Mortgage Refinancing, Consumer Spending, and Competition: Evidence from the Home Affordable Refinancing Program

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Abstract

Using proprietary loan-level data, we examine the ability of the government to impact mortgage refinancing activity and spur consumption by focusing on the Home Affordable Refinancing Program (HARP). The policy relaxed housing equity constraints by extending government credit guarantee on insufficiently collateralized mortgages refinanced by intermediaries. Difference-in-difference tests based on program eligibility criteria reveal a significant increase in refinancing activity by HARP. More than three million eligible borrowers with primarily fixed-rate mortgages refinanced under HARP, receiving an average reduction of 1.4% in interest rate that amounts to $3,500 in annual savings. Durable spending by borrowers increased significantly after refinancing, with larger increase among more indebted borrowers. Regions more exposed to the program saw a relative increase in non-durable and durable consumer spending, a decline in foreclosure rates, and faster recovery in house prices. A variety of identification strategies suggest that competitive frictions in the refinancing market partly hampered the program's impact: the take-up rate was reduced by 10% to 20% and annual savings lower by $400 to $800 among those who refinanced. These effects were amplified for the most indebted borrowers, the key target of the program. A life-cycle model of refinancing quantitatively rationalizes these patterns and produces significant welfare gains from altering the refinancing market by removing the housing equity eligibility constraint, like HARP did, and by lowering competitive frictions. Our work has implications for future policy interventions, pass-through of monetary policy through household balance-sheets and design of the mortgage market.

Keywords: Financial Crisis, HARP, Debt, Refinancing, Consumption, Spending, Household Finance, Mortgages, Competition, Policy Intervention

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I. Introduction

Mortgage refinancing is one of the main channels through which households can benefit from decline in the cost of credit. Indeed, because fixed rate mortgage debt is the dominant form of financial obligation of households in the U.S and many other economies, refinancing constitutes one of the main direct channels for transmission of simulative effects of accommodative monetary policy (Campbell and Cocco 2003, Stroebel and Taylor 2012; Scharfstein and Sunderam 2014, Keys, Pope, and Pope 2016, Beraja et al. 2017). Consequently, in times of adverse economic conditions, central banks commonly lower interest rates in order to encourage mortgage refinancing, lower foreclosures, and stimulate household consumption. However, the ability of such actions to influence household consumption through refinancing depends on the ability of households to access refinancing markets and on the extent to which lenders compete and pass-through lower rates to consumers. This paper uses a large-scale government initiative called the Home Affordable Refinancing Program (HARP) as a laboratory to examine the government's ability to impact refinancing and spur household consumption and to assess the role of competitive frictions in hampering such activity.

While ours is the first paper that systematically analyzes these issues, their importance became apparent in aftermath of the recent financial crisis when many mortgage borrowers lost the ability to refinance their existing loans (Hubbard and Mayer 2009).[1] The government launched HARP as it was faced with a situation in which millions of borrowers in the economy were severely limited from accessing mortgage markets. The program allowed eligible borrowers with insufficient equity to refinance their agency mortgages by extending explicit federal credit guarantee on new loans. Since repayments of all eligible loans were effectively already guaranteed by the government prior to this intervention, the program did not constitute a significant new public subsidy.[2] Instead, by facilitating eligible borrowers to refinance their loans to lower their payments regardless of their housing equity, the program implied a transfer from investors in the mortgage securities backed by eligible loans to indebted borrowers.[3]

Our paper unfolds in three parts. First, we quantify the impact of HARP on mortgage refinancing activity and analyze consumer spending and other economic outcomes among borrowers and regions exposed to the program. This allows us to assess consumer behavior around refinancing among borrowers with Fixed Rate Mortgages (FRMs), the predominant contract type in the U.S.

[1] CoreLogic estimates that in early 2010, close to a quarter of all mortgage borrowers owed more than their houses were worth and another quarter had less than 20% equity, a common threshold for credit without external support.

[2] The government sponsored enterprises guarantee repayment of principal and interest to investors on agency loans underlying the mortgage-backed securities issued by them.

[3] By decreasing the debt service costs of eligible borrowers, HARP may have reduced the cost of outstanding government guarantees on these loans due to reduction in their default rate. At the same time, by stimulating mortgage refinancing, HARP can reduce the proceeds of investors in the mortgage-backed securities backed by these loans. We discuss the overall aggregate implications of these effects in Section VIII.

Second, after demonstrating that a substantial number of eligible borrowers did not benefit from the program, we analyze the importance of competitive frictions in the refinancing market in hampering HARP's reach. This sets us apart from prior work that has focused on the demand-side borrower specific factors, like inattention, in explaining sluggish response of borrowers to refinancing incentives (Andersen, Campbell, Nielsen, and Ramadorai 2014). Finally, we develop a life-cycle model of refinancing that quantitatively rationalizes these empirical patterns and produces significant welfare gains from altering the refinancing market by removing the housing equity eligibility constraint, like HARP did, and lowering competitive frictions.

We use a proprietary dataset from a large secondary market participant to execute our analysis. The dataset covers more than 50% of conforming mortgages (more than 20 million) sold in pools issued with guarantees of the Government Sponsored Entities (GSEs). This loan-level panel data has detailed information on loan, property, and borrower characteristics and monthly payment history. Importantly, this data contains unique identifiers (Social Security Numbers) for each borrower allowing us to construct their refinancing history, determine the *present* and *prior mortgage terms* during the refinancing process including fees charged by GSEs for insuring credit default risk (g-fee), the servicer responsible for their prior and current mortgage, as well as accurately capture various forms of consumer debt using their linked credit bureau records.

We start our analysis by assessing the impact of the program on the mortgage refinancing rate. To get an estimate of the counterfactual level in the absence of the program, we exploit variation in exposure of similar borrowers to the program. Specifically, we use high loan-to-value (LTV) loans sold to GSEs (the so-called conforming loans) as the treatment group since these loans were eligible for the program. Loans with observationally similar characteristics, but issued without government guarantees (non-agency loans), serve as a control group since these mortgages were ineligible for the program. Using difference-in-differences specifications we find a large differential change in the refinancing rate of eligible loans relative to the control group after the program implementation date. Thus, by addressing the problem of limited access to refinancing due to insufficient equity, HARP led to substantial number of refinances (more than 3 million). We also quantify the extent of savings received by borrowers on HARP refinances and find around 140 basis points of interest rate savings were passed through on the intensive margin. This amounts to about $3,500 in annual savings per borrower -- a 20% reduction in monthly mortgage payments.

We also analyze the consumer spending patterns among borrowers who refinanced under the program. Our analysis based on new auto financing patterns suggests that borrowers significantly increased their durable (auto) spending (by about $1,600 over two years) after the refinancing date, about 20% of their interest rate savings. This increase in spending is substantially larger among more indebted borrowers with high loan-to-value ratios on their mortgagees. Additional data and tests provide external validity and support the view that these effects were due to the program.

We augment this analysis by assessing how outcome variables, measured at the zip code level -- such as non-durable and durable consumer spending, foreclosures, and house prices—changed in regions based on their exposure to the program. Regions more exposed to the program experienced a meaningful increase in durable and non-durable consumer spending (auto and credit card purchases), relative decline in foreclosure rate, and faster recovery in house prices.

Although the first part of the paper illustrates that the program had considerable impact on refinancing activity and consumption of borrowers, it also shows that a significant number of eligible borrowers did not take advantage of the program. In the second part of our analysis, we investigate the role of intermediary competition in impacting HARP's reach and effectiveness.

There are at least a couple of reasons why competitive frictions could play an important role in the program implementation. First, to the extent that an existing relationship might confer some competitive advantage to the incumbent servicer -- whether through lower (re-) origination costs, less costly solicitation, or better information -- such advantages could be enhanced under the program since it targeted more indebted borrowers. Second, in an effort to encourage servicer participation, the program rules imposed a lesser legal burden on *existing* (incumbent) servicers.

To shed light on the importance of such factors, we start by comparing the interest rates on HARP refinances to the interest rates on regular conforming refinances originated during the same period (*HARP-conforming refi spread*). The latter group serves as a natural counterfactual, as the funding market for such loans – extended to creditworthy borrowers with significant housing equity -- was quite competitive and remained fairly unobstructed throughout the crisis period. Thus, the spread captures the extent of pass-through of lower interest rates to borrowers refinancing under the program *relative* to those refinancing in the conforming market. Importantly, our detailed data on GSE fees for insuring credit risk of loans (g-fees) allows us to precisely account for differences in interest rates due to differential creditworthiness of borrowers refinancing in the two markets.

We find that, on average, a loan refinanced under HARP carries an interest rate that is 16 basis points higher relative to conforming mortgages refinanced in the same month. This suggests a more limited pass through of interest savings under HARP relative to the regular conforming market. The markup is substantial relative to the mean interest rate savings on HARP refinances (140 basis points). Moreover, consistent with the idea that borrowers with higher LTV loans may have very limited refinancing options outside the program, providing higher advantage to incumbent lender, the spread increases substantially with the current LTV of the loan, reaching more than 30 basis points for high LTV loans. In addition, we find that loans refinanced under the program by larger lenders – ones who are likely to have market power in several local markets -- carry higher spreads. These patterns persist when we account for a host of observable loan, borrower, property and regional characteristics and remove g-fees that account for differential mortgage credit risk due to higher LTV ratios. We also exploit variation *within* HARP borrowers that relates the terms of their refinanced mortgages to the interest rate on their legacy loans, i.e., rate on the mortgage prior to HARP refinancing. Borrowers with higher legacy rates experience substantially smaller rate reductions on HARP refinances compared with otherwise observationally similar borrowers with lower legacy rates. This is consistent with presence of limited competition where incumbent lenders can extract more surplus from borrowers with higher legacy rates since such borrowers could be incentivized to refinance at relatively higher rates.

Next, in our main test of the importance of competitive frictions we take advantage of the change in the program rules introduced in January 2013. The rule relaxed the asymmetric nature of higher legal burden for new lenders refinancing under the program relative to incumbent ones and was aimed competitive frictions in the HARP refinancing market. We use a difference-in-difference setting around the program change to *directly* assess how changes in competition in the refinancing market impacted intensive (mortgage rates) and extensive (refinancing rates) margins. We find a sharp and meaningful reduction in the *HARP-conforming refi spread* (by more than 30%) around the program change. Moreover, there was a concurrent increase in the rate at which eligible borrowers refinanced under the program (6%) relative to refinancing rate in the conforming market. These estimates imply that refinancing rate among eligible borrowers would be about 10 to 20 percentage points higher if HARP refinances were priced similar to conforming ones (accounting for variation in g-fees). The effects are the largest among the group of the borrowers that were the main target of the program – i.e., those with the least amount of home equity. These are also borrowers, as shown earlier, who displayed larger increase in spending *conditional* on program refinancing. Thus, competitive frictions may have reduced the effect of HARP on refinancing and consumption of eligible households, especially those targeted by the program.

The last part of the paper develops a life-cycle model of refinancing to make quantitative sense of these empirical findings and shed some light on the welfare effects of the program on eligible borrowers. In the model, households make optimal consumption, savings, housing, and mortgage choices, while facing stochastic income, house prices, and interest rates. The model features illiquid housing and long-term mortgage debt with costly refinancing, creating a realistic dynamic refinancing decision problem. In deciding when to refinance, the households trade off the refinancing fees versus future expected utility gains due to reduced mortgage rate. Moreover, in the absence of HARP, in order to refinance, the households also need to satisfy the housing equity constraint reflecting the underwriting guidelines for regular conforming loans: the LTV ratio of the new loan cannot exceed 80%. This constraint implies that households who experienced a sufficient decline in their home values are ineligible for refinancing unless they save enough money to deleverage. We calibrate the model to match household wealth-to-income and house value-to-income ratios for the relevant age groups in the data.

The model implies that access to refinancing through HARP, without LTV eligibility constraint, leads to an initial increase in annual consumption of eligible borrowers from about $600 to more than $2,800. The model-implied consumption increase is greatest for highly indebted borrowers and borrowers with a relatively high prior mortgage rates. In particular, refinancing borrowers consume on average between 40% (for least indebted) to up to about 80% (for most indebted) of extra liquidity generated from rate reduction. These model-implied estimates of consumption increase due to HARP are broadly consistent with our empirical estimates based on durable (auto) consumption. They also imply that borrowers who refinanced their loans under HARP increased their consumption by about $20 billion in the aggregate during the first three years after refinancing. To quantify the net effect of the availability of HARP, we also compute the lifetime welfare gains for eligible borrowers. We find these gains to be unambiguously positive averaging about 6.9% of lifetime utility and increasing with borrower LTV and legacy mortgage rate.

