survey the literature on financial literacy, and DellaVigna (2009) provides a thorough review of empirical research at the intersection of psychology and economics, which provides additional context for our results. Relative to the settings explored in this literature, the financial magnitude of failing to refinance is especially large.

Our work is also related to prior research in real estate and finance that has shown the existence of a subset of households that fail to refinance despite the benefits from refinancing being large. In concurrent work, Johnson, Meier, and Toubia (2015) use administrative data from a large financial institution to show that more than 50% of a large group of homeowners did not refinance through the financial institution's preapproved offer (or any other institution's offer) despite the potential for large savings. Using additional evidence, the authors argue that both time preferences and suspicion are leading factors for the failure to refinance in their sample. Agarwal, Ben-David, and Yao (2014) find that homebuyers exhibit the sunk cost fallacy when deciding whether to refinance, which can lead to suboptimal levels of refinancing. Other papers have provided at least some evidence that these optimal thresholds are not used by all individuals during earlier periods.[1] The most closely related papers are those by Green and LaCour-Little (1999),

[1]See, for instance, Green and Shoven (1986), Schwartz and Torous (1989), Stanton (1995), Bennett, Peach, and

Campbell (2006), Schwartz (2006), Chang and Yavas (2009), and Deng and Quigley (2013). Each of the these papers attempts to understand the failure to refinance phenomenon more generally and provides varying degrees of evidence on anomalous behavior on the part of homeowners with regard to optimal refinancing decisions during earlier time periods. A concurrent literature has raised behavioral explanations for refinancing patterns in Denmark (Andersen, Campbell, Meisner-Nielsen, and Ramadorai, 2015) and Italy (Bajo and Barbi, 2015). Key contributions of our paper relative to these include the representativeness, accuracy, and immediacy of our loan-level data to better estimate the current magnitude of the failure to refinance in the US and, importantly, our ability to restrict our focus to households whose payment histories and loan-to-value ratios (across all liens) are such that we can reasonably assume their ability to refinance.

Our paper is also informed by a large policy literature that emerged during the recent housing crisis when researchers attempted to gauge the number of homebuyers who could be able to refinance [see, for example, Hubbard and Mayer (2009) and related op-ed articles and congressional testimony (e.g., Mayer, 2012)]. This policy discussion includes attempts to both understand how many people could refinance but were failing to do so and how various government programs can increase the eligibility of some homeowners to refinance who would otherwise be unable to do so. Furthermore, we provide evidence demonstrating that a lack of financial savvy can be costly to homeowners (see Bucks and Pence, 2008). For example, Woodward and Hall (2012) argue that borrowers on average lose out on $1,000 for failing to effectively shop for mortgage brokers and that the loss is heterogeneous across consumer types.

Our work builds on two recent papers that explore households' refinancing choices. Agarwal, Rosen, and Yao (2012) empirically investigate the time-varying option value of refinancing and find that over half of borrowers who refinance do so at a suboptimal time, though more experienced refinancers make smaller mistakes. Agarwal, Driscoll, and Laibson (2013) provide the first optimal closed-form solution to the households refinancing problem under a plausible set of parameters. In our paper, we use this closed-form solution to calculate the fraction of households that suboptimally fail to refinance in our data. Whereas Agarwal, Rosen, and Yao (2012) examine the optimal timing for those who choose to refinance, we focus solely on the failure to refinance.

Finally, our paper is related to the literature that provides evidence of less than 100% take-up of social services [for a review, see Currie (2004)]. These papers, such as recent work on earned income tax credit (EITC) take-up by Bhargava and Manoli (2015), provide evidence that individual biases (inattention, status quo bias, self-control issues, etc.) can play an important role in the failure to take-up, along with lack of information, complexity, and potential stigma. Because a stigma generally is not associated with refinancing a mortgage, our results complement the evidence in this literature on the importance of individual biases and lack of simple information as factors that can lead to surprisingly low take-up rates.

The paper proceeds as follows. In Section 2 we provide background on the mortgage market and refinancing in the United States. In Section 3 we describe the unique loan-level data set we use and show the size and magnitude of the failure to refinance in the US during the recent decline in interest rates. In Section 4 we analyze the efforts of a nonprofit to help its clients refinance. Finally, we provide a discussion of policy implications and conclude in Section 5.

Peristiani (2001), and Hurst and Stafford (2004).

2 Background on mortgage markets and refinancing

Two primary mortgage loan instruments are used in the US: an adjustable-rate mortgage (ARM) and a fixed-rate mortgage. A standard ARM has a floating nominal interest rate that is indexed to the general level of short-term interest rates. A standard FRM has a fixed interest rate over the life of the mortgage loan and thus eliminates any uncertainty about the required stream of payments, even if interest rates increase substantially. If, however, interest rates move significantly downward, a household in the US with an FRM can benefit by refinancing, that is, paying off the old mortgage (known as a prepayment) and taking out a new fixed-rate loan at the lower prevailing rate.

According to Campbell (2013), approximately 90% of the mortgages in the US are 30-year nominal FRMs, with the remainder of mortgages either ARMs or shorter-duration FRMs. This dominance of 30-year FRMs in the US is different from most other countries in the world and is likely an artifact of a relatively stable inflation history and a variety of public policies that promote this mortgage design (Green and Wachter, 2005). More important in the context of our paper, because most borrowers have FRMs, homeowners suffer serious consequences if they fail to take advantage of refinancing options when interest rates decline.

The decision to refinance is typically complicated and involves a large number of factors, such as the up-front costs associated with refinancing, the probability of moving within a short period of time, a discount factor on future savings, expectations about future interest rate changes, current mortgage balance, risk preferences, and current and future marginal tax rates. Households should optimally refinance when the expected benefits from lower monthly debt servicing costs outweigh the up-front costs of refinancing and the cost of forgoing the option value to refinance in the near future.

Agarwal, Driscoll, and Laibson (2013) derive a closed-form optimal refinancing rule based on the difference between a households contract rate and the current mortgage interest rate. Their solution requires the consideration of a large number of parameter values (a marginal tax rate, discount factor, probability of moving, etc.), as well as other more general assumptions (e.g. that the nominal mortgage interest rate follows a continuous-time random walk). For a reasonable set of parameter values, they find that interest rates must fall by 100 to 200 basis points to make refinancing optimal. The optimal rate is particularly sensitive to up-front points and closing costs for the mortgage, as these costs are immediate and not discounted like the longer-term benefits of refinancing. When these costs fall, the refinancing threshold rate rises sharply, with $1,000 in up-front costs associated with roughly 25 basis points movement in the threshold. We apply this closed-form optimal solution, using a conservative set of parameter values, to a sample of recent mortgage loans active during a period of historically low interest rates.

3 Size and magnitude of the failure to refinance

In this section, we describe our data set, estimate the extent of failing to refinance, and explore robustness and heterogeneity across a number of dimensions.

3.1 Description of loan-level data set

Our analysis is based on approximately one million observations of a nationally representative sample of mortgage loans that were active in December 2010. The data come from CoreLogic Solutions (henceforth "CoreLogic") and are provided through a CoreLogic Academic Research Council (CLARC) data grant.[2] Mortgage-level data are provided by most of the top 20 mortgage servicers in the nation, and the sample is drawn from mortgage records covering both the agency and the non-agency segments of the mortgage market. In total, the CoreLogic database covers roughly 85% of the mortgage market.

To make our calculations of the financial benefit of refinancing as consistent across mortgageholders as possible, the sample provided to us was randomly drawn from the overall sample of fixed-rate mortgages of single-family, owner-occupied homes that are not overseen by the Federal Housing Administration and US Department of Veterans Affairs (FHA/VA) programs, are not manufactured or mobile homes, and are not in foreclosure proceedings as of December 2010. The sample was also restricted to loans with an outstanding balance of at least $75,000 as of December 2010.

The data contain information about each mortgage including date of origination, credit score of borrower at origination, loan-to-value ratio at origination, unpaid balance (in December 2010), interest rate, time remaining on the loan, the zip code of the house location, and a full payment history (late payments, missed payments, etc.). In addition to these variables, we have access to any other mortgage liens for which the household is responsible. We also merge 2010 Census information that includes zipcode-level variables such as median average income and education levels. Local unemployment rates at the county level are from Bureau of Labor Statistics.

We also merge zipcode-level housing price data from Zillow. Using the loan-to-value ratio for each mortgage at origination and the date of origination, we are able to compute the loan-to-value ratio for each mortgage (including all mortgage liens) at subsequent dates. Due to incomplete Zillow coverage, we are unable to compute December 2010 loan-to-value ratios for approximately 15% of the sample. Also, we have Zillow housing price data starting in 1997. For homes that had an origination date prior to when our Zillow data begin in 1997 (0.4% of our total sample), the loan-to-value ratios that we compute do not take into consideration any price movements that occurred prior to 1997. Because house prices were generally increasing through the 1990s, this is likely to result in loan-to-value ratios that are biased upward for these households. For robustness, we also apply the CoreLogic proprietary valuation model to calculate updated LTV and CLTV values, and the results are similar (and available upon request).

The CoreLogic data are unique for the amount of detail that is available for each mortgage. Although these data are likely the best available large-scale data source on refinancing, a number of limitations remain. First, we do not observe refinancing directly in the CoreLogic data, only the prepayment of a mortgage, which could be due to either refinancing or moving to a new home. Second, although we observe measures of borrower creditworthiness at the time the loan was originated, this information is not updated in the panel data. We do, however, have the full payment history for each

[2]More information on accessing the data can be found on the CLARC website at `http://www.corelogic.com/about-us/researchtrends/academic-research-council.aspx`.

loan. Third, we do not have any direct information regarding how long homeowners intend to remain in their home. Finally, we have no indication of the presence, duration, or size of prepayment penalties. These are unlikely to be an issue in 2010, as nearly all fixed-rate agency loans [Federal National Mortgage Assocation (Fannie Mae), Freddie Mac, and the FHA] do not carry prepayment penalties, while non-agency prepayment penalty periods (traditionally two or three years) had likely expired by this time.

[Insert Table 1 near here]

Table 1 provides summary statistics for our sample. The first column in Table 1 indicates that a typical active loan in December of 2010 was paying an interest rate of 5.52%, had 23 years remaining, and had an unpaid balance of just over $200,000. The average loan-to-value ratio at origination was approximately 70% and in 2010 was 74%. The small increase in LTV is due to the fact that many loans were originated early in the housing boom and experienced only a small relative decline in value on net in the boom and bust. The additional columns in Table 1 provide the same summary statistics when we restrict our sample to loans with certain characteristics.

[Insert Fig. 1 near here]

Of particular importance for our research is the distribution of interest rates being paid across homeowners. Panel A of Fig. 1 illustrates the distribution of interest rates for our full sample. While the average interest rate being paid is 5.52%, substantial variation exists, with many households paying interest rates near the market rate in December 2010 (4.3%) and other households paying interest rates well over 6%. Panel B in Fig. 1 shows the distribution of interest rates being paid by households when we restrict the sample to households that appear as if they should be eligible to refinance. As expected, the distribution of interest rates for this latter sample is narrower, but substantial heterogeneity in mortgage rates remains, with many homeowners continuing to make mortgage payments on rates well above the market rate of 4.3%, indicated by the solid black line.

3.2 Estimating the scope of the failure to refinance

Using our loan-level data set, Table 2 provides the main results regarding the failure to refinance. The first row results are based on the full sample and, thus, the naïve assumption that all households could refinance in December 2010 at the prevailing rate of 4.3% if they chose to do so. For this full sample of mortgages, we first estimate the share of households that would experience positive savings if they were to refinance in December of 2010. The savings from refinancing are calculated by taking the difference between the total interest payments on the remaining term of the mortgage at the contract rate and the total interest payments on the remaining term at a counterfactual refinanced interest rate. Using data from Freddie Mac PMMS series, the average interest rate for a 30-year, fixed-rate mortgage in November 2010 (immediately prior to our sample window) was 4.3%, so we use 4.3% as the baseline prevailing interest rate. Rates moved significantly lower after this period. These savings are then reduced by the up-front costs that are

typically associated with refinancing a home (1% in points and $2,000, see Agarwal, Driscoll, and Laibson, 2013). Using this measure of savings, we estimate that 91.4% of households in our full sample could save money over the life of the loan by refinancing.

[Insert Table 2 near here]

This simple measure of savings, however, does not include several obviously important factors. For example, it does not take into consideration the tax incentives associated with paying mortgage interest rates, the probability of moving, and the discounting of money over time. Thus, the 91.4% estimate is likely to dramatically overstate the percentage of households that would benefit from refinancing.

To obtain a more accurate measure of how many people should refinance (still assuming that everyone is eligible to do so), we apply the optimal refinancing formula found in Agarwal, Driscoll, and Laibson (2013) to our nationally representative mortgage data. We also use the parameter values that they suggest in their baseline illustrative calibration. These parameter values include a discount rate of 5% per year, a 28% marginal tax rate, and a probability of moving each year of 10% (as well as an assumption that the real mortgage rate and inflation jointly follow Brownian motion). We consider these parameter values to be conservative, in that they suggest that people should refinance only when it is unambiguously in their best interest to do so. With these parameter values, we use Agarwal, Driscoll, and Laibson's "square-root rule" and compute the change in interest rates required for a household to optimally decide to refinance their house. The square root rule is straightforward to calculate on any calculator and is a second-order Taylor series approximation to the authors' closed-form exact solution, which requires the use of Lambert's W-function. For details, see Agarwal, Driscoll, and Laibson (2013), page 601. Based on this calculation, we report in the third column of Table 2 that 41.2% of households in our full sample were in a position to optimally refinance.

Table 2 also gives a sense of the magnitude of the foregone savings. Conditional on refinancing being optimal for a household, we estimate that the median household would benefit from refinancing by $184 per month, or approximately $54,313 of unadjusted savings over the life of the loan. Using the same parameter values above (discount rate of 5% per year, 28% marginal tax rate, and a 10% probability of moving each year), we calculate the median present-discounted value of refinancing once all considerations have been made to be approximately $13,000. The savings amount is based on the difference between the present-discounted total payments made by households after December 2010 if they continue to pay at their current interest rate and the present-discounted total payments made by households after December 2010 if they refinanced and maintained a new mortgage interest rate equal to the going rate in December 2010.

The main factor that the calculation in the first row of Table 2 neglects is that many households in December 2010 could have wanted to refinance but were unable to do so because of credit problems or because their loan-to-value ratio was too high. The subsequent rows in Table 2 impose increasingly restrictive requirements on mortgages in our sample in an attempt to limit the sample to households that likely would have been eligible in December 2010 to refinance their house had they chosen to do so. While these sample restrictions are not perfect, they allow for a better estimate of how many households are failing to refinance due to nonoptimal decision making as opposed to institutional features that

cause them to be ineligible. Our sample restrictions could be imperfect in several different ways. For example, having good initial FICO scores and never missing a payment does not mean with certainty that the household has a high enough credit score to qualify for a refinance. Thus, this restriction might not be restrictive enough. At the same time, it could be too restrictive. A household that had good initial FICO scores and simply was late on one house payment could have a credit score that is high enough to refinance even though we categorize it as ineligible.

The second row in Table 2 restricts the sample to households with good credit scores at the time of origination (FICO $>$ 680) and with an initial loan-to-value ratio of less than 90%. These restrictions are intended to capture the stringent underwriting standards that prevailed in the aftermath of the housing crisis relative to the housing boom period. Sensitivity of our results to different sample restrictions is available upon request. Imposing this sample restriction slightly reduces the percentage of households that we estimate would see positive savings over the life of the loan from 91.4% to 89.0%, and the percentage of people who should optimally refinance according to the Agarwal, Driscoll, and Laibson (2013) formula declines from 41.2% to 31.1%. The reduction in the percentage of people who should optimally refinance that we observe when we restrict the sample to more creditworthy households with lower loan-to-value ratios could be a result of selecting households that were more likely to be eligible to refinance (and thus more of them do so) or a result of selecting on the types of households that are savvier and more likely to refinance when rates go down. We are unable to distinguish between these two explanations for the percentage decline that we observe and assume it is likely to be a combination of both factors.

While having good credit and a low loan-to-value ratio at origination helps us to restrict the sample to households that are more likely to be eligible to refinance in December 2010, many households could have had good initial credit but then saw their credit score drop below usual mortgage underwriting standards during the recession. To help eliminate households with a credit rating that declined after securing their initial loan, we further restrict the sample to households that have not missed a mortgage payment or even had one late payment (one of the clear signs of credit trouble). This sample restriction has only a small effect on the percentage of people who should have optimally refinanced (now down to 27.5%).