Finally, our model also confirms that the markup fees induced by competitive frictions adversely affected the benefits to HARP to borrowers. Absent any HARP specific markups, we would have seen higher individual annual consumption responses of about $150 to up to $300 dollars among typical program eligible borrowers. Consistent with our empirical findings the model also indicates that removal of HARP markups would result in a substantial increase in the refinancing rate of eligible borrowers ranging from 6 (for least indebted) to about 20 percentage points (for most indebted). These intensive and extensive effects together imply that removal of markups would increase the welfare of eligible borrowers between 0.6% to 1.5% of their lifetime utility.

Our paper is closely related to a recent literature that examines the importance of institutional frictions and financial intermediaries in effective implementation of stabilization programs, particularly in housing markets. In particular, focusing on the Home Affordable Modification Program (HAMP), Agarwal et al. (2017) provide evidence that servicer-specific factors related to their preexisting organizational capabilities – such as servicing capacity -- can importantly affect the effectiveness of policy intervention in debt renegotiation that rely on such intermediaries for its implementation.[4] In contrast, our work suggests that competition in intermediation market may also play a role in effective implementation of some stabilization policies.

Our paper is also related to the growing literature on the pass-through of monetary policy, interest rates, and housing shocks through household balance sheets (e.g., Hurst and Stafford 2004; Mian, Rao, and Sufi 2013; Mian and Sufi 2014, Chen, Michaux, Roussanov 2014, Auclert 2015; Agarwal, Chomsisengphet, Mahoney, and Strobel 2015; Beraja et al. 2017; Di Maggio et al. 2016, 2017). Within this literature we provide a novel and comprehensive assessment of the largest policy intervention in refinancing market during the recent crisis. Our household life-cycle model

[4] Since HARP requires servicer participation for its implementation, such factors (e.g. servicer capacity constraints) could also affect its reach. Notably, refinancing is a relatively a routine activity that servicers have significant experience doing. In contrast, HAMP's aim was to stimulate mortgage renegotiation, a more complex activity that servicers have limited experience with and requiring significant servicing infrastructure. Thus, relative to HAMP, competitive frictions could play a more important role in HARP, compared with servicer organizational capabilities.

with refinancing option is related to the quantitative models emphasizing the importance of housing and mortgage markets for household and aggregate outcomes (e.g., Kaplan, Mitman, and Violante 2016; Favilukis, Ludvingson, Van Nieuwerburgh 2017) and to the recent quantitative models emphasizing the importance of refinancing for pass-through of interest rate shocks (e.g., Wong 2015; Greenwald 2016, Beraja et al. 2017). We contribute to this literature by tying the predictions of a rich structural model of household refinancing decisions to the micro evidence on the effects of the largest direct intervention in the refinancing market. Our findings also complement those of Scharfstein and Sunderam (2014) who show that, in general, refinancing markets with a higher degree of lender concentration experienced a substantially smaller pass-through of lower market interest rates to borrowers. Within a broader context on market competitiveness and pricing power, this paper is related to work of Rotemberg and Saloner (1987) and to research on pass-through and competition in lending (e.g., Neumark and Sharpe 1992).

We also contribute to the vast literature on studying consumption responses to various fiscal stimulus programs. Some studies include Shapiro and Slemrod (1995, 2003), Jappelli et al. (1998), Souleles (1999), Parker (1999), Browning and Collado (2001), Stephens (2008), Johnson, Parker, and Souleles (2006), Agarwal, Liu, and Souleles (2007), Aaronson et al. (2012), Mian and Sufi (2012), Parker, Souleles, Johnson, and McClelland (2013), Gelman et. al. (2014) and Agarwal and Qian (2014). Our analysis relies on a period with lower interest rates, where borrowers with insufficiently collateralized mortgages had large incentives to refinance, but were unable to do so (Hubbard and Mayer 2009). HARP generated an exogenous increase in supply of refinancing opportunities and we find significant increase in consumer spending among borrowers and regions exposed to the program. Our evidence suggests that consumer spending response to mortgage refinancing can be an important part of transmission of monetary policy to the economy since lower rates generally induce more refinancing.

Our paper is also related to the recent empirical literature that studies borrowers' refinancing decisions (e.g., Koijen et al. 2009, Agarwal, Driscoll and Laibson 2013; Anderson et. al. 2014; Keys, Pope and Pope 2016, Agarwal, Rosen and Yao 2016;). This literature focuses on borrower specific factors like limited inattention and inertia in explaining their refinancing decisions. While such borrower specific factors can also help account the muted response to HARP (see Johnson et al. 2016 for recent evidence), our work emphasizes the importance of financial intermediaries and the degree of market competition in explaining part of this shortfall.

Finally, our work relates broadly to the recent growing literature on the housing and financial crisis (e.g., Mayer et al. 2009 and 2014; Keys et al. 2010, 2012; Charles, Hurst and Notowidigdo 2013; Eberly and Krishnamurthy 2014; Hsu, Matsa and Melzer, 2014; Stroebel and Vavra 2014; Melzer 2017). We contribute to this literature by providing the first comprehensive assessment of the largest intervention aimed at stimulating mortgage refinancing during the Great Recession.

II. Background and Empirical Strategy

II.A U.S. Mortgage Markets before and during the Great Recession

The U.S. mortgage markets are characterized by several unique features. First, a majority of mortgage contracts offer fixed interest rates and amortize over long time periods, commonly set at 15 or 30 years. Second, most mortgages can be repaid in full at any point in time without penalties, typically by taking out a new loan backed by the same property (refinancing). Finally, the majority of mortgages, the so-called conforming loans, are backed by government-sponsored enterprises or GSEs.[5] The GSEs guarantee full payment of interest and principal to investors on behalf of lenders and in exchange charge lenders a mixture of periodic and upfront guarantee fees (called "g-fees"). In practice, both types of g-fees are typically rolled into the interest rate offered to the borrower and are collected as part of the monthly mortgage payment. The interest rates charged to borrowers are thus affected by three main components: the yield on the benchmark Treasury notes to capture prevailing credit conditions, the credit profile of the borrower that affects the g-fee charged for insurance of default risk (which depends on factors such as FICO credit score and LTV ratio), and finally, a lender's markup. In addition the borrowers need to satisfy a set of criteria to be eligible for conforming financing based on factors such as loan amount and LTV ratio.[6]

Under this institutional setup, a borrower with a FRM might be able to take advantage of declines in the general level of interest rates by refinancing a loan. The economic gain from refinancing is clearly affected by potential changes in borrower creditworthiness, as well as the mortgage market environment. During periods of favorable economic conditions, such as those between 2002 and 2006, refinancing market functioned smoothly. Borrower incomes and credit scores remained steady. Home prices increased, allowing equity extraction at refinancing while maintaining stable LTV ratios. Defaults were rare and supply of mortgage credit was plentiful.

Each of these components changed dramatically during the Great Recession. Rapidly rising unemployment rates and the attendant stress to household ability to service debt obligations impaired income and credit scores. As home prices dropped precipitously, many borrowers were left with little or no equity in their homes, making them ineligible for conforming loan refinancing. By early 2010, close to a quarter of all mortgage borrowers found themselves "underwater", i.e. owing more on their house than it was worth (CoreLogic data). Refinancing was also made more difficult by a virtual shutdown of the private securitization market, as investors fled mortgage-

[5] As of the end of 2013, GSE-backed securities (agency mortgage backed securities (MBS)) accounted for just over 60% of outstanding mortgage debt in the U.S. About half of the agency MBS market is backed by Fannie Mae, slightly less than 30% is backed by Freddie Mac, and the rest is backed by Ginnie Mae, which securitizes mortgages made by the Federal Housing Administration (FHA) and Veterans Administration (VA). For the purposes of this paper, given our data, our discussion of GSEs will be limited to the practices of Fannie Mae and Freddie Mac.

[6] Conforming mortgages cannot exceed the eligibility limit, which has been $417,000 since 2006 for a 1-unit, single-family dwelling in a low-cost area. In addition, most such loans have LTV ratios at origination no greater than 80%.

backed securities not explicitly backed by the federal government leading to a massive exit of lenders from the subprime mortgage industry such as Countrywide, Washington Mutual, Wachovia and IndyMac. Since refinancing underwater or near-underwater loans would be considered extending unsecured credit and trigger prohibitive capital charges, balance sheet (portfolio) lending for such borrowers dried up as well.

Overall, due to the environment in the credit industry, borrowers with insufficient home equity were shut out of refinancing markets, even as countercyclical monetary policy actions drove mortgage interest rates to very low levels.

II.B The Home Affordable Refinancing Program (HARP) and Asymmetric Pricing Power

In the face of massive disruptions in mortgage markets, the Treasury Department and the Federal Housing Finance Agency (FHFA) developed a program to allow households with insufficient equity to refinance their mortgages. This policy action – the Home Affordable Refinancing Program, or HARP –instructed GSEs to provide credit guarantees on refinances of conforming mortgages, even in cases when the resulting loan-to-value ratios exceeded the usual eligibility threshold of 80 percent. Initially, only loans with an LTV of up to 105% could qualify. Later in 2009, the program was expanded to include loans with an estimated LTV at the time of refinancing up to 125%. Finally, in December 2011, the program rules were changed again by removing any limit on negative equity for mortgages so that even those borrowers owing more than 125% of their home value could refinance, creating what is referred to as "HARP 2.0". After a number of extensions of its end date, HARP on December 31, 2018.

Given the size of GSE-backed mortgage holdings, opening up refinancing for this segment of the market had the potential to influence household consumption. Although refinancing imposes losses on the existing investors in mortgage backed securities (MBS) who have to surrender high-interest paying assets in a low-interest-rate environment, it benefits borrowers by lowering their interest payments and substantially reducing the NPV of their mortgage obligations. Consequently, HARP aimed to provide economic stimulus to the extent that liquidity-constrained borrowers had higher marginal propensities to consume than MBS investors. As we discussed in the introduction, since all eligible loans were already guaranteed by the government prior to this intervention, the program did not constitute a significant new public subsidy. Instead, by facilitating eligible borrowers to refinance their loans the program implied a transfer from investors in the mortgage securities backed by eligible loans to indebted borrowers. It also potentially lowered the likelihood of delinquencies and subsequent foreclosures, and resultant deadweight losses (Mian et al. 2011).

HARP got off to a slow start, refinancing only about 300,000 loans during the first full year of the program. Overall, more than 3 million borrowers refinanced during the first five years of the program, which amounts to up to between 40 to 60 percent of potentially eligible borrowers as of the program start date in March 2009.[7] Market commentary pointed to a number of flaws in the program design, which included frictions with junior liens and origination g-fee surcharges (LLPAs) that limited borrowers' potential gains from refinancing. Crucially, lender willingness to participate in HARP was potentially undermined by ambiguities about the program's treatment of representations and warranties (R&W).[8] Any mortgage found to be in violation of its R&W can be returned ("put back") to the originator, who would then bear all of the credit losses. The risk of put backs became particularly pronounced in the wake of the financial crisis when mortgage investors and GSEs began conducting aggressive audits for possible R&W violations on every defaulted loan. In the case of low-equity and underwater loans targeted by HARP the risk of default was considered to be particularly high. As a result, mortgage originators that securitized their loans through GSEs could have regarded R&W as a major liability.