Along with the possibility that households saw their credit scores decline after securing a loan, a household's loan-to-value ratio could have increased due to declining home prices between origination and December 2010. We therefore limit the sample to households whose current LTV is less than 90% based on our zipcode-adjusted LTV ratios described in the Subsection 3.1. This restriction reduces the sample by approximately 25% and is driven by the elimination of mortgages for homes that experienced a large amount of depreciation during the Great Recession. The percentage of people who should optimally refinance in this more restricted sample is 23.4%.

One reason that some households are unable to refinance is the existence of second liens that were taken out on the home. Our final sample restriction focuses on households with a current LTV ratio on their cumulative loans (CLTV) for the house of less than 90%. In total, the sample restrictions that we impose in an attempt to focus on homeowners who are likely eligible for a refinance reduces our sample from roughly 995,000 to 376,000 households. These creditworthy households are also least likely to face loan-level risk-based pricing adjustments and, thus, the prevailing PMMS rate

could be most reflective of their likely price of mortgage credit. After imposing these restrictions, our final estimate is that approximately 20% of households in December of 2010 had not refinanced their mortgage when it appears to have been both optimal and feasible to do so. We explore the sensitivity of this estimate in detail in Subsection 3.3.

The average unadjusted savings available to the median household in this 20% of households was $160 per month, or $45,473 over the remaining life of the loan. When adjusting this using the parameter values discussed above, we find that the median present-discounted value of forgone savings was equal to approximately $11,500. However, this estimate masks a large degree of heterogeneity in the amount of potential savings. Fig. 2 provides a simple histogram of the unadjusted savings for the 20% of households that we argue were failing to refinance, revealing that 25% of households would save more than $68,000 in unadjusted reduced mortgage interest payments over the life of the loan and 11% of households would save more than $100,000.

[Insert Fig. 2 near here]

If interest rates had increased sharply starting in December 2010, our estimates suggest that approximately 20% of households would have lost their chance to refinance even though it would have been optimal for them to do so. Interest rates, however, continued to decline through the end of 2012 and reached record lows of 3.35% for 30-year fixed-rate mortgages. This continued interest rate drop provided an opportunity for the 20% of households we estimate as failing to refinance in December 2010 to finally decide to refinance and to realize greater savings because of even lower rates.

We obtained from CoreLogic an update for all loans in our December 2010 sample. We know what fraction of these loans prepaid at some point between December 2010 and December 2012. Given the even greater savings (due to historically low rates) and additional time, many of the 20% of households that had failed to refinance by December 2010 prepaid their mortgage in the subsequent two-year period. Again, our measure is a mortgage prepayment, so we cannot distinguish between refinances and moves. However, 40% of the households that we estimate should have refinanced in December 2010 were still living in their house by December 2012, continued to make full and on-time monthly payments, and yet had not refinanced their mortgage despite the further decline in interest rates.

3.3 Robustness analysis

An important assumption that we make in this study is that households that would qualify for refinancing can reasonably be identified. This is a difficult task given that we are studying a period of financial contraction and tightening underwriting standards among lenders. By focusing on households with certain FICO scores at origination, certain CLTV ratios, and households that never missed a payment, we are able to reasonably restrict the sample to people who would likely qualify for a refinance. However, even with these restrictions, one could worry that a subset of our homeowners experienced a decrease in their credit score between origination and December 2010.

Unfortunately, we are unable to obtain post-origination credit scores for our sample of homeowners. However, for

robustness, we can explore how credit scores evolved over this time period using a separate credit score data set.[3] In conjunction with researchers with restricted access to the Equifax Credit Risk Insight Servicing McDash (CRISM) [Equifax merged with Loan Performance Services (LPS)/McDash] data set, we analyzed credit score movements among a population that closely approximates the individuals in our sample who we believe are failing to refinance.

We restrict the sample of individuals in this new credit score data to those who originated a mortgage sometime between January 2005 and December 2007 and who had not refinanced their origination as of December 2010. The starting origination dates were chosen to mirror the median individual in our CoreLogic data set who was failing to refinance. We also restrict the sample using the same rules that we use in the CoreLogic analysis. The sample was restricted to owner-occupied single-family non-FHA/VA fixed-rate mortgages originated with a FICO score greater than 680, had an origination LTV ratio less than 90%, and had not missed a payment between origination and December 2010.

This credit data sample is thus the closest approximation to the sample of homeowners in our analysis who we claim are failing to refinance despite being able to do so. We then look at the credit scores in December 2010 for this sample. Our assumption has been that all of these individuals are eligible to refinance (whereas all of their credit scores could have deteriorated below mortgage eligibility thresholds, which is the reason they are failing to refinance). Using the credit score data, we find that 90.7% of the individuals in the sample continue to have FICO scores above 680 in December 2010. This result provides support for our assumption that the individuals in the most restricted sample of our data are eligible to refinance, yet fail to do so. However, it also suggests that a few individuals (9.3%) that we classify as failing to refinance could be unable to do so, due to credit score deterioration. Thus, our estimate of 20% of individuals failing to refinance could be biased upward and a more conservative number would be 18.1%.

Notably, this analysis suggests that mortgage payment history is a high-quality proxy for subsequent creditworthiness in the absence of current credit score data. Repeating the same analysis for the subsample of borrowers who missed at least one payment, more than half of the sample have scores less than 680 as of December 2010. In a simple regression framework, we find that conditional on FICO score at origination, an indicator for a missed mortgage payment at some point in the payment history lowers average December 2010 FICO scores by 83 points. Furthermore, this payment variable has substantial explanatory power, effectively doubling the r-squared with its inclusion. In sum, we find that mortgage borrowers who consistently made payments had credit scores that generally remained creditworthy through the Great Recession.

In Appendix Table A1, we explore how sensitive our results are to the parameters of the optimal refinancing threshold calculation. In the first set of columns, we compare our baseline result to naïve refinancing thresholds of 100, 150, or 200 basis points. Our baseline based on the Agarwal, Driscoll, and Laibson optimal formula is most comparable to a naïve 150 basis point threshold, which suggests that 16% of households should have refinanced at the market rate of 4.3%, and that these households would have saved $140 per month.

[3]See Amromin, Keys, and Murto (2016). We thank Gene Amromin and Michael Murto for their generous assistance and contributions to this analysis.

In the next sets of columns, we reestimate the optimal refinancing formula using different parameters for impatience, the likelihood of moving, and up-front costs. While our results are not especially sensitive to the patience and moving parameters, Table A1 shows that the calculation of optimal refinancing is highly dependent on the magnitude of up-front costs. In the absence of up-front costs, fully 94.6% of households should have refinanced by December 2010. Raising the up-front costs dramatically reduces the share that would benefit from refinancing, as the up-front cost is immediate and not discounted (in contrast to the benefits of refinancing, which arrive throughout the life of the loan). For this reason, we have been careful to choose our baseline up-front cost to be $2,000 plus 1%, which is consistent with that of Agarwal, Driscoll, and Laibson, as well as recent survey results of average refinancing costs.[4]

3.4 Homeowner heterogeneity

Another way to better understand the failure to refinance is to explore differences in the failure rate within our already-restricted sample of homeowners. Although we do not have microdata on households employment status either at origination or at later dates, we can explore this dimension by stratifying our results based on county-level unemployment rates. The first set of results in Table 3 uses the 376,036 loans from our most restricted sample (homeowners with FICO > 680, current CLTV < 90, and never missed a payment) and breaks down the failure to refinance of these individuals into quartiles based on county-level unemployment rates in 2010. Comparing the top and bottom quartiles of counties in the unemployment distribution, we find similar proportions of households that failed to refinance. Among homeowners living in the quartile of counties with the lowest unemployment rates in 2010 (less than 7.7%), 19% should have optimally refinanced but did not do so. Similarly, for homeowners in the top unemployment rate quartile (greater than 10.9% in 2010), 20.2% should have optimally refinanced but did not do so. The lack of a steep gradient in unemployment rates is suggestive evidence that, among creditworthy households, there is consistent and widespread failure to refinance when it is optimal to do so.