Policymakers recognized this issue and HARP lessened the underwriting requirements and the attendant R&W on loans refinanced through the program. However, this relief from put back risk on refinanced loans was granted *asymmetrically,* favoring lenders that were *already* servicing mortgages prior to their being refinanced through HARP. Such lenders faced few underwriting requirements and little exposure to this risk. In contrast, lenders that were refinancing mortgages that they did not already service had to face stringent R&W treatment.[9] Finally, HARP rules were also asymmetric in servicer treatment since the program required less onerous underwriting if performed through a borrower's existing servicer rather than through a different servicer.[10]

II.C *Post-HARP 2.0 Developments*

In January 2013, FHFA addressed concerns about the open-ended nature of R&W violation reviews. This took on two forms: (1) FHFA clarified a sunset provision for R&W reviews, setting the time frame over which such reviews could be done at 1-year for HARP transactions; (2) FHFA clarified which violations were subject to this sunset and which were severe enough (e.g. fraud) to be subject to life-of-the-loan timeframe. These changes went into effect in January 2013. The clarification of the R&W process may have had a direct effect on the competitive advantage of same-servicer HARP refinances. Before the sunset provisions, a new servicer was taking on an

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[7] Based on Treasury and FHFA, 8 million borrowers could have been eligible for the program: 4-5 million borrowers having the opportunity to refinance under HARP 1.0 and an additional 2-3 million borrowers becoming eligible due to the removal of the LTV eligibility limit under HARP 2.0). See FHFA, "HARP: A Mid Program Assessment" (2013).
[8] In every transaction, the mortgage originator certifies the truthfulness of information collected as part of the origination process, such as borrower income, assets, and house value. This certification is known as R&W.
[9] Mortgage originators that securitized loans through GSE typically retained servicing rights on those mortgages. In their role as a servicer, they collected payments, advanced them to the MBS trustee, and engaged in a variety of loss mitigating actions on delinquent loans. We use the terms "servicer" and "lender" interchangeably. Notably, the difference in treatment highlighted here may result in higher expected origination costs for would-be competitors of existing lenders. Additionally, this market power to existing servicers may have been more consequential for high LTV borrowers since such borrowers would be associated with greater default risk, and hence higher put back risk.
[10] For instance, under HARP the lender had to verify that eligible borrowers missed at most one payment on their existing loan during the previous 12 months. This information was already available with the incumbent lender.

indefinite (or at least ambiguous) R&W risk. However, with the provision in place, this risk was limited to a 1-year window for a pre-specified set of violations.

III. Data and Empirical Setting:

III.A Data

The main data comes from a proprietary database of conforming mortgages securitized by a large secondary market participant. The conforming loans are mortgages that satisfy the underwriting guidelines of GSEs (such as Fannie Mae and Freddie Mac). These mortgages are usually made to borrowers with relatively high credit scores, low initial LTV ratios, and fully documented incomes and assets. In addition, these mortgages must meet the conforming loan limit. Recall that only conforming mortgages were eligible for refinancing under HARP. Thus, our data, which covers more than 50% of conforming loans – i.e., more than 20 million of outstanding residential mortgages as of implementation of HARP in March 2009 -- is well suited to study the program.

This loan-level monthly panel data has detailed dynamic information on rich array of loan, property, and borrower characteristics (e.g., interest rates, location of the property and current borrower credit scores and LTV ratios) and monthly payment history (e.g., delinquent or not). Importantly, as this data contains unique Social Security Numbers (SSN) for each borrower, we can track the refinancing history of each borrower, the servicer responsible for prior and current mortgage of the borrower, and whether refinancing was done under HARP. This matched data allows us to obtain all the *present* and *prior mortgage terms* including all relevant information on fees applied during the refinancing process including GSE g-fees.

This detailed panel data on the refinancing history of each borrower constitutes a considerable advantage over commercially available products, which do not provide information on the entire sequence of transactions at the borrower level. This rich data allows us to account for detailed borrower level characteristics as well as conduct *within* borrower analysis to assess how terms of loans obtained under HARP relate to the terms of their previous transactions.

The data provider has merged the mortgage data with each borrower's consumer credit bureau records by using unique identifier. These merged data allow us to observe the credit history of mortgage holders in each month. In particular, we see auto debt balance information, which allows us to construct empirical measures of new auto spending patterns at the borrower level. Our data ends in mid-2013, a period after which there were relatively few HARP originations.

We also employ loan-level mortgage data collected by BlackBox Logic that covers more than 90% of privately securitized mortgages not sold to GSEs. These data were merged with borrower-level credit report information collected by Equifax using a proprietary match algorithm giving us a similar set of variables as our main dataset.[11] We focus on a set of borrowers with loans in this data that are similar on observables to those in our main sample. However, as these loans were not sold to GSEs they were not eligible for the program. Consequently, this group of loans serves as a counterfactual for the loans that could be potentially refinanced under the program.

Finally, in our regional analysis we collect individual loan-level information from four databases. The first source is the LPS database maintained by Black Knight Financial Services, which provides dynamic information on the vast majority of loans in the United States. We complement this dataset with the information from the BlackBox database, which yields almost complete coverage of mortgage loans in the United States, allowing us to compute zip-code-level characteristics for variables such as average borrower FICO credit scores, fraction of HARP eligible loans among all mortgages in a zip code, average mortgage interest rates, as well as zip code level foreclosure rates. The second dataset provided by the Office of the Comptroller of Currency allows us to measure the quarterly credit card spending of borrowers in a particular zip code. The third database comprises the auto sales data from R. L. Polk & Company (see Mian, Rao, and Sufi 2013), which allows us to directly measure the car purchases in a zip code. Finally, we also use zip code level house price indices from CoreLogic.

III.B Empirical Setting

Our empirical analysis consists of two main parts. In the first part we aim to quantify the impact of HARP on mortgage refinancing and assess household spending and other economic outcomes around the program implementation. In the second part, we investigate the role of intermediary competition on the reach and effectiveness of the program.

We start our analysis by assessing the impact of the program on the mortgage refinancing rate. We focus on fixed-rate mortgages, the predominant mortgage type in the U.S., which, unlike adjustable-rate mortgages, cannot automatically benefit from lower market rates. To get an estimate of the counterfactual level in the absence of the program, we use borrowers that are similar on observables, but are ineligible for HARP. Specifically, high LTV loans sold to GSEs ("conforming" loans) serve as the treatment group, while observationally similar loans issued without government guarantees ("non-agency" loans) – ineligible for HARP -- serve as a control group. Using a difference-in-differences specification we assess the differential change in the refinancing rate of the treatment group relative to the control group around implementation of HARP. The identification assumption is that, in the absence of the program, the refinancing rates in the control and treatment groups would evolve similarly (up to a constant difference).

[11] BlackBox is a private company that provides a comprehensive, dynamic dataset with information on privately securitized subprime, Alt-A, and prime loans originated after 1999. Equifax is a major credit reporting agency that provides monthly data on consumer credit standing.

Next we quantify the extent of savings received by borrowers refinancing under HARP and shed some light on consumer spending patterns around the refinancing activity under the program. For this purpose, we exploit the richness of our data -- in particular the ability to track borrowers across transactions matched to consumer credit bureau records using SSNs -- to construct empirical proxies capturing consumer durable spending patterns. This data allows us to assess the reduction in interest rates provided to borrowers who refinanced under HARP, as well as track changes in their consumption activity around refinancing dates.

Next, we assess regional outcome variables such as non-durable consumer spending, foreclosures, and house prices in regions more exposed to the program. Here, we rely on zip code data, since we do not have more micro data for variables like consumer credit card spending or house prices. The main challenge when attempting to infer such a connection is that a national program such as HARP affects borrowers in all regions. We address this challenge by exploiting regional heterogeneity in the share of loans that are eligible for HARP. In particular, we obtain a measure of ex-ante exposure of a region to the program as the regional (zip code) share of conforming mortgages with the high LTV ratios. Similar to Mian and Sufi (2012) and Agarwal et al. (2017), we account for general trends in outcomes during the program period by focusing on relative change in the evolution of outcomes between regions with differential ex-ante exposure.

In the second part of our analysis, we investigate the role of intermediary competition on the reach and effectiveness of HARP. The main obstacle in evaluating the potential role of limited competition is to get an estimate of the counterfactual level in the absence of such frictions. We circumvent this issue in three ways. First, we construct the difference in interest rates on HARP refinances and regular conforming refinances, both originated during the same period and made to borrowers of similar credit risk ("*HARP-conforming refi spread"*). The regular conforming refinances represent creditworthy borrowers with significant housing equity who could refinance outside of HARP. This group serves as a natural counterfactual since the market for such loans was quite competitive and remained fairly unobstructed throughout the period of study. In computing the spread, we also take advantage of our detailed data that allows us to precisely account for variation in interest rate spreads due to differences in loan credit risk by absorbing variation due to g-fees. In our empirical tests we assess how the *HARP-conforming refi spread* varies with LTV of the loan and across lenders, while accounting for the rich array of borrower, property, and loan characteristics. Higher LTV loans should see higher spreads since they may see limited competition due to a stronger incumbent advantage.

While potentially suggestive, the first set of tests may not fully address the concerns that such differences may reflect other factors besides competitive frictions. To address such concerns, in our second set of tests, we exploit variation within HARP borrowers. In particular, we relate the terms of refinanced mortgages to the empirical measure of their bargaining power. As we discuss in detail in Section V.C, in the presence of competitive frictions, all else equal, borrowers with higher legacy rates -- i.e., rates on mortgages prior to HARP refinancing – should face larger markups on their refinanced loans.

Finally, in our key test, we exploit the change in the program rules from January 2013 onwards that lowered the put back risk of new lenders for loans originated previously by other lenders. As discussed in Section II.C, this change effectively alleviated barriers to competition in the HARP refinancing market. To the extent these barriers were quantitatively important, we expect to see a meaningful reduction of the *HARP-conforming refi spread* after the program change and an increase in refinancing activity under the program. In particular, we exploit a difference-in-differences setting, analyzing the differential change in HARP interest rate (intensive margin) and refinancing activity (extensive margin) relative to mortgage rates and refinancing activity of regular conforming loans around the program change date.

IV. Program Effect

IV.A Descriptive Statistics

We start by presenting the characteristics of loans that were eligible to be refinanced under HARP and contrasting these with similar loans that were ineligible for the program. As discussed in Section III.B, the treatment group consists of all GSE FRM loans that would have been HARP eligible (that is GSE loans with current LTV greater than 80%) and the control group consists of all FRM loans that are similar on all other dimensions (such as FICO, LTV, interest rates, and loan balances) except that these are non-GSE loans and therefore are ineligible for HARP.[12] This results in a sample of about 92,000 loans equally split between treatment and control. We track the refinancing patterns of these loans from April 2008 to December 2012.

Table 1 presents statistics of loans in the treatment and control groups in the pre-program period (i.e., from April 2008 to February 2009). As can be seen, loans in the two groups consist of borrowers with similar FICO scores (728 in the control group versus 727 in the treatment group), LTV ratios (95.6 in the control group versus 95.5 in the treatment group)[13] and interest rates (6.62 in the control group versus 6.60 in the treatment group), and similar outstanding loan balances ($186,525 in the control group and $183,614 in the treatment group). Notably, in unreported tests we also confirm that these differences remain similar throughout the pre-program period.

IV.B Micro Analysis: Refinancing Activity

Figure 1A presents the first set of results related to the program. Here we plot the quarterly HARP refinancing rate in the treatment group. As can be observed, not surprisingly, there is a gradual

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[12] The matching is one-to-one done based on FICO, current LTV (as of March 2008), interest rates, and loan using a sample of more than a million program eligible FRM loans and more than 200,000 non-GSE FRM loans.

[13] Our main data includes monthly information on current LTV ratio of GSE loans. For non-GSE loans, we get monthly current LTV using outstanding balance and appraised property value from zip level CoreLogic house price indices.

increase in the refinancing activity done under the program once the program starts in 2009:Q1.[14] The estimates presented in the figure suggest that the refinances done in the treatment group under the program – i.e., the fraction of treatment loans refinanced under HARP every quarter -- is about 1.6%. In terms of cumulative effect over the sample period being depicted in the figure (until December 2012), we get about 25% of the eligible loans being refinanced under the program. As per the US Treasury, up to 8 million loans were broadly eligible for HARP (see Section II.B). Hence, our estimates applied to the entire stock of potentially eligible mortgages imply that about 2 million loans were refinanced under the program by end of 2012 and about 3 million loans by end of 2014. This compares well with the 2.16 million loans refinanced under HARP by 2012 and the 3.27 million loans reported by the US Treasury by December 2014.

The above analysis focuses only on HARP refinancing activity done on the GSE loans that were eligible under the program. However, the overall effect of the program on refinancing activity among the eligible loans also needs to account for any changes in refinancing activity that are induced outside the program. To do so we estimate the differential change in *total* refinancing activity – i.e., refinancing done under HARP or otherwise -- in the treatment loans relative to the control loans. We estimate a difference-in-difference estimation around the program start date, reporting the estimates on differential change in refinancing activity after conditioning on borrower and loan characteristics. Visually, as can be observed from Figure 1B, the overall effects on refinancing activity are similar to the direct treatment effect implied by the program refinances. In addition, there is no significant differential change in the refinancing rate between the treatment and control groups prior to the program, further validating our empirical design.

In Table 2A, we present the overall estimates of the program effect also accounting for various controls. In particular, in Columns (1) to (4) we use whether or not a loan refinances in a given quarter as the dependent variable and estimate the change in this variable for treatment loans relative to the control sample, accounting for a rich set of loan, borrower, and regional characteristics. The key explanatory variable is the *HARP Eligible* × *After Q1* 2009 that captures the differential change in refinancing rate of HARP eligible loans relative to confirming refinances after the program start date (after Q1 2009). The estimation is performed on quarterly data. On average, treatment loans see an increase in refinancing activity by about 1.4-1.7% every quarter.

Taken together, HARP induced a significant increase in refinancing activity, although a sizeable proportion of eligible loans did not refinance under the program. Moreover, our findings suggest the program did not lead to a significant substitution of refinances performed outside of the program with ones done under HARP. This is not surprising once we note that both the treatment

[14] It is worth noting that take up rate was initially on the slower side and picked up from December 2011 once "high LTV" loans (i.e., loans with LTV of greater than 125) were made eligible under the program.

and control groups experienced very low refinancing rates prior to the program, due to virtual shutdown of the refinancing market for loans with high LTV in the period before the program.

The analysis so far has focused on the extensive margin (i.e., new refinancing activity). In Table 2B we turn our attention to the intensive margin to assess the extent of savings received by borrowers refinancing under HARP. Columns (1) and (2) present the results for a sample of more than three hundred thousand loans that refinanced under the program where the dependent variable is the difference between the interest rate in a given quarter and initial interest rate. The variable, *After HARP*, takes the value of one in the quarters following the HARP refinancing date and is zero otherwise. The results suggest that borrowers refinancing under the program obtained a reduction of roughly 1.4 percentage points (140 basis points) in their mortgage rate. These results are robust to including MSA fixed effects as well as a variety of borrower and loan level controls. This is an economically significant reduction since the average pre-program mortgage rate among the eligible sample is 6.6%. As Columns (3)-(4) of Table 2B indicate, this mortgage interest rate reduction implies about $884 in savings to the borrowers per quarter, translating into about $7,000 in cumulative savings over the two-year period following the refinancing. We obtain similar results when analyzing the subset of HARP loans that are a part of matched sample described in Table 1.

Overall, the results in Section IV.B suggest that the program led to a significant increase in refinancing activity among eligible loans and, conditional on refinancing under the program there were significant savings received by the borrowers.

IV.C Micro Analysis: Consumer Spending

We now assess changes in consumer spending patterns around the refinancing activity under the program. In particular, we use individual consumer credit bureau records merged with the dynamic mortgage performance data using each borrower's SSN. This data allows us to observe the current credit history of mortgage holders during the months preceding and following the HARP refinancing date. Using this data, we can identify new auto financing transactions within each borrower (new purchases financed with auto debt or new car leases), since such transactions are usually accompanied by a significant discontinuous increase in a borrower's outstanding auto debt. It also allows us to measure a net dollar increase in new auto consumption associated with such new auto financing transactions (e.g., a difference between a new and prior auto debt level when new auto financing happens). As the vast majority of auto purchases in the U.S. are financed with debt (up to 90% according to reports by CNW Marketing Research), we will use these variables as empirical proxies capturing consumer durable spending patterns. We identify new auto financing transactions if the borrower auto balance increases in a given month by at least $2,000. Our results are robust to perturbations around these thresholds (e.g., $3000 or $5000 thresholds).

We first investigate whether borrowers change their durable spending patterns after HARP refinancing. For that purpose, we estimate a specification where the dependent variable takes the value of one if a new auto financing transaction takes place within a given borrower in a given quarter and is zero otherwise. We include a set of controls capturing borrower, loan, and regional characteristics. Again, the key control is the *After HARP*, which takes the value of one in the quarters following the HARP refinancing date. The results are presented in Columns (5) and (6) of Table 2B. The sample includes more than three hundred thousand loans that refinanced under HARP for which we have reliable auto balance data.

On average, there is an increase in the quarterly probability of new car purchases associated with new auto financing after the HARP refinancing by about 0.8%, implying 6.4% absolute increase during the two years following the refinancing. This amounts to an increase of about 10% relative to the mean level probability of new auto financing prior to the HARP refinancing. Columns (7) and (8) present similar regressions using the net dollar increase in auto debt associated with new auto financing transactions – i.e., the difference between new and prior auto debt in the quarter of new car purchase -- as the dependent variable. We find a net increase in the auto consumption on the order of $185-$198 per quarter after HARP refinancing, amounting to about $1,600 over the period of two years following the refinancing. We obtain similar results if we restrict the analysis to subset of HARP loans in the matched sample of Table 1. Combining this effect with the estimated savings due to HARP refinancing from Columns (3) and (4) of Table 2B suggests that the borrowers allocate about 20-22% of the extra liquidity generated by rate reductions to new car consumption. This elasticity is very similar to that in Di Maggio et al. (2017) who study the effects of rate reductions due to resets among borrowers with ARMs.

Next, we assess the dynamics associated with these spending patterns. We use the same specification as above but include a set of quarterly time dummies that capture the three quarters preceding the HARP refinancing and the eight quarters following the HARP. Appendix A.1 shows the estimated quarterly time. Borrowers do not display differential changes in the quarterly probability of new auto financing or net dollar increase in new auto financing prior to the HARP refinancing. After the HARP refinancing, however, we observe a significant increase in both the probability and net dollar amount of new auto financing. Although the largest effect occurs during the second quarter after refinancing, we observe a persistent increase in the probability of buying a new car and the associated net dollar increase in financing even two years after refinancing.[15]

Figure 2A shows the cumulative increase in the net dollar amount of new auto financing implied by the estimated quarterly time effects we discussed above. Borrowers display a net increase in

[15] Mian and Sufi (2012) analyze the CARS program consisting of government payments to dealers for every older less fuel efficient vehicle traded in by consumers for a fuel efficient one. They find that almost all of the additional purchases under CARS were pulled forward from the near future. Our contrasting results might reflect the different nature of stimulus: refinancing generates persistent interest savings that can amount to thousands of dollars over time.

new car consumption after the HARP refinancing, with the cumulative effect of about $1,600 over the two-year period. This economic effect is in line with the average effect reported in Table 2B.

Our analysis suggests that borrowers who refinanced under the program significantly increased their spending on durables (new cars). An obvious concern with taking these effects as being induced by refinancing is that the decision to refinance under the program could be endogenously determined along with other consumer activity (such as spending on cars). Notably, these effects are not only centered at the quarter of HARP refinancing but present across the board after the refinancing. Thus, our findings are not likely just due to endogenous timing by borrowers. Nevertheless, it is possible that borrowers initiated refinancing, anticipating a change in auto spending well into the future. We therefore conduct two more tests to shed more light on this issue.

First, we isolate our analysis to subset of high LTV borrowers who refinanced their loans in the vicinity of the program announcement. In other words, the decision to refinance for the bulk of these borrowers was essentially determined by the supply of refinancing – made possible once the program was initiated. We find similar effects for such borrowers.

In the second test addressing this concern, we assess changes in consumer spending among eligible loans relative to a control group of borrowers – i.e., loans in the non-GSE market with similar characteristics as loans eligible for HARP. We employ data from Black Knight Mortgage Analytics merged with credit bureau data from Equifax, which is similarly structured as our main sample. This data allows us to track the consumer spending patterns in the control group, including after refinancing in the private market. It also includes loans in the treatment group that were handled by the other GSE besides ours, affording us additional power. In essence, this test – given the broader data in the treatment group -- allows us to assess the external validity of our findings.

Appendix A.2 shows the results of this analysis. First, we confirm that we obtain a similar inference in this broader sample relative to our main analysis. As can be seen, the treatment and control groups are similar on observables in this broader sample. Moreover, treatment loans see an increase in refinancing activity by about 1.5% every quarter relative to the control group, which is very similar to the estimated 1.4-1.7% increase in Table 2. We also confirm that borrowers experience a similar consumption increase *after refinancing* in this sample as our results earlier. In unreported tests we find a net increase in the auto consumption (about $163 per quarter) after HARP refinancing in the broader sample, which is line with our estimates in Table 2B. Overall, these findings point to the broader validity of our results.

Next, we assess the impact of the program on consumption of eligible borrowers. Given our results so far, what should we expect in consumption of borrowers whose refinancing is caused by the program? Our results in Table 2A imply that the program induced about one-fourth of eligible borrowers to refinance their loans by December 2012. Notably, this increase in refinancing occurred gradually -- on average about 12.5% of borrowers participated in the program in a given quarter. Moreover, Table 2B provided the effect of HARP refinancing on new auto consumption. Thus, we would expect the quarterly increase in auto consumption among eligible borrowers -- relative to the control group -- to be roughly 12.5% of the estimated values presented in Table 2B.[16] That is, we should expect about $25 increase in new auto spending and about 0.1% increase in probability of buying a new car per quarter among eligible borrowers. This is precisely what we find. Appendix A.2 shows that the average quarterly increase in new auto spending in the treatment group relative to the control one after the program implementation is around $29-32 and about 0.1% increase in probability of buying a new car. This evidence is consistent with the increase in consumption after refinancing among eligible borrowers being induced by the program.

Next, we explore heterogeneity in these findings. In particular, we assess if these effects vary depending on the housing wealth of borrowers. We sort borrowers into two groups based on their housing wealth as proxied by their current LTV ratios. Figure 2B shows the estimated cumulative increase in net dollar amount of new auto financing in the above and below median LTV groups. As is evident, there is a significant heterogeneity in this effect across borrowers. During the first years after HARP refinancing, borrowers with lower housing wealth (above median LTV ratios) experience about a 20% larger increase in new auto consumption relative to borrowers with below median LTV ratios. These differential patterns are highly statistically significant and we also verify that they were not driven by the differences in mortgage balances or differences in mortgage rate reductions across these groups. In fact, after scaling new auto financing data by initial mortgage payments or the dollar amount of reductions due to HARP refinancing, we obtain similar relative differences in the cumulative patterns among these groups.[17] As we will show in Sections V and VI, while high LTV borrowers exhibit strongest responses to refinancing, they were also the group most adversely affected by competitive distortions embedded in HARP program design.

We conclude by investigating whether borrowers experiencing a larger reduction in interest rate show a larger increase in durable (auto) consumer spending. In particular, we estimate a specification where the dependent variable is a change in new auto financing after HARP refinancing (relative to its level prior to refinancing). We include a set of controls capturing borrower, loan, and regional characteristics as well as a variable, *Rate reduction*, which measures the extent of mortgage rate reduction due to HARP (in percentage points). Appendix A.3 shows these estimates. We find that borrowers experiencing a larger interest rate reduction due to HARP refinancing display a larger increase in durable spending. A one percentage point increase in rate reduction due to HARP is associated with a 0.12 to 0.2 percentage point increase in the quarterly

[16] In other words, the effect on consumption among eligible borrowers would reflect the increase in average participation rate (the extensive margin) times an increase conditional on refinancing (the intensive margin).

[17] These findings are consistent with life-cycle household finance models (Zeldes 1989; Carroll and Kimball 1996; Carroll 1997) that predict a larger increase in consumption due to a positive income shock among borrowers with lower wealth. Similarly, we find that borrowers with below median credit score – those more likely to face credit constraints -- increase their durable spending more after HARP refinancing relative to borrowers with above median credit scores. We find similar heterogeneity in borrower consumption in the sample used in Appendix 2.

probability of new auto financing and a net increase of about \$37 to \$55 in the quarterly new auto financing. These estimates do not capture the base effect of refinancing under HARP (on average borrowers receive a reduction of around 140 basis points). Rather, they reflect the relation between the extent of rate reduction and new auto financing among those that refinanced their loans.[18]

IV.D Regional Analysis: Refinancing Activity, Consumer Spending, Foreclosures and House Prices

In this section, we use regional data to assess the regional outcome variables such as consumer spending, foreclosures, and house prices. We rely on zip code data, since we do not have more micro data for variables like consumer credit card spending on non-durables or house prices.

As we noted in Section III.B, our analysis exploits regional heterogeneity in the share of loans that are eligible for HARP. We obtain a measure of ex-ante exposure of a region to the program, *Eligible Share*, as the regional (zip code) share of conforming mortgages with LTV ratios greater than 80% prior to the program implementation date. As discussed earlier, these loans are broadly eligible for the program. We account for general trends in economic outcomes over the time period of the study by focusing on the *relative* change in the evolution of economic outcomes during the program period. Our identification assumption is that in the absence of the program, and controlling for a host of observable risk characteristics including the pre-program evolution of house prices, the economic outcomes in regions (zip codes) with a larger share of eligible loans would have a similar evolution as those with a lower share, up to a constant difference.