[Insert Table 3 near here]

The next two sets of results in Table 3 decompose the failure to refinance by quartiles of FICO score at origination and current CLTV. Even among households in the highest FICO credit score quartile (FICO > 793) and in the lowest CLTV quartile (current CLTV $< 54\%$), we find nontrivial rates of failing to refinance (12.3% and 17.5%, respectively). The percentage of households that are failing to refinance, however, is different across quartiles with the lower FICO score and higher CLTV households showing much higher rates of non-refinancing than their counterparts. The gradient in failure to refinance across these quartiles could be a result of selecting on households that were more likely to be eligible to refinance (and thus more of them do so), selecting on the types of households that are financially savvier, or selecting on individuals who are more patient in their time preferences (they have not let their credit scores drop or taken

[4]See, for instance, the 2012 bankrate.com survey of refinancing costs: `http://www.bankrate.com/finance/mortgages/when-to-refinance-your-mortgage-1.aspx`.

out second liens) and are therefore more likely to put in the effort to refinance when rates go down to take advantage of long-term benefits.

The fourth set of results in Table 3 stratifies the failure to refinance by quartiles of the loan amount (remaining unpaid principal balance) for each household. Given the fixed cost involved with refinancing, households with a much higher loan amount stand to gain significantly more from refinancing than households with a smaller loan amount. Surprisingly, we find very little difference in the failure to refinance (21.2% versus 19.1%) for households in the bottom quartile of loan amount (loan amount < \$140,000) and households in the top quartile of loan amount (loan amount > \$288,000).

The final two sets of results in Table 3 stratify the failure to refinance by income and education status of homeowners. The CoreLogic data do not provide information about income or education for individual loans. We therefore use zipcode-level Census data for both median income and percentage of individuals with a bachelor's degree to stratify the sample. We find small, but limited, evidence of differences that exist in the failure to refinance across these zipcode-level quartiles (possibly due to the large geographic units used to measure education and income levels). For example, 19.0% of households residing in zip codes with above median education are suboptimally not refinancing, and 20.9% of households with below median education are suboptimally not refinancing.

3.5 Spatial heterogeneity

In addition to heterogeneity across different types of homeowners, the failure to refinance can be heterogeneous across geographic areas. One could expect variation in our effects across space for several reasons. First, originators could play a large role in whether people choose to refinance. Some mortgage lenders could have been more active in reaching out to homeowners to encourage same-lender refinancing. These originator effects could produce geographic clustering of refinancing behavior. Second, geographic differences in the failure to refinance could be driven by information or peer effects [see for example, Chetty, Friedman, and Saez (2013) for evidence of peer effects on the take-up of the EITC]. Lastly, the concentration of lenders could impact the ability of individuals to refinance. For example, Scharfstein and Sunderam (2014) provide evidence that high concentration in mortgage lending reduces refinancing efforts by homeowners when mortgage rates decline.

Our data lack critical information that would allow us to determine the exact mechanism for spatial heterogeneity [e.g., we do not observe the originating lender in our data; we also cannot track individuals as they move from one location to another to test for peer effects as in Chetty, Friedman, and Saez (2013)]. However, we can show the extent of geographic variation in our data as a way to gain a richer understanding of how failing to refinance occurs and to provide suggestive evidence of mechanisms.

We calculate the failure to refinance using our most restricted sample (homeowners with FICO > 680, current CLTV < 90, and never missed a payment) separately for each state in the US The failure-to-refinance rates vary from around 8% or 9% in Mississippi, Wisconsin, and Minnesota to around 30% in Florida, Oklahoma, and New York. An F-test easily rejects the null that the failure-to-refinance rates are the same across geographic areas, with $F(47, 374408 = 106.3)$.

However, as can be seen in Fig. 3, there does not appear to be any obvious regional clustering of failing to refinance. In results not shown, we find no relation between state-level failure-to-refinance rates and state laws on the treatment of second liens in the refinancing process (see Bond, Elul, Garyn-Tal, and Musto, 2015). Thus, mechanisms such as peer effects or originator effects could be driving differences that we see, but they are likely doing so at the state level or even more locally.

[Insert Fig. 3 near here]

Lender concentration could also contribute to the geographical differences that we find. We once again calculate the failure to refinance using our most restricted sample by Metropolitan Statistical Area (MSA). We then correlate this measure of failing to refinance with a measure of lender concentration that is available at the MSA level.[5] We use the market share of the top four lenders in each MSA as a measure of concentration and weight the correlation by the number originations in each MSA. The scatter plot of this correlation can be seen in Fig. 4. We find that, if anything, the relation between market concentration and failing to refinance is in the opposite direction as one might hypothesize (more market concentration is associated with lower rates of failure to refinance, $t = -2.47$). Explanations for why we fail to find a positive correlation could be that lender market concentration is endogenously determined and we are not obtaining a causal effect or that any impact of lender concentration on refinancing rates is swamped by other orthogonal differences (e.g., differences in homeowner characteristics) that can impact refinancing behavior.

[Insert Fig. 4 near here]

4 Micro-level evidence

By using a large, random sample of households in Section 3, we were able to provide broad representative evidence regarding the failure to refinance in the US. While these data were ideal for producing an estimate of the scope of the problem, a more micro-level data set could provide even cleaner evidence of individual financial mistakes with regard to refinancing and on the behavioral mechanisms at play.

To this end, we partnered with a nonprofit organization called Neighborhood Housing Services of Chicago, Inc. (NHS). Founded in 1975, NHS's stated mission is to create opportunities for individuals to live in affordable homes. Its efforts are primarily concentrated in lower-income communities in Chicago to provide services including, among others, education programs for new homeowners, foreclosure prevention services, reclaiming vacant properties, and preserving and rehabilitating older homes. In addition to these various services, NHS's nonprofit lending affiliate, Neighborhood Lending Services (NLS) acts as a mortgage lender and servicer to homeowners in the Chicago area. Because they are nonprofit organizations interested in helping homeowners, including those that they lend to, NHS and NLS educate their

[5] We thank Amit Seru for providing us with these data.

clients on the pros and cons of refinancing and emphasize the importance of considering long-term savings, short-term costs, and other factors. In some cases, NLS actively encourages its clients to refinance their mortgages when interest rates decrease to an advantageous level.

In July 2011, NHS sent a letter to 446 households whose mortgages NLS services. The letter (see Appendix Fig. A1) provided the details of an offer to refinance their current mortgage loan at a 4.7% interest rate. Notably, no money up-front was required to refinance, as the appraisal fee and a loan origination fee of 1% of the loan amount could be rolled into the new loan. Thus, liquidity constraints do not serve as an explanation for incomplete take-up in this setting. The letter as sent only to households that NHS had already determined were eligible to refinance their mortgages (screening included thresholds for current loan-to-value ratios and required that the homeowners be current on their payments) and that would benefit from doing so (based on unadjusted savings calculated using the unpaid balance and interest rate at origination). The letter encouraged homeowners to call an NLS loan officer.

The data associated with this letter campaign that took place in the summer of 2011 are ideal for the purposes of our paper. The letter campaign isolated homeowners who were eligible and would benefit financially (according to NHS) from refinancing, and it allows us to measure exactly how many of them chose to take up the offer. Furthermore, these homeowners had a preexisting relationship with NHS and NLS and had attended homeownership counseling in one of their local offices, so this refinance offer was from a trusted source in the community. In addition, because NLS is the servicer of these loans, we are able to calculate exactly how much savings each household would have received if it refinanced at a 4.7% interest rate.

The summary statistics from the letter campaign (Wave 1) are presented in Table 4. Over 84% (375 of the 446) of the households that received the refinance offer did not respond to the preapproved, no up-front cost, offer to refinance their mortgage. This is consistent with our findings in Section 3 that a large portion of the population chooses not to refinance even when they are eligible to do so and substantial savings are available. The NHS sample is not intended to serve as a nationally representative sample, as NHS typically lends in disproportionately low-income and minority communities. However, to generalize slightly, we interpret this finding as suggesting that sending a preapproved offer letter to the 20% of households we found in Section 3 that could and should refinance would likely result in a relatively low take-up rate.

[Insert Table 4 near here]

Using the same strategy discussed in Section 3, we calculate the forgone unadjusted savings over the life of the loan for each homeowner who received a letter in Wave 1 from NLS. We estimate that the 16% of homeowners that took up NLS's first refinance offer would go on to pay $85 less per month, or $24,500 less in total interest payments over the life of the loan by lowering their rate. The savings available to NHS borrowers is smaller relative to the estimated savings for the national average household because the rate reductions were not as dramatic and mortgage balances were smaller relative to the mortgage holders in the CoreLogic data. The median household of the 84% that did not respond to the offer to refinance saw forgone savings of $17,700 over the life of the loan by failing to respond to the refinance offer.

Thus, those households that took up the offer had a slightly larger financial benefit to do so, but the difference is not statistically significant.

Because rates continued to decrease, NLS decided to send a similar letter in July 2012 with an offer to refinance its clients' mortgages at a 3.99% interest rate (Wave 2). This letter was sent to 140 households (nearly all of whom had been nonresponders in Wave 1) that continued to have loan-to-value ratios that NLS deemed low enough and had loans that were current. The large reduction in the number of households receiving a letter in Wave 2 relative to Wave 1 was a direct result of declining home values (and therefore increasing LTV ratios) over this time period in the relevant neighborhoods of the Chicago area. The results from this second wave of refinance offers also are presented in Table 4. Still, over 75% of households did not respond, resulting in a take-up rate of 24.3%. The median household that took up the refinance offer had a large savings opportunity of $100 per month reduction in mortgage outlays ($29,900 unadjusted savings over the life of the loan), but once again households that chose not to respond to the offer letter also saw a large (and not statistically distinguishable) forgone unadjusted savings opportunity ($24,700).

In May 2013, NLS once again decided to conduct a mail campaign to encourage its clients to refinance their mortgages (Wave 3). A total of 193 households were deemed eligible and preapproved by NLS to refinance. Each of these households again received an offer to refinance its house at a 4% interest rate. During this third mail campaign, we worked with NLS to divide letter recipients into three treatment groups. Each group received a different letter with a different treatment. For example, one letter provided more direct information about the amount of savings that homeowners could receive both over the life of the loan and on a month-to-month basis if they were to refinance. The results from this third wave of refinance offers are presented in Table 4. Only 13.0% of households took up the offer to refinance. As in the previous two waves, higher potential savings significantly predicts a higher take-up of the refinance offer. However, once again, those that did not take up the offer passed on substantial reductions in debt service costs (in this case, an savings opportunity of $94 per month, or $26,400 on average over the life of the loan). We find no differences in take-up across the treatment groups, but, due to the very small sample sizes (fewer than ten households refinanced in each group), we are unable to reject economically meaningful differences across the randomized groups.

In an attempt to shed light on why households chose not to refinance, we (in conjunction with NHS and NLS) designed and conducted a short survey after the expiration of the third mail offer. Eligible households that did not refinance were contacted by phone and asked to answer a few simple questions about the refinance process. Of the non-refinancing households, 32 were reached by phone and were willing to answer the survey questions. The survey results suggest that up to one-quarter of the households did not open the letter that they received from NLS. Of those that did open the letter, just over one-third indicated that they planned to call the loan officer but did not get around to it or were simply too busy to make the phone call. Another one-third indicated that they did not call the loan officer because they did not think the savings were significant enough. At the end of the survey, 12 out of the 32 households said they would be happy to have a loan officer call them to discuss the possibility of refinancing their home. These survey results are consistent with behavioral explanations such as procrastination and inattention, as well as lack of information, as possible reasons that households fail to respond to offers that appear to be in their financial best interest.

To further explore the determinants of take-up of refinancing offers, we estimate regressions (combining across mail campaigns) to predict take-up based on observable characteristics of borrowers mortgage contracts. The available measures of mortgage characteristics are the remaining length of the loan term, the unpaid balance, and the initial interest rate. In results not shown, we find that the size of the loan is the only statistically significant predictor of take-up in these reduced-form specifications, with an increase in loan amount of $10,000 associated with a 1.2 percentage point increase in the likelihood of refinancing. On a baseline refinancing rate of 16.7%, this is an increase of 7%.

Notably, conditional on loan amount, we find no relationship between the interest rate at origination and the likelihood of refinancing among NHS households. We interpret this lack of a relation with caution, as both larger loan amounts and lower interest rates can be associated with the ability to qualify for a larger and less expensive loan and perhaps greater financial savvy. Nonetheless, based on our data, it appears that households were not responsive to the relative savings induced from variation in the price of their outstanding debt. Instead, households were more responsive when total lifetime savings through refinancing is driven by a larger unpaid mortgage balance.

The micro evidence that we provide here is consistent with concurrent work by Johnson, Meier, and Taubia (2015). In their paper, the authors use administrative data on approximately 800,000 preapproved refinancing offers that were sent to homeowners as part of the Home Affordable Refinance Program (HARP). Similar to our setting, the preapproved offers that their sample received waived many of the fees associated with refinancing and had no up-front costs. Similar to the low take-up that we observe, Johnson, Meier, and Taubia find that only approximately 16% of homeowners respond to their initial letter, with less than 50% refinancing over the following 290 days. Follow-up experiments and surveys by the authors support the view that both time preferences and suspicion are likely contributors to the failure to refinance in their sample.

In sum, the results from three letter campaigns of a nonprofit mortgage lender further establish that many households in the US choose not to refinance despite being eligible to do so and despite a large amount of savings potential.

5 Discussion and conclusion

This paper analyzes an important anomaly: the failure of households to refinance their mortgage when interest rates decline, despite substantial monetary benefits from doing so. We analyze a detailed loan-level data set containing a large random sample of US mortgages and demonstrate that approximately 20% of households that appeared unconstrained to refinance failed to do so at some point during the recent decline in interest rates. The median household would have saved $160 per month over the remaining life of the loan, and the total present-discounted value of the forgone savings for these 20% of households was approximately $11,500. Given that this 20% of households represents roughly 400,000 mortgages from the full sample in the CoreLogic database, which represents 85% of the mortgages in the US, our estimates conservatively suggest that the total forgone savings of U.S. households over this period was approximately $5.4 billion. The $5.4 billion represents 6.8% of the outstanding mortgage debt of the households that are failing to refinance and 0.04% of total US mortgage debt, which was estimated by the Federal Reserve to be $13.5 trillion in 2010.

Thus, it appears that the size and scope of the failure to refinance is substantial and that this is a particularly large household financial mistake.

Clearly, failing to refinance can have important implications for a household's financial well-being. However, failing to refinance can have broader macroeconomic repercussions as well (Campbell, 2006). While the failure to refinance primarily represents a simple transfer from homeowners to investors in mortgage-backed securities, for several reasons this transfer might not be simply a zero-sum game. In the situation in which low interest rates are a result of a financial crisis, refinancing can have a stimulating effect by placing money in the hands of homeowners who might have a higher marginal propensity to consume than investors and who are located in a country where the financial crisis occurred (and where stimulus is likely to be the most welcome). Foreign entities hold a substantial share of mortgage-backed bonds (Tracy and Wright, 2012). In addition, transfers to homeowners by way of refinancing in the aftermath of a financial crisis can significantly lower the probability of default (Fuster and Willen, 2015). For instance, Agarwal, Amromin, Ben-David, Chomsisengphet, Piskorski, and Seru (2012) find that a 1 percentage point decline in mortgage interest rates through loan modifications is associated with approximately a 4 percentage point decline in the probability of default. Overall, Eberly and Krishnamurthy (2014) argue that lowering interest rates can be one of the most efficient policies that the government can undertake following a housing crash (even more useful than alternative modifications involving principal reductions).

What policies could be affective at helping homeowners to refinance? The magnitude of the financial mistakes that households make suggests that psychological factors such as procrastination, trust, and the inability to understand complex decisions are likely barriers to refinancing (Gerardi, Goette, and Meier, 2013). One policy that has been suggested to overcome the need for active household participation would require mortgages to have fixed interest rates that adjust downward automatically when rates decline (Campbell 2013). To the extent that it is undesirable to reward only those households that are able to overcome the computational and behavioral barriers of the refinance process, policies such as an automatically refinancing mortgage can be beneficial. Although an automatically refinancing mortgage contract would be more expensive up front for all borrowers in equilibrium, it would remove the cross-subsidization in the current mortgage finance system, in which savvier homeowners who use their refinancing option when rates decline are subsidized by those households that fail to do so. Automatically refinancing mortgages can also be an effective policy intervention that is designed with debt crises in mind. An alternative policy approach is to streamline the refinance process in important ways. For example, in the wake of the recent financial crisis, Boyce, Hubbard, Mayer, and Witkin (2012) propose that refinancing be streamlined (e.g., by removing reappraisal or income verification requirements) to provide rapid economic stimulus.