We start with more than 10,000 zip codes for which we can compute the share of program eligible loans. Figure 3 shows the distribution of these zip codes in the data. There is a significant variation in the share of eligible loans across zip codes ranging from just few percent of all mortgages to more than 70% of loans being program eligible. We further confine our analysis to zip codes that have at least 250 mortgages and for which we have reliable data on outcome variables. This leaves us with a sample of about 3,400 zip codes.

We first verify that, consistent with our loan level evidence, zip codes with a larger share of HARP eligible loans are indeed more likely to experience more HARP refinances and consequently a larger mortgage interest rate reduction due to the program. A one percentage point absolute increase in the ex-ante share of eligible loans for HARP is associated with an increase of about 0.24 percentage points in the fraction of loans that refinance under the program (see Appendix A.4). Moreover, the "first stage" results in Columns (1)-(2) of Table 3A show that there is a strong association between the share of loans that are ex ante eligible for HARP and the average interest rate reduction due to the program in a zip code. The effects are economically meaningful: a one

[18] In unreported results, we address potential endogeneity of rate reduction by instrumenting for the extent of rate reduction with a level of market interest rate prevailing at the time of origination of legacy loan. This approach is similar to the one in Section V.C where we instrument legacy rate with the Treasury rate. The results are similar.

percentage point absolute increase in the ex-ante share of eligible loans for HARP is associated with a reduction of about 0.38 basis points in the average zip code mortgage interest rate.

We next turn to the association between the average mortgage interest rate reduction due to HARP and household spending on non-durables and durables. As Table 3B shows, consistent with our borrower-level results from Section IV.B, zip codes with larger rate reductions due to HARP experienced a relative increase in durable and non-durable consumer spending. A relative reduction of about 0.15% in mortgage interest rate payments due to HARP in a zip code is associated with a differential increase of about 0.13% in the credit card spending growth (Column 2) and an increase of about 0.2% in auto purchase growth (Column 4). Figure 4A and 4B plot the average growth in credit card spending and auto sales, respectively in more (above median *Eligible Share*) and less exposed (below median *Eligible Share*) zip codes to the program. Consistent with the results in Table 3B, these figures show that we observe a significant relative increase in spending growth in more exposed zip codes after the program implementation. Overall, these findings, similar to our micro evidence, suggest that following mortgage refinancing under the program, borrowers significantly increase their durable and non-durable consumption.[19]

We next investigate foreclosures and house price patterns across zip codes. The results in Table 3B indicate that regions more exposed to HARP experienced a relative improvement in the housing market. The estimates in Table 3B imply that a relative reduction of about 0.15% in average mortgage interest payments in a zip code is associated with a decline of about 0.025% in the foreclosure rate (Column 6) and an increase of 0.13% in the house price growth rate (Column 8). Figure 4C reinforces these findings by showing that the areas more exposed to the program experienced relative improvement in house prices after the program implementation.

Overall, these findings support the view that policies aimed at reducing mortgage rates can have a meaningful impact on consumer spending and house prices. This evidence is consistent with Agarwal et al. (2017), who find that mortgage modification programs, when used with sufficient intensity, may improve a range of economic outcomes. It is also consistent with Di Maggio et al. (2017) who show that a sizable decline in mortgage payments due to ARM resets induces a significant increase in new financing of durable consumption and an improvement in household credit standing.

Taken together, our evidence in this section suggests that borrowers and regions exposed to the program experienced a sizable increase in consumption. However, as we already established in Section IV.B, a significant proportion of eligible borrowers did not participate in the program. In

[19] In unreported results we also find that the regions more exposed to HARP experienced a relative reduction in consumer debt delinquency rate (a reduction of 10 basis points in the average zip code mortgage rate due to HARP being associated with a 0.4% reduction in the quarterly consumer debt delinquency rate). This finding suggests that borrowers use some of the extra liquidity generated by mortgage rate refinancing to service and repay their debts.

the next section we explore whether competitive frictions in the refinancing market inhibited program participation and the pass-through of lower interest rates to households, thereby adversely affecting the program impact on consumer spending among eligible borrowers.

V. Role of Competition in Inhibiting Program Effectiveness

V.A Descriptive Statistics

As noted in Section III.B, we start our analysis by constructing a simple measure that captures the difference in interest rates on mortgages refinanced though HARP and on conforming ones that are refinanced outside of the program. This measure allows us to quantify the extent of pass-through of lower interest rates to borrowers on HARP refinances *relative* to conforming ones with higher rates being associated with a lower pass-through. Notably, in the absence of competitive pressure, lenders may have incentive to charge borrowers higher rates on HARP refinances because such mortgages can generally be sold for more in the secondary market.[20]

We define the *HARP-conforming refi spread* as the difference between the interest rates on a given HARP loan and the interest rate on a randomly assigned conforming mortgage in the data – i.e., those with LTV of 80% -- originated during the same calendar month, in the same location (MSA), and for a borrower with a similar FICO credit score at the time of refinancing.[21] As noted, the latter group represents conforming mortgage contracts of creditworthy borrowers carrying significant housing equity that could be refinanced outside of HARP, and for whom the refinancing process remained fairly unobstructed throughout the crisis period.

Importantly, in computing this spread we take advantage of the fact that the credit risk of these loans to investors is fully insured by the GSEs. As we discussed in Section II, GSEs charge predetermined fees (g-fees) for insurance of credit risk and these fees are reflected in mortgage rates charged to the borrower. We use our precise data on actual g-fees charged on each loan and remove this fee from interest rates charged to borrowers on HARP and the benchmark conforming loans while computing the *HARP-conforming refi spread*.[22] Consequently, the *HARP-conforming refi spread* should not reflect the relative difference in credit risk between HARP and conforming mortgages, which includes differences in credit scores and LTV ratios.

We focus on the period 2009-2012, which broadly corresponds to the first three years of program implementation. We later extend this analysis through the first half of 2013, a period that featured

[20] Note that as GSEs fully insure credit risk of conforming loans, the consideration that higher rates may lead to more defaults and losses is relatively unimportant for the investors in the secondary market.
[21] The conforming loan has FICO score within 20 points of the corresponding HARP loan. To avoid concerns about interest rate term premiums, we restrict our attention to 30-year FRMs, the most common HARP refinanced loan.
[22] As discussed in Section II, HARP pricing surcharges were in form of upfront fees, typically converted into periodic interest rate charges. We use this actual conversion to adjust the observed interest rates on HARP loans.

changes in program rules as discussed in Section II.C. Notably, the vast majority of refinancing under HARP occurred until mid-2013 (more than 80%), and thus are covered by our analysis.

The first column of Table 4A confirms the existence of a sizeable mortgage rate differential between HARP and conforming loan refinances. Over the course of 2009-2012, the *HARP-confirming refi spread* (g-fee adjusted) averaged about 16 basis points suggesting that there might be support for market power driven pricing of HARP loans. This markup is substantial relative to mean interest rate savings on HARP refinances in our sample (about 140 basis points).

Next, we assess if the spread is related to HARP specific features, by constructing an alternative benchmark interest rate spread between regular conforming (non-HARP) refinances in which existing servicers may also have some market power and purchase mortgages in which there is likely no such advantage. With refinancing transactions, an existing relationship might confer some competitive advantage to the existing servicer, whether through lower (re-) origination costs or less costly solicitation. In our analysis we compare conforming refinancing transactions with conforming purchase ones, both of which have an LTV of 80 – since the market for conforming LTV 80 mortgages – both refinancing and purchase – are very liquid and quite competitive.

Columns (3) and (5) in Table 4A show the resulting *conforming refi-purchase spread*, computed as the difference between average interest rates on conforming refinances and purchase transactions originated in the same month. The data confirm that market competitiveness kept a tight lid on whatever advantages the existing servicer might have had in the conforming refinancing market. In particular, during the period preceding HARP 2005-2009, the average *conforming refi-purchase spread* was virtually zero (-0.55 basis points in Column (5)). Notably, the spread remained below 3 basis points even during the crisis period (2009-2012) corresponding to the time of HARP implementation in our study (Column (3)). These results suggest that the conforming refinancing market operated with more lender competitiveness than the HARP market.

Table 4A provides further evidence on the central feature of HARP discussed at length in Section II.B, namely, the preferential treatment of existing servicers. Such asymmetry in treatment may lead to an unusually high share of new loans refinanced through the existing (or "same") servicers under HARP. Consistent with this view, as shown in Column (1), among HARP transactions conducted during 2009-2012, 54% of loans were refinanced by the existing servicer. On the other hand, as shown in Column (3), during the same period only about 33% of regular conforming loans were refinanced with the same servicer. This number is even lower – about 1 in 5 -- during the period preceding the crisis (Column (5)).

Our discussion in Section II.B focused on the likely relationship between loan LTV and the degree of pricing power afforded to the existing servicer under HARP. Table 4B breaks down the key summary statistics of HARP refinances by four LTV categories: LTV ranging from 80 to 90, 90 to 105, 105 to 125 and greater than 125. We observe that the *HARP-conforming refi spread* increases substantially with LTV despite the fact that in computing this spread we removed adjustment by GSEs (g-fees) that accounts for differential mortgage credit risk due to higher LTV ratios. In particular, the spread for loans with LTV greater than 125 is nearly thrice (33.7 basis points) that for loans with LTV between 80 and 90. However, even for the loans closest to the regular conforming LTV levels (those in the 80-90 LTV category), the average spread persists at a non-negligible level of 11 basis points. These differences exist despite that the fact that the borrower and loan characteristics in this subsample of 80-90 LTV loans (Column (1) in Table 4B) are quite similar to those for the subsample of 80 LTV conforming refinancing loans (Column (3) in Table 4A). Moreover, these differences exist even though we account for variation in interest rates due to differences in credit risk by removing g-fees in computing this spread. Table 4B also reveals that the fraction of loans refinanced by the same servicer also substantially increases with mortgage LTV ratios: about 51% of loans with LTV ranging from 80-90% were refinanced by the same servicer compared with 78% of loans with LTV higher than 125%.

V.B Cross-Sectional Variation in HARP-Conforming Refi Spread

We build on the analysis in Table 4 by systematically evaluating the determinants of the *HARP-conforming refi spread* by estimating the loan-level specifications of the following form:

$$\left(r_{i,t}^{HARP} - r_{i,t}^{COMF}\right) = \alpha + \beta X_{i,t} + \varepsilon_i. \quad (1)$$

The dependent variable, $\left(r_{i,t}^{HARP} - r_{i,t}^{COMF}\right)$, is the *HARP-conforming refi spread* for the HARP loan refinanced at *t* by borrower *i*.[23] $X_{i,t}$ is a vector of controls that consists of a set of borrower and loan observable characteristics such as LTV all measured at *t*, and any remaining differences in these characteristics between the HARP loan and the corresponding conforming loan.

As a first step, we compare the mean spread across the four LTV categories, treating loans with LTVs between 80 and 90 as the omitted group. Column (1) of Table 5 confirms our earlier finding of uniformly positive fee-adjusted *HARP-conforming refi spreads* that are monotonically increasing in LTV. As we observe in Column (2), after accounting for characteristics such as borrower FICO scores, MSA fixed effects, year-quarter fixed effects for timing of refinancing transactions, and servicer fixed effects, we still find that *HARP-conforming refi spreads* is monotonically increasing in LTV. HARP loans with the highest LTV (LTV > 125) carry rates that are about 15.7 basis points higher than HARP loans in the excluded category (80 < LTV ≤ 90), which amounts to more than a 140% increase in the rate spread relative to that group. Since we

[23] This spread is computed as the difference between the interest rate (net of its g-fee) on the loan by borrower *i* that was refinanced under HARP at time *t*, $r_{i,t}^{HARP}$, and $r_{i,t}^{CONF}$, which is the monthly interest rate (net of its g-fee) of a conforming mortgage with LTV of 80%, originated during the same calendar month, in the same location (MSA), and to a borrower with a similar FICO credit score at the time of refinancing as the HARP loan of borrower *i*.

remove the exact g-fee that GSEs charge for insuring credit risk, it is unlikely that sizeable positive spread among HARP loans with high LTV ratios reflects greater default risk of these loans.

We next assess the robustness of the descriptive statistics related to refinancing by incumbent bank for loans financed under HARP relative to those in the conforming market in Columns (3) and (4) of Table 5. Consistent with our prior evidence, HARP loans with higher LTV ratios are much more likely to be refinanced by the same servicer compared with conforming refinances that serve as an excluded category (33% of conforming loans are refinanced by the same servicer). The coefficient for LTV>125 in Column (4) shows that, conditional on observables, HARP loans with LTV ratios greater than 125 are more than twice as likely to be refinanced by the same servicer compared with conforming refinances (33%+39%=72% versus 33%).[24]

V.C Variation in HARP-Conforming Refi Spread: Using Legacy Interest Rates

While potentially suggestive, our evidence in Section V.B may reflect other omitted factors. To address this concern, we next exploit variation *within* HARP borrowers. We develop and test the conjecture that the legacy interest rate on the mortgage prior to refinancing is also systematically related to the degree of pass-through under HARP. Specifically, we expect that, in the presence of competitive frictions, between two HARP loans that are identical on every dimension except for the legacy interest rate, the loan with the higher legacy rate would obtain a higher post-refinancing rate. Appendix B illustrates this concept in greater detail.

To investigate the above conjecture of the positive relationship between the legacy interest rate and the interest rate on HARP refinances we estimate the following loan-level specifications:

$$\left(r_{i,t}^{HARP} - r_{i,t}^{COMF}\right) = \alpha + \beta X_{i,t} + \gamma \times r_i^{Previous} + \varepsilon_i. \quad (2)$$

As in specification (1) the dependent variable, $\left(r_{i,t}^{HARP} - r_{i,t}^{COMF}\right)$, is the *HARP-conforming refi spread* of the loan by borrower *i* refinanced under HARP at time *t* and $X_{i,t}$ is a vector of observable borrower and loan characteristics associated with the loan. Because we are interested in assessing the relation between this spread and the legacy interest rate, we include an additional control variable, $r_i^{Previous}$, which reflects the interest rate on the loan before HARP refinancing by borrower *i*. γ measures the association between *HARP-conforming refi spread* and the legacy rate.

[24] It is natural to ask if these effects are present uniformly across lenders. To the extent that our controls capture the relevant borrower, loan, and regional characteristics one would expect no significant difference in the HARP spread across lenders, if the refinancing market was fully competitive. Appendix A.6 plots the *HARP-conforming refi spread* for different lenders in our sample. The coefficients (with 95% confidence intervals) correspond to lender fixed effects from the specification that corresponds to column (2) of Table 5. Controlling for other observables, there is a sizable and statistically significant variation in the *HARP-conforming refi spread* across the lenders, ranging from as low as -20 basis points to about 20 basis points. There is also a strong positive relation between the magnitude of the spread charged by a lender and the lender's size (proxied by log assets) with the correlation being 56%. This evidence is consistent with the notion that lenders with market power extract surplus from borrowers.

Table 6A shows the relation between the *HARP-conforming refi spread* and the legacy interest rate. The panel preserves the setup of Table 5, while adding the mortgage rate prior to refinancing as a control variable. We estimate a post-refinancing markup of about 9.6 basis points per 100 basis points in the higher legacy rate, holding borrower and loan characteristics fixed. This effect implies that the 100 basis points higher legacy rate is associated with a more than 50% increase in the markup relative to its mean level and about a 7% reduction in interest rate savings compared with average savings on HARP refinances. Notably, borrowers with higher LTVs continue to suffer from higher *HARP-conforming refi spreads* even conditioning on the legacy rate.

It is possible that, despite accounting for variety of a borrower, loan, and regional characteristics, our results may still be driven by some unobservable factors correlated with higher legacy rates. To address this issue we rely on Section II.A where we discussed that mortgage pricing is tightly linked to the benchmark Treasury rates. In particular, we instrument the legacy interest rate on a mortgage with the 10-year U.S. Treasury yield prevailing at the time of origination of the legacy mortgage to obtain variation in the borrower's legacy rate that is exogenous to individual and regional characteristics.[25] This analysis produces similar results suggesting that unobserved borrower or regional level variation are not likely impacting our findings.

V.D Evidence from "Difference in Difference" around the Program Change

In our main test of competitive frictions, we establish a *direct* connection between changes in the degree of competition in refinancing market and the interest and take-out rates. We take advantage of the change in the program rules regarding the assumed legal risk of servicers for loans they were refinancing. As discussed in Section II.C, from January 2013 the program rules were changed significantly, limiting the legal risk of a lender who refinances a loan originated by another lender. Accordingly, we expect this policy change to result in a more competitive HARP market, leading to a reduction in the *HARP-conforming refi spread* and an increased program participation rate.

To investigate this, we estimate the loan-level specifications of the following form:

$$\left(r_{i,t}^{HARP} - r_{i,t}^{COMF}\right) = \alpha + \beta X_{i,t} + \delta \times (2013\ HARP\ Refi)_i + \varepsilon_i. \quad (3)$$

[25] Table 6B shows that there is indeed a strong association between 10-year U.S. Treasury yield and mortgage rates – a 1% increase in the 10-year Treasury rate is associated with a highly statistically significant 0.55% to 0.61% increase in the mortgage rate. Moreover, the high R^2 values of 0.45 in the baseline model (Column 1) and 0.50 in the full model (Column 2) indicates that mortgage rates indeed track the "risk free" rate quite closely. We investigate the relationship between the *HARP-conforming refi spread* and the predicted legacy mortgage rate from the first stage regression. Focusing on the full specification, where we effectively exploit *within-quarter* variation in the relationship between Treasury rates and legacy mortgage rates, we find the estimated coefficient on the instrumented prior rate (10.91) is similar in magnitude to the estimated coefficient on the observed rate (9.61) obtained through the OLS model of Table 6A. The full specification contains categories for LTV range, FICO, FICO squared, MSA fixed effects, servicer fixed effects and, importantly, for the quarter-year fixed effects corresponding to the date of origination of the legacy loan.

We follow the same structure as specification (2) with a few changes. First, we focus on a new and extended time period, mid 2012 through the end of our sample period (mid-2013). Second, we add a dummy variable, *2013 HARP Refi*, which equals one for loans refinanced under the HARP program in the first half of 2013 and zero for those refinanced in 2012. As before, the vector of the control variables X captures the borrower and loan characteristics measured at the time of HARP refinancing as well as the legacy interest rate on the loan. The key coefficient, δ, measures the change in the *HARP-conforming refi spread* around the program change in January 2013.

Before doing the formal analysis we explore how the two groups of loans in the difference-in-difference analysis compare on various observables before the program change. First, we explore the pre-program change evolution of FICO and LTV of borrowers in HARP refinances relative to conforming refinances (see Appendix A.5). We find that the difference in LTV ratios across borrowers in the two groups remains constant in the pre-program period. In particular, the average LTV ratio for HARP refinances consistently remains about 30% above that for conforming refinances, with little relative change over time. Recall that, by construction, conforming refinances have LTV ratios equal to 80%. Likewise, we do not observe any differential change in the borrower credit scores between the two groups in the pre-program change period. Thus, the two groups of loans seem well situated for us to conduct our analysis.

Table 7 presents the results.[26] As can be observed across Column (1) and (2), δ is negative and significant, implying that there is a substantial reduction in the *HARP-conforming refi spread* after the program change. A borrower who refinances under HARP during the first half of 2013 enjoys, on average, a discount of around a 9.03 basis points relative to an otherwise similar borrower who secured a HARP refinance during the second half of 2012. The estimated size of this effect is stable, ranging from -8.11 to -9.03 basis points, across specifications that account for a plethora of borrower, loan, and regional level as well as servicer fixed effects.

To confirm that the change in the spread occurs precisely around the program change, we explore the timing of the effects documented in Table 7. In particular, we replace the *2013 HARP Refi* dummy in specification (3) with monthly dummies corresponding to the month in which a given loan was refinanced under HARP (the excluded category is loans made in June 2012). This specification allows us to investigate the monthly changes in the *HARP-conforming refi spread* around the program change in January 2013. We present the results in Figure 5A. Two facts are worth discussing. First, the *HARP-conforming refi spread* remains at a stable level in 2012. Note that what we have plotted are demeaned spreads. The average spread during this period is about 27 basis points. Second, and more important, there is a sharp reduction in the spread by about 10

[26] Note that the specification above already removes g-fees that accounts for borrower credit risk. Moreover, since our dependent variable is measured relative to conforming refinances, any movements in the refinancing market that also affect conforming refinances are differenced out.

basis points precisely in January 2013. This amounts to more than 30% reduction in *HARP-conforming refi spread*. This difference persists until the end of our sample period.

Finally, we investigate the impact of the program change on the refinancing rate of eligible borrowers. For that purpose, in Column (3) and (4) of Table 7, we estimate a similar specification to (3) but where now the dependent variable takes the value of 1 if the loan refinances in a given month and is zero otherwise. The excluded category is loans that are eligible for conforming refinances (loans with current LTV as of June 2012 less than 80). The key coefficient of interest is the *2013 × HARP*, which captures the change in the refinancing rate of HARP eligible loans relative to conforming loans. Column (4) of Table 7 shows that, after the program rule change, we observe a 0.12 percentage point increase in the refinancing rate among eligible loans (about a 6% relative increase). Figure 5B verifies that the timing of this effect coincides with the change in the program rules. We also verify that almost all of this increase can be accounted for by an increase in the HARP refinances among eligible loans following the change in the program rules.

Our evidence suggests that an increase in competition between servicers resulted in a meaningful decline in interest rates on *HARP* refinances (intensive margin) and an increase in the HARP refinancing rate (extensive margin). We next assess market wide effects of competitive frictions.

V.E Assessing Market Wide Effects of the Competitive Frictions

Our evidence in Sections V.A-V.D suggests that the limited competition had meaningfully reduced the pass-through of lower interest rates to consumers. The estimates we obtain are substantial. We find that, on the intensive margin, borrowers would receive a 10 to 20 percentage points higher reduction in mortgage payments if HARP refinances were priced as competitively as conforming refinances (after accounting for g-fees). Moreover, on the extensive margin -- after applying the estimates from Section V.D to the stock of all eligible loans as of the program start date -- the refinancing rate among eligible borrowers would be 9.6 percentage points larger by December 2012 if the HARP-conforming spread was zero. In addition, this effect on take up rates due to elimination of the HARP interest rate markup is about twice as large (19.8 percentage points) among eligible borrowers with high LTV ratios (LTV>125).[27]

Notably, this stronger extensive margin effect of markups could be particularly detrimental for consumption response obtained from the program. The reason is that, as we showed in Section IV.C, these highly indebted borrowers display (conditional on refinancing), a larger increase in

[27] In computing these effects we note that the estimates in Table 7 imply that a decline of about 1 basis point in the HARP-conforming refi spread is associated with a 0.013% increase in the monthly refinancing rate among eligible borrowers. Assuming that this estimate is applicable over the initial 45 months of the program (until December 2012) and taking into account that average HARP-confirming refi was about 16 basis points, implies that reducing this spread to zero would increase the refinancing rate by about 9.6%. As the spread for loans with LTV>125 is about 33 basis points (Table 4B) performing the same computation for this subset implies that reducing the spread to zero for these loans would increase the refinancing rate by about 20%.

spending from savings they receive from refinancing. Thus, the competitive frictions operating through both extensive and intensive margin, may have meaningfully reduced the program impact on consumer spending among eligible borrowers (especially in its first few years). [28]

VI. Interpreting our Findings in a Quantitative Life-Cycle Model of Refinancing

VI.A Quantitative Life-Cycle Model of Refinancing

We now develop a life-cycle model of refinancing that quantitatively rationalizes these empirical patterns and helps evaluate welfare effects of altering the refinancing market by removing the housing equity eligibility constraint, like HARP did, and lowering competitive frictions.

We consider a setting where a household lives for finite number of discrete life-cycle periods, t = 0, . . . , A, with a probability of survival from period $a - 1$ to a of λ_a, and $\lambda_A = 0$. Calendar time is indexed by t, with periods of the same length as the life-cycle periods; household age in calendar period t is denoted by a_t. Every period until retirement at age a_R, the household receives labor income $Y_t(a_t)$ that follows an exogenous stochastic process. After retirement, the household receives a constant fraction of its last labor income $Y_t(a_R)$ until death. The household chooses consumption of housing services S_t and other goods C_t (the numéraire) every period to maximize expected lifetime utility. The per-period utility function $u(C_t, S_t)$ is assumed to satisfy the usual properties of being strictly increasing and concave in its two arguments arguments. Lifetime utility at age $a_t = 0$ is given by

$$E_t \left\{ \sum_{t=0}^{A} \beta^t \left[\Lambda_{a_t} \lambda_{a_{t+1}} u(C_t, S_t) + \Lambda_{a_t} (1 - \lambda_{a_{t+1}}) B_t \right] \right\},$$

where B_t is the bequest the household leaves to its children in case it does not survive until period $t + 1$, and $\Lambda_{a_t} = \prod_{s=0}^{t} \lambda_{a_s}$ is the unconditional probability that the household is alive in period $t < A$.