Notably, the US federal government has sought to encourage refinancing after the recent financial crisis. In March 2009, the Federal Housing Finance Agency (FHFA) and the US Department of the Treasury announced a large-scale refinance program entitled the Home Affordable Refinance Program. This program was designed to help borrowers with federally guaranteed loans to refinance even if they had little or no equity in their homes. Homeowners who were current on their mortgage payments and met the other conditions of the loan (including having less than 125% loan-to-value

on their mortgage) could refinance to a lower interest rate. When HARP was announced, FHFA and the Treasury Department estimated that four million to five million borrowers whose mortgages were backed by Fannie Mae and Freddie Mac could take advantage of the refinancing program. By September 2011, however, fewer than one million borrowers had refinanced their mortgages under HARP, remarkably similar in scope to the failure to refinance we find in our loan-level analysis. Although amendments to the program have resulted in more households taking up refinance offers, the overall take-up rate remains low relative to expectations.

Consistent with the findings in our paper, the experience of HARP suggests that eliminating the failure to refinance by homeowners is not straightforward. During a period of aggressive monetary policy to reduce interest rates faced by consumers, many homeowners did not benefit from lower costs of servicing mortgage debt. Future research should continue to explore products, such as automatically refinancing mortgages, and policies to reduce barriers to refinancing through both informational and behavioral channels to encourage homeowners to take advantage of mortgage-related savings when interest rates decline.

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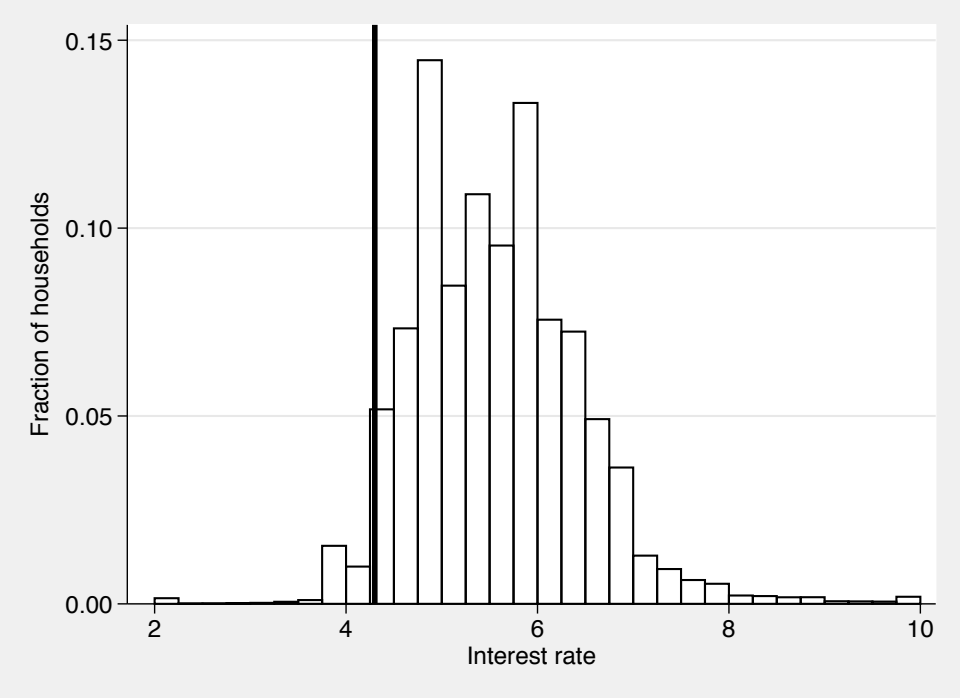
Panel A: Full sample



Panel B: Loans with initial FICO > 680, current CLTV < 90, and never missed a payment

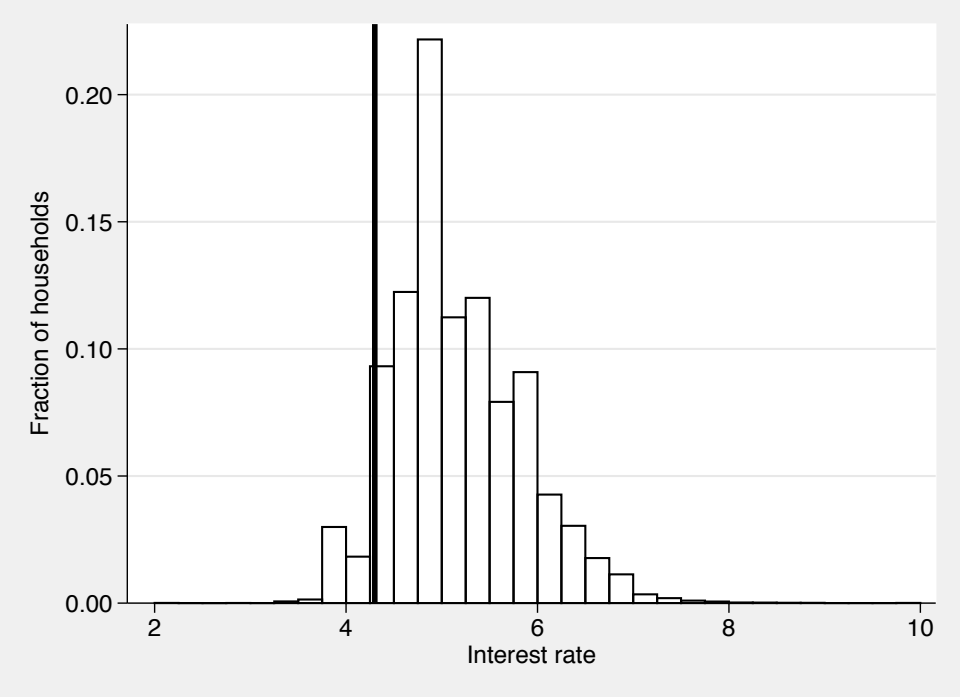


Fig. 1. Distribution of interest rates in December 2010. Panel A shows the distribution of interest rates of mortgage loans originated prior to November 2010 and active in December 2010. Panel B shows the distribution of interest rates for a restricted sample of loans with a high likelihood of refinancing eligibility: FICO scores above 680, current combined loan-to-value (CLTV) ratio below 90%, and never missed a payment. The vertical line indicates the prevailing mortgage rate of 4.3% in December of 2010. See text for detailed description of sample selection criteria.

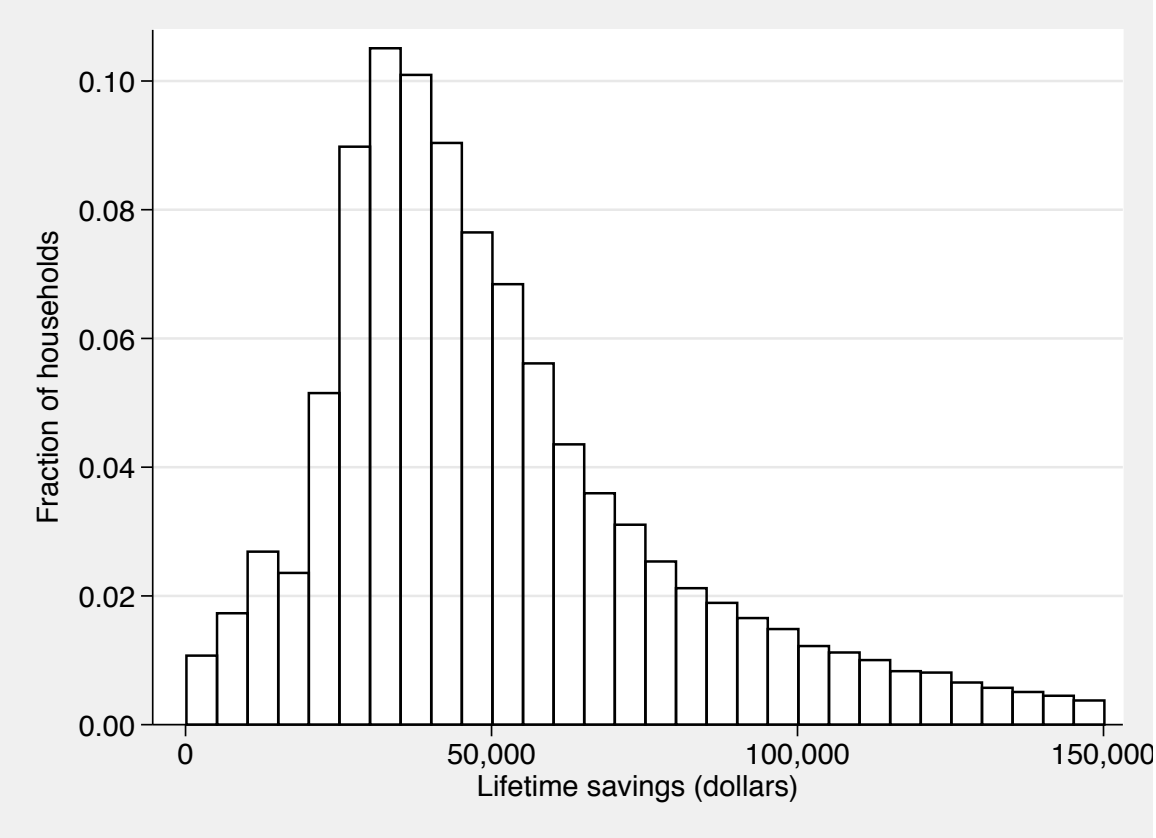


Fig. 2. Distribution of unadjusted lifetime savings for the 20% of households that should optimally refinance in December 2010. Savings are calculated based on the remaining unpaid balance, the remaining loan term, and the difference between the market interste rate and the interest rate at origination. The sample consists of mortgage loans originated prior to November 2010 and active in December 2010 with a high likelihood of refinancing eligibility: FICO scores above 680, current combined loan-to-value (CLTV) ratio below 90%, and never missed a payment. See text for detailed description of sample selection criteria.

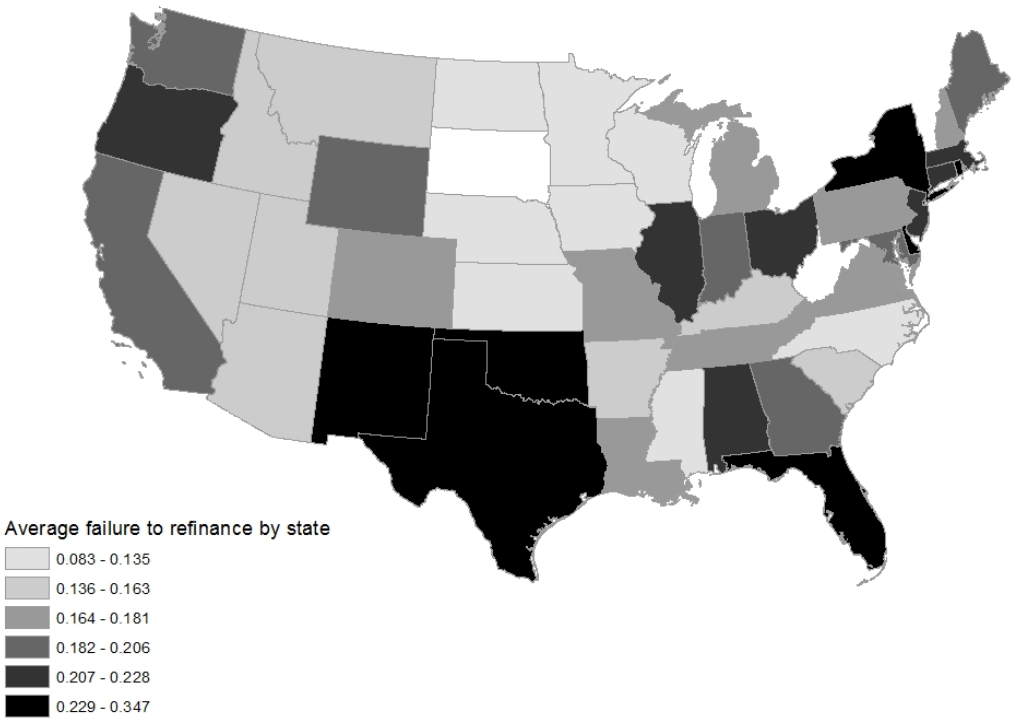


Fig. 3. Geographic variation in the failure to refinance. The figure shows state-level failure-to-refinance rates based on households that should optimally refinance in December 2010. The sample consists of mortgage loans originated prior to November 2010 and active in December 2010 with a high likelihood of refinancing eligibility: FICO scores above 680, current combined loan-to-value (CLTV) ratio below 90%, and never missed a payment. See text for detailed description of sample selection criteria.

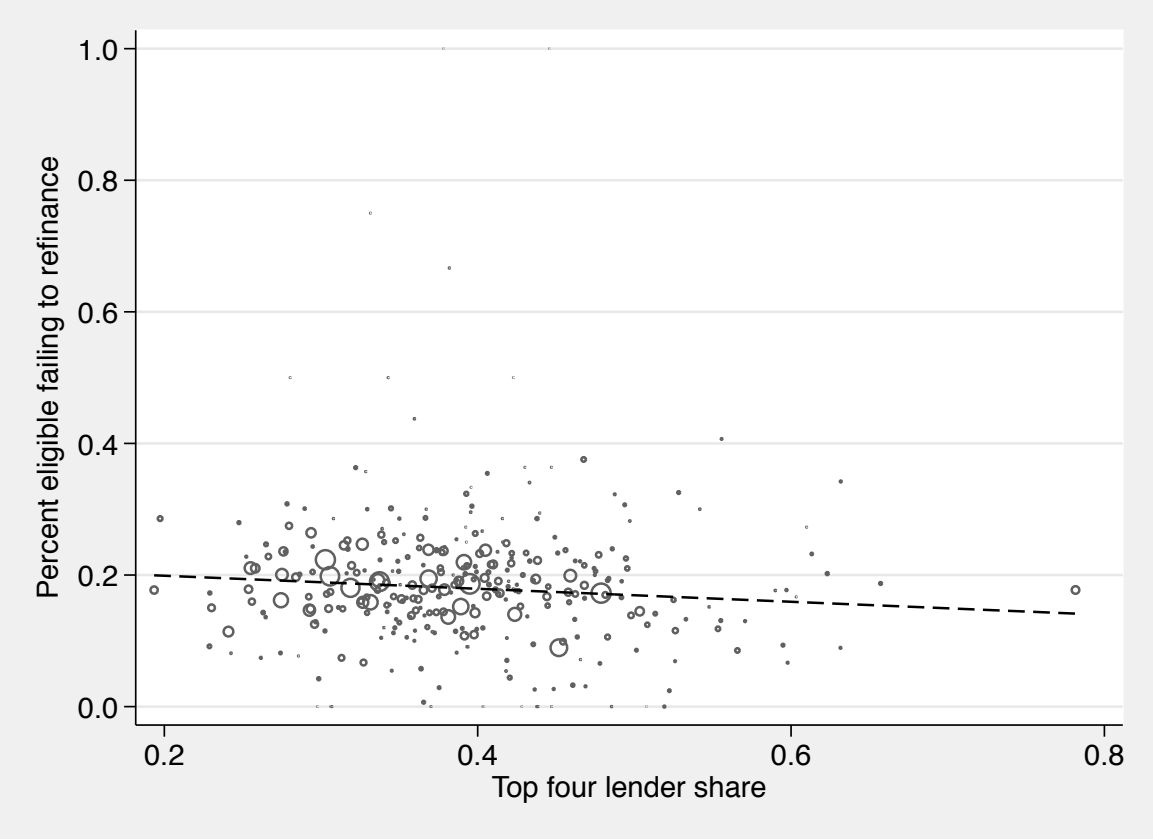


Fig. 4. Metropolitan Statistical Area (MSA)–level relationship between refinancing and lender concentration. The figure shows the correlation between the share of households that should optimally refinance in December 2010 but failed to do so in an MSA and the degree of lender concentration in that MSA. Lender concentration is measured as the share of the top 4 lenders in the MSA. Circle size represents the number of observations in our sample from the MSA. The sample consists of mortgage loans originated prior to November 2010 and active in December 2010 with a high likelihood of refinancing eligibility: FICO scores above 680, current combined loan-to-value (CLTV) ratio below 90%, and never missed a payment. See text for detailed description of sample selection criteria.

Table 1

This table provides summary statistics (average values) for the CoreLogic sample of mortgage loans originated prior to November 2010 and active in December 2010. Each column represents a tighter underwriting standard for potential refinancing by lenders. See text for detailed description of sample selection criteria. LTV = loan to value.