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[28] As a further check, we explore whether the program was less effective in regions with a larger concentration of servicers with higher *HARP-conforming refi spreads* – i.e., those that charge borrowers' higher rates on loans refinanced under the program. Recall from Section V.B that a significant servicer level variation in the *HARP-conforming refi spread* that is not accounted for by borrower, loan, and regional level characteristics. To conduct this analysis, we classify the top quartile of servicers with the highest estimated fixed effects in Appendix A.6. These high cost servicers account for more than 60% of loans in our data. Consequently, we compute the zip code level *Eligible and High Cost Servicer Share* as a fraction of loans in a zip code that both are program eligible and are serviced by high cost lenders. Regions where a larger share of eligible loans is handled by high cost servicers do experience significantly lower rate reduction due to HARP. Our estimates (Appendix A.4) suggest that on average the pass-through of lower interest rates to consumer through program refinances would be about 35% lower in a zip code where all eligible loans are serviced by high cost servicers compared with a zip code where all eligible loans are serviced by low cost servicers. Both the intensive and extensive margin play an important role: fewer HARP eligible borrowers (about 17% less) would refinance their loans in the areas where all eligible loans were handled by high cost servicers.

A house of size H_t produces housing services with the linear technology $s_t = H_t$. A unit of the housing asset sells for price P_t. In addition to the housing asset, the household can save the amount L_t in a risk-free bond. The household can also borrow an amount M_t in mortgage debt. The market interest rate for new mortgage contracts in period t ("market rate") is given by the combination of the short-term risk free rate plus a mortgage spread ς:

$$r_t^M = r_t + \varsigma.$$

In order to borrow, the household has to own a house and use part of its value as collateral. In particular, when the household buys a house, it can at most borrow an amount $(1 - \delta_H)$ of the house value to finance the purchase, where δ_H is the fraction required as a down payment:

$$M_t \leq (1 - \delta_H) P_t H_t$$

At the time of the house purchase, the household needs to pay a mortgage closing fee proportional to the mortgage principal, υM_t. The contract fixes the current market rate and the initially chosen mortgage principal for the duration of the mortgage. The mortgage principal amortizes at a fixed rate of δ_M. Further, mortgage interest payments are deductible from taxable income at a marginal tax rate of τ_I. We assume that houses are illiquid, and that selling a house requires a transaction cost ρ that is proportional to the value of the house. The effective proceeds from selling a house of size H in period t are hence $(1 - \rho) P_t H$.

We assume individual household income is given by

$$Y_{t,i} = \bar{Y}_t \tilde{Y}_t^A exp\left(f\left(a_{t,i}\right) + \eta_{t,i}\right),$$

where $\bar{Y}_t$ is the level of aggregate per-capita income growing at deterministic rate g,

$$\bar{Y}_t = \bar{Y}_{t-1} exp(g),$$

and $\tilde{Y}_t^A$is the cyclical component of aggregate income with mean one. Both $f\left(a_{t,i}\right)$ and $\eta_{t,i}$ are idiosyncratic income components: $\eta_{t,i}$ is a mean-zero income shock and $f\left(a_{t,i}\right)$ is the deterministic age-specific mean income. Idiosyncratic income shocks are persistent and follow an AR(1) process at the level of the individual household

$$\eta_{t,i} = \rho^\eta \eta_{t-1,i} + \epsilon_t^\eta,$$

where ϵ_t^η is i.i.d. with mean zero and standard deviation σ_η. Similarly, house prices follow the process:

$$P_t = \bar{P} \bar{Y}_t \tilde{P}_t^A,$$

where $\bar{P}$ is a constant determining the scale of house prices relative to trend GDP, and $\tilde{P}_t^A$is the cyclical component of house prices with mean one. Given our assumption on preferences and the partial equilibrium setting, only housing expenditure matters from the perspective of household optimization. Therefore, $\bar{P}$ is merely a normalization.

Together with the cyclical components of income and house prices, the risk free savings rate follows a first-order vector autoregressive process (VAR). Denote the vector containing three aggregate state variables as $Z_t = [\tilde{Y}_t^A, \tilde{P}_t^A, r_t]'$. Then

$$\log(Z_t) = A + B\log(Z_{t-1}) + \epsilon_t ,$$

where A is a 3x1 vector and B is a 3x3 matrix of coefficients, and ϵ_t is a 3x1 vector of mean-zero innovations with variance-covariance matrix Σ.

We use power utility with coefficient γ and a Cobb-Douglas aggregator over nondurable and housing consumption:

$$u(C_t, H_t) = \frac{\left(C_t^{1-\chi} H_t^{\chi}\right)^{1-\gamma}}{1-\gamma}.$$

The Cobb-Douglas exponent χ parameterizes optimal housing expenditure. For the bequest motive, we adopt the functional form

$$B(W_t) = \bar{B}\,\frac{(W_t \bar{P}^{-\chi})^{1-\gamma}}{1-\gamma}.$$

Bequest utility has the same power form in total wealth as regular utility. Parameter $\bar{B}$ determines the strength of the bequest motive. Similarly, for the utility penalty of defaulting households, we assume

$$\Delta(W_t) = \kappa\,\frac{(W_t \bar{P}^{-\chi})^{1-\gamma}}{1-\gamma},$$

with κ determining the magnitude of the penalty.

We can summarize terms of a mortgage contract that a household has obtained in some previous period by the remaining mortgage balance and the "locked-in" mortgage rate. To describe the decision problem of the household, it is useful to distinguish the following cases.

1. The household always has the option of staying in the current house and keeping the same mortgage terms, while either staying on the fixed amortization schedule or prepaying part of the mortgage balance. This means the mortgage rate going into next period stays fixed.
2. The second option is to stay in the current house, but refinance the mortgage at the current market rate. In this case, the closing fee needs to be paid. In the absence of HARP, in order to refinance, households need to satisfy the housing equity constraint: the LTV ratio of the new

loan with respect to the current market value of the house cannot exceed 80%. Consequently, households who experienced a sufficient decline in their home values are ineligible for refinancing unless they save enough to deleverage. Introduction of HARP is equivalent to removal of this refinancing eligibility constraint.

3. The third option is to buy a new house and obtain a new mortgage at the market rate. In this case, the closing fee needs to be paid and the down payment requirement is enforced with respect to the value of the new house.
4. Finally, the household can choose to default on its mortgage. In this case, the mortgage debt is erased, the house is seized by the mortgage lenders, and the household has to rent for its remaining life. Further, the household incurs a one-time additive utility penalty that is an increasing function of household wealth.

For brevity, we leave a formal statement of the value functions to Appendix C, which also discusses in detail the numerical solution of the model. Our benchmark calibration strategy is as follows. The housing related parameters are set to common values in the literature on housing markets that represent long-run estimates. We calibrate the remaining preference parameters to match data moments from the 2010 Survey of Consumer Finances (SCF). To determine the coefficients of the VAR for the exogenous state variables, we estimate a VAR on the GDP per capita, price index based on private residential fixed investment and one-year treasury, all annual for the period 1954-2016. More details are provided in Appendix Section C.4.

Figure C.1 in Appendix C shows that the model does a good job of replicating the patterns of the average wealth-to-income and house value-to-income ratios in the cross-section of households in the 2010 SCF.[29] Overall, the model provides a close enough fit to the data that we are comfortable using it to assess the counterfactual effects of altering the refinancing market.

VI.B Quantifying the Consumption and Welfare Effects of Program Features

To examine the effect of program features on household well-being, we start by simulating optimal consumption and refinancing of a large sample of households in the model with age, income and house value close to the median borrower in the sample. We do this in settings with and without features of the HARP program. In these simulations, we assume that these households have the same low initial liquid savings as we vary the loan-to-value ratio holding *constant* the mortgage principal (i.e., we vary the ex-post house values, all else kept the same). We evaluate the short-term consumption effect as well as the long-term gain to eligible borrowers using our model by computing (i) the average annual change in consumption over the first three years of the program and (ii) the lifetime welfare gains as a percentage of the borrower utility due to the program.

[29] As is common in life-cycle models with housing and mortgage choice, the model somewhat overstates leverage of old households relative to the data.

Counterfactual: Removing the Housing Equity Eligibility Constraint (HARP)

This counterfactual assesses the impact of HARP, since its introduction is equivalent to removal of the 80% LTV refinancing eligibility constraint. Table 8A shows the average change in annual consumption due to HARP in the first 3 years of the program relative to the world without HARP in the cross-section of borrowers based on their current LTV ranges and their pre-refinance mortgage rate (majority of HARP eligible borrowers have prior mortgage interest rates ranging from 5.5% to 7%). These results are calculated based on model simulations, assuming the borrower can refinance to an average mortgage rate of 4.5% plus the monopolistic markups obtained from our results in Table 4B. Most borrowers experience a significant increase in annual consumption due to HARP ranging from $600 for least indebted borrowers, with low prior rates to $2,870 for most indebted borrowers, with high initial prior rates. The consumption response increases with the borrower's LTV (holding the prior rate constant). This is consistent with our empirical findings showing a stronger consumption response among borrowers with higher LTV ratios.

Overall our model implies that borrower consumption increases from about 40% of extra liquidity generated from rate reductions for less indebted to about 80% for most indebted. These model-implied estimates of consumption increase due to HARP are consistent with our estimates from Section IV.C. Notably, our empirical estimates suggest that, on average, households allocate about 20-22% of the extra liquidity generated by rate reduction to new car consumption (about $800 per year). Using a method similar to Di Maggio et al. (2017) we can infer the overall consumption response to be in the order of 50 to 80% of additional disposable income, which given the estimated magnitude of the stimulus, is in line with the model implied consumption response.

These estimates also imply that more than 3 million borrowers who refinanced their loans under HARP increased their consumption in the aggregate by about $20 billion during the first 3 years after refinancing. We obtain this by applying the average propensity to spend from the refinancing stimulus implied by our model to all the borrowers who refinanced under HARP and received about $3,500 average reduction of their annual mortgage interest payment. Note that the longer-term effect on annual consumption of these borrowers can be a bit ambiguous since even in a world without HARP, highly indebted borrowers who do not default eventually refinance by paying down a sufficient fraction of the debt from savings.

Table 8B shows the welfare gains due to HARP as a percentage of the borrower's lifetime utility in the cross-section of borrowers based on their current LTV and their pre-refinance (prior) mortgage rate. Eligible borrowers experience substantial welfare gains due to HARP, amounting to about 6.9% increase in their lifetime utility. Like in the case of consumption increase, the utility gains due to HARP increase with the borrower current LTV ratio and with the prior interest rate and range from about 0.4% for least indebted borrowers with relatively low prior rates to more than 10% for most indebted borrowers with higher prior rates. The large utility gains for the most indebted borrowers are due to avoiding costs of mortgage default and foreclosure that can occur with fairly high probability among these borrowers in a world without the refinancing program.

Counterfactual: HARP with Lowered Competitive Frictions

We now conduct a counterfactual to assesses the impact of HARP in an environment with no monopolistic markup by lenders who help borrowers refinance. Table 8C shows the additional welfare gains as a percentage of the borrower's lifetime utility that arise by eliminating the HARP interest rate markups. We follow the same procedure to compute this as discussed earlier. Removal of HARP markups results in substantial increase in the borrower lifetime utility averaging about 0.6% of lifetime utility. This ranges from about 0.2% for least indebted borrowers with relatively low prior rates to about 1.5% for most indebted borrowers with high prior rates.

These gains arise from two sources. First, removal of HARP interest rate markups increases savings and consumption of borrowers who would have also refinanced under HARP with markups (intensive margin). Second, by increasing savings from refinancing, the removal of HARP markups also increases the take up rate of the program (extensive margin).

Figure 6A sheds light on the first effect by comparing the consumption increase due to HARP of typical borrowers in our data. who refinance their loans under both regimes. Removal of HARP markups results in an additional annual increase in consumption ranging from $150 for least indebted to about $300 for most indebted ones.

To assess the effect on the extensive margin, we focus on a representative sample of more than a million GSE loans that were eligible for the program as of its implementation date in March 2009. Figure 6B shows the percentage of borrowers who refinanced their loans during the first three years based on the optimal refinancing implied by our model. Top black solid line shows the case in which HARP allows borrowers to refinance with no monopolistic markups. The middle solid gray line shows the case in which borrowers refinance but face the monopolistic markups under HARP. The bottom dashed gray line shows the case when there is no HARP.