	(1)	(2)	(3)	(4)	(5)
Variables of interest					
Interest rate	5.52	5.29	5.22	5.22	5.10
Years remaining	23.4	23.3	23.3	22.9	22.9
Unpaid balance	$205,218	$215,481	$215,248	$216,296	$212,102
Monthly payment	$1,370	$1,421	$1,414	$1,420	$1,395
FICO score at origination	737	758	761	761	765
LTV at origination	70.7	66.4	65.9	64.6	62.7
Computed LTV in December 2010	74.2	68.5	67.1	62.4	60.2
Sample restrictions					
FICO > 680 and LTV < 90	No	Yes	Yes	Yes	Yes
Never missed a payment	No	No	Yes	Yes	Yes
Current LTV < 90	No	No	No	Yes	Yes
Current CLTV < 90	No	No	No	No	Yes
Number of observations	994,188	650,490	573,973	477,601	376,036

Table 2

This table provides estimates of the fraction of mortgage borrowers who optimally could have refinanced in December of 2010 but had not done so and the savings had they refinanced. The sample consists of mortgage loans originated prior to November 2010 and active in December 2010. See text for detailed description of sample selection criteria and savings calculations. All savings calculations include transaction costs of one point (1% of the unpaid balance) plus $2,000. Optimal threshold is calculated using Agarwal, Driscoll, and Laibson (2013) formula.

Sample	Number of observations	Share with positive unadjusted savings	Percent optimal in December 2010	Median unadjusted savings if optimal	Median adjusted savings if optimal
Full sample	994,188	91.4	41.2	$54,313	$13,260
Initial FICO > 680 and initial LTV < 90	650,490	89.0	31.1	$53,831	$13,218
Initial FICO > 680 and initial LTV < 90, never missed a payment	573,973	88.2	27.5	$52,075	$12,815
Initial FICO > 680 and current LTV < 90, never missed a payment	477,601	87.2	23.4	$48,344	$12,174
Initial FICO > 680 and current CLTV < 90, never missed a payment	376,036	85.7	20.0	$45,473	$11,568

Table 3

This table provides estimates of the fraction of mortgage borrowers who optimally could have refinanced in December of 2010 but had not done so, and the savings had they refinanced, across a range of borrower, mortgage, and geographic characteristics. The sample consists of mortgage loans originated prior to November 2010 and active in December 2010. See text for detailed description of sample selection criteria and savings calculations. All savings calculations include transaction costs of one point (1% of the unpaid balance) plus $2,000. Optimal threshold is calculated using Agarwal, Driscoll and Laibson (2013) formula.

	Share with positive unadjusted savings	Percent optimal in December 2010	Median unadjusted savings if optimal	Quartile range
By unemployment rate quartile				
Least unemployment	84.5	19.0	$47,667	< 7.7%
Second quartile	85.3	20.6	$44,432	7.7% < *x* < 9.2%
Third quartile	86.3	20.0	$44,561	9.2% < *x* < 10.9%
Most unemployment	86.8	20.2	$45,520	> 10.9%
By FICO score quartile				
Lowest FICO	90.0	29.1	$46,150	< 741 (but > 680)
Second quartile	87.3	21.3	$45,651	741 < *x* < 773
Third quartile	84.3	16.4	$45,307	773 < *x* < 793
Highest FICO	81.1	12.3	$43,670	> 793
By current CLTV quartile				
Lowest CLTV	79.1	17.5	$37,285	< 54%
Second quartile	83.9	18.9	$42,518	54% < *x* < 69%
Third quartile	87.7	19.6	$47,429	69% < *x* < 80%
Highest CLTV	91.4	23.4	$52,437	> 80% (but < 90%)
By loan amount quartile				
Smallest loan amount	85.4	21.2	$30,324	< $140,000
Second quartile	83.0	20.6	$39,496	$140,000 < *x* < $196,000
Third quartile	85.0	19.0	$53,248	$196,000 < *x* < $288,000
largest loan amount	89.5	19.1	$94,599	> $288,000
By education quartile				
Least educated county	85.4	19.6	$39,846	< 28.7%
Second quartile	86.4	22.1	$45,488	28.7% < *x* < 33.8%
Third quartile	85.4	18.8	$46,033	33.8% < *x* < 41.1%
Most educated county	85.6	19.1	$53,292	> 41.1%
By Income quartile				
Least income county	85.4	20.7	$40,467	< $53,418
Second quartile	85.8	19.8	$43,840	$53,418 < *x* < $61,555
Third quartile	85.6	18.8	$46,618	$61,555 < *x* < $75,566
Most income county	86.0	20.4	$52,663	> $75,566

Table 4

This table summarizes the three waves of Neighborhood Lending Services (NLS) refinancing mail campaigns, undertaken in May 2011 (Wave 1), July 2012 (Wave 2), and May 2013 (Wave 3). The first two waves included outgoing calls from loan officers. The third wave was exclusively conducted by mail.

Mail campaign characteristics, by wave	
Wave 1	
Number of letters sent	446
Percent that refinanced	15.9
Median original interest rate	6.2%
Median unadjusted savings for those that refinanced	$24,500
Median unadjusted savings for those that did not refinance	$17,700
Wave 2	
Number of letters sent	140
Percent that refinanced	24.3
Median original interest rate	6.1%
Median unadjusted savings for those that refinanced	$29,900
Median unadjusted savings for those that did not refinance	$24,700
Wave 3	
Number of letters sent	193
Percent that refinanced	13.0
Median original interest rate	6.1%
Median unadjusted savings for those that refinanced	$48,200
Median unadjusted savings for those that did not refinance	$26,400

Name
Address
City, State Zip
Loan # Date

Your mortgage company, Neighborhood Lending Services (NLS), has a one-time offer to reduce your mortgage interest rate. You have been selected because you have shown that you are able to make your mortgage payments on time, so we would like to give you the opportunity to take advantage of today's lower interest rates.

This is an offer to **refinance** your primary mortgage you have NLS.

For a limited time, we are offering you a **fixed-rate of X.XX%** to refinance your NLS loan. In addition to this lower fixed-rate, we are offering the following incentives:

- **No application fee**
- **Streamlined processing**
- **Appraisal fee can be included in the loan**
- **Reduced loan origination fee of 1% of your loan amount**
- **Loan terms up to 30 years (or less if you desire)**
- **Possible closing cost assistance and other assistance for income-eligible borrowers**

This allows you to take advantage of this lower rate with no out of pocket costs. You could be enjoying your new, lower fixed –rate loan before the summer is over.

To take advantage of this offer, certain conditions apply:

- **You must apply for this refinance loan by July 12, 2013**
- **Loans are subject to an appraisal of your home**
- **You must be current on your NLS loan(s) payments**
- **No cash out is allowed - this loan is solely to refinance your existing NLS loan**
- **New co-borrowers cannot be added to the loan**

If you would like to apply immediately, contact one of our Loan Officers below to start your application for this lower-rate refinance loan.

Fig. A1. Example of Neighborhood Lending Services (NLS) refinancing offer letter.

Table A1

This table provides estimates of the fraction of homeowners who would have optimally benefited from refinancing under a variety of different parameter assumptions, and provides a comparison to naïve basis point (BP) thresholds commonly found in financial advice columns. The results show that the optimality threshold implied by our baseline parameters [which are the same as those used in Agarwal, Driscoll, and Laibson (2013)] is most similar to a straightforward 150 basis point threshold, and that the optimality threshold is most sensitive to changes in the required up-front refinancing costs.

		Naïve threshold			Up-front costs			Patience		Moving	
	Baseline parameters	100 BP threshold	150 BP threshold	200 BP threshold	$0 + no points	$1,000 + 0.5 point	$4,000 + 2 points	More impatient	More patient	More likely to move	Less likely to move
Percent optimal	20.0%	33.8%	16.0%	5.1%	94.6%	37.6%	5.7%	16.8%	22.0%	15.3%	23.4%
Unadjusted savings if optimal	$45,473	$33,426	$39,280	$44,465	$20,601	$36,644	$66,178	$48,510	$44,109	$50,340	$42,825
Monthly savings if optimal	$159.30	$117.23	$140.43	$163.57	$68.29	$125.95	$228.73	$169.85	$154.99	$175.97	$150.47
Adjusted savings if optimal	$11,568	$8,710	$10,194	$11,608	$5,487	$9,351	$16,169	$12,273	$11,286	$12,702	$10,989