The impact of HARP and markups on the refinancing take up increases with borrower's LTV. Among borrowers with LTV ratios between (0.8,0.9] about 30% refinance in the absence of HARP during the first three years. They do so by deleveraging to be eligible for regular refinancing. Introducing HARP with markups increases the refinancing rate of these borrowers to about 50%. The removal of HARP markups pushes the refinancing rate up to about 56%. On the other hand, virtually none of the borrowers with LTV ratios greater than 125% would be able to refinance their loans in the absence of HARP. Introducing HARP with markups allows about 63% of these borrowers to refinance their loans during the first 3 years of the program. The removal of HARP markups pushes the refinancing rate of these borrowers up to about 82%. Overall, these model-based estimates indicate that removal of HARP markups results in a substantial increase in the refinancing rate of eligible borrowers ranging from 6 (for least indebted) to about 20 percentage points (for most indebted). It is worth noting that the magnitude of these effects is similar to the one implied by extensive margin effects based on our empirical estimates from Section V.

VII. Conclusion

We underscore the importance of the mortgage refinancing as one of the key channels of transmission of interest rate shocks onto the real economy, especially in economies such as U.S. that are dominated by FRMs. In doing so we emphasize the importance of polices like HARP that relax the equity refinancing constraints during the adverse economic conditions. Our findings have implications for future policy interventions, pass-through of monetary policy through household balance sheets and design of the mortgage market.

Our results suggest that significant number of eligible borrowers did not take advantage of the large-scale and well-advertised refinancing program. While certainly the borrower specific factors or other institutional frictions (e.g., like servicer capacity constraints) may help account for this muted response, our paper finds that limits to competition in refinancing market was also a factor. Moreover, by adversely altering refinancing activity – the take up rate as well as the pass through -- competitive frictions may have significantly reduced the program effect on consumption of eligible households, especially indebted households who may have the highest propensity to spend from additional liquidity (see Mian, Rao and Sufi 2013).[30] Thus, provisions limiting the competitive advantage of incumbent banks with respect to their existing borrowers should be a consideration when designing stabilization polices such as HARP. This insight would also apply to other polices whose implementation depends on the intermediaries that may have some incumbency advantage with respect to targeted agents.

Our results also speak to HARP's impact on redistribution and the overall consumption response in the economy. As Beraja, Fuster, Hurst and Vavra (2017) note in their work focusing on pre-HARP period refinancing then was only available to more creditworthy borrowers with lower LTV ratios, which could exacerbate regional economic inequality. Although we cannot quantify the overall GE effects of the program that include its impact on income and consumption of mortgage investors, our results suggest that less creditworthy and more indebted eligible borrowers significantly increased their spending following refinancing. To the extent that such borrowers have the largest marginal propensity to consume, HARP could increase overall consumption and alleviate the regional dispersion in economic outcomes (Auclert 2015).

Our findings also have implications for the debate regarding optimal mortgage contract design (e.g., Piskorski and Tchistyi 2010, Campbell 2013; Keys et al 2013; Eberly and Krishnamurthy

[30] Because these indebted households face higher default risk and have larger propensity to spend from additional liquidity (see Keys et al 2016), they are the key target of stabilization polices such as HARP.

2014), highlighting potential benefits of ARMs. In particular, by automatically reducing mortgage rates when market rates are low, ARMs can help alleviate frictions due to the limited competition in the loan refinancing market. Moreover, as ARMs can allow quick refinancing of borrowers regardless of the extent of their housing equity or creditworthiness, such contracts may reduce the need for large-scale refinancing programs like HARP, which, as we show, can face implementation hurdles. There are also additional benefits of ARMs that might be useful to discuss in our context.[31] Of course, such benefits need to be carefully weighed against the potential adverse costs of ARMs. We leave this issue for further research.

Finally, we note that our analysis using conforming market pricing as a benchmark does not imply that the conforming refinancing market was fully competitive. In fact, recent evidence by Scharfstein and Sunderam (2014) suggests that there are also frictions limiting pass-through of interest rate shocks in the regular conforming refinancing market. Their findings suggest that our estimates are, if anything, a lower bound on the overall effects of importance of competition for program implementation.

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[31] By automatically reducing mortgage rates, ARMs may help alleviate the barriers to loan renegotiation due to securitization (Piskorski et al. 2010; Agarwal et al. 2011) and lender concerns regarding borrowers' strategic behavior (Mayer et al. 2014). In addition, as ARM contracts do not require the active participation of borrowers in the process of rate reduction, they can help alleviate the adverse effects of borrower inertia and inattention on mortgage refinancing (see Keys, Pope, and Pope 2016 and Andersen et al. 2014 for the recent evidence on these factors). See also Piskorski and Tchistyi (2010) for benefits of ARMs for less creditworthy borrowers in an optimal dynamic contracting framework with costly default.

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Table 1:
Summary Statistics for HARP and Non-HARP Eligible Loans

This table presents summary statistics of key variables in the pre-HARP period (2008: Q2 to 2009: Q1) in the treatment and control groups. The treatment group consists of GSE 30-year fixed-rate mortgages that have current LTV ratios greater than 80 as of March 2008 (one year prior to the program). The control group consists of a sample of full documentation prime non-GSE 30-year fixed-rate mortgages (privately securitized) that have current LTV ratios greater than 80 as of March 2008. Since, these loans were not sold to GSEs they are not eligible for HARP. These loans were further matched based on FICO credit scores of borrowers, current LTV ratios, interest rates, and loan amounts. *Data Source:* Large secondary-market participant and BlackBox Logic.

	Treatment (HARP Eligible)		Control (Non-HARP Eligible)	
	Mean (1)	S.D (2)	Mean (3)	S.D (4)
LTV	95.5	5.2	95.6	5.8
FICO	727.7	46.4	728.4	43.7
Interest Rate	6.60	0.64	6.62	0.66
Balance	183,614	91,718	186,525	110,104
Number of Loans	46,154		46,154	

Table 2:

Borrower-Level Evidence: HARP, Refinancing Rate, Mortgage Payments, and Durable Spending (New Auto Financing)

Panel A of this table presents OLS estimates from regressions that track whether or not a loan refinances around the program implementation (Q2 2008 till Q4 2012). The dependent variable takes the value of one in the quarter a given loan refinances and is zero otherwise (the refinanced loans exit the estimation sample). The variable, *HARP Eligible*, takes the value of one if a loan belongs to the treatment group as defined in Table 1 and is zero otherwise. The variable, *After Q1 2009,* takes the value of one for the quarters after Q1 2009 and is zero otherwise. Column (1) presents the basic specification with no other controls but a constant term, *HARP Eligible* dummy, *After Q1 2009* dummy, and the interaction term of these two variables (*HARP Eligible) × After Q1 2009*). Column (2) adds borrower controls that include variables such as FICO credit score, LTV, interest rates. Column (3) adds the fixed effects for the location (MSA) of the property (*MSA FEs*). Column (4) clusters standard errors at the MSA level. The estimation sample consists of a matched set of treatment and control loans (as defined in Table 1). The estimates in Column (1)-(4) of Panel A are in percentage terms and the estimation is performed on quarterly data. Panel B presents OLS estimates from regression where the dependent variable is the current interest (Column 1 and 2), the quarterly mortgage interest rate payments (Column 3 and 4), the variable that takes value of one if the new auto financing takes place in a given quarter and is zero otherwise (Column 5 and 6), and the net amount of new auto financing in dollars (Colum 7 and 8) (the difference between the new and prior auto debt in the quarter in which new financing takes place). The variable, *After HARP*, takes value of one in the quarters after HARP refinancing rate and is zero otherwise. The sample includes all the loans that refinanced under HARP for which we have reliable auto balance data. In Column (2), (4), (6), (8) of Panel B the standard errors are clustered at MSA level and the estimates in Columns (1)-(2) and (5)-(6) are expressed in percentage terms. The *Year-Quarter FEs* correspond to the quarter-year fixed effects for the date of HARP refinancing. Standard errors are included in the parentheses.

Panel A: HARP and the refinancing rate

	(1)	(2)	(3)	(4)
(HARP Eligible) × After Q1 2009	1.73	1.35	1.37	1.37
	(0.05)	(0.07)	(0.07)	(0.11)
Borrower Controls	No	Yes	Yes	Yes
MSA FEs	No	No	Yes	Yes
Observations	1,372,731	1,372,731	1,372,731	1,372,731
Adjusted R-Square	0.001	0.003	0.01	0.01

Panel B: Mortgage payments and durable spending (new auto financing) after HARP refinancing

	Mortgage rate		Mortgage payments		Probability of new auto financing		Net amount of new auto financing	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
After HARP	-1.40	-1.42	-884.11	-884.67	0.78	0.84	185.08	198.88
	(0.00)	(0.07)	(0.24)	(37.93)	(0.03)	(0.04)	(5.63)	(9.38)
Borrower Controls	No	Yes	No	Yes	No	Yes	No	Yes
Year-Quarter FEs	No	Yes	No	Yes	No	Yes	No	Yes
MSA FEs	No	Yes	No	Yes	No	Yes	No	Yes
Observations	4,125,726	4,125,726	4,125,726	4,125,726	4,125,726	4,125,726	4,125,726	4,125,726
Adjusted R-Square	0.617	0.868	0.515	0.667	0.001	0.002	0.001	0.002

Table 3:

Regional Evidence: Consumer Spending, Foreclosures, and House Prices and Zip Code Exposure to HARP

This table examines the relation between regional (zip code level) consumer spending, foreclosures, and house prices and the average mortgage rate reduction in a zip code due to HARP (in basis points) instrumented with the pre-program share of loans in a zip code that are eligible for HARP. The pre-program program eligible share, *Eligible Share*, is the fraction of outstanding first-lien mortgage loans in a zip code that are conforming and have current LTV ratios greater than 80 prior to the program implementation. Column (1) of Panel A presents the first stage specification without controls, in which the average mortgage interest rate reduction due to HARP, *Rate Reduction due to HARP*, is instrumented with the share of program eligible loans. Column (2) repeats the first stage, but includes a series of controls including the zip code average FICO credit score, LTV ratio, interest rate on mortgages along with the average zip code house price growth over the prior five years and state fixed effects. Panel B shows the corresponding second stage estimates results for the change in the quarterly credit card spending growth rate (Column 1 and 2), the auto purchase growth rate (Column 3 and 4), the foreclosure rate (Column 5 and 6), and the house price growth rate (Column 7 and 8), all computed as the average of the respective value during the program less its pre-program level. The analysis is based on a sample of 3,443 zip codes. The estimation period is 2008:Q1 through 2013:Q2. Standard errors are included in parentheses.

Panel A: Average mortgage interest rate reduction due to HARP in a zip code (*First Stage*)

	(1)	(2)
Eligible Share	31.4	38.0
	(0.007)	(0.010)
Zip Code Controls	No	Yes
State FEs	No	Yes
Adj. R-squared	0.47	0.71

Panel B: Instrumented “Interest rate reduction due to HARP” and consumer spending (credit card and auto), foreclosures, and house prices (*Second Stage*)

	Credit card spending		Auto purchase growth		Foreclosure rate		House price growth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rate Reduction due to HARP	0.119	0.129	0.394	0.201	-0.010	-0.025	0.353	0.134
	(0.028)	(0.036)	(0.019)	(0.021)	(0.002)	(0.002)	(0.015)	(0.008)
Zip Code Controls	No	Yes	No	Yes	No	Yes	No	Yes
State FEs	No	Yes	No	Yes	No	Yes	No	Yes
Adj. R-squared	0.01	0.03	0.06	0.42	0.01	0.64	0.07	0.83

Table 4:

Summary Statistics for HARP and Conforming Refinances

This table presents the summary statistics for mortgage loans that were refinanced under the Home Affordable Refinance Program (HARP) during 2009-2012 period (Column 1 and 2) alongside conforming refinances originated during 2009-2012 period (Column 3 and 4) and 2005-2009 period (Column 5 and 6). The sample consists of more than 800,000 of HARP and conforming refinances. The variable *HARP-conforming refi spread* (in basis points) is computed as the difference between the interest rate on a given HARP refinanced loan and the mean interest rate for conforming refinances with a loan-to-value ratio (LTV) equal to 80 percent originated in the same month. This spread is guarantee-fee adjusted by subtracting guarantee fees from the HARP and conforming refinance rates before computing the spread. The variable *Conforming refi-purchase spread* (in basis points) is computed as the difference between the interest rate on a given conforming refinanced loan and the mean interest rate for purchase loans with an 80 percent LTV ratio originated in the same month. The *Same servicer refi* dummy takes a value of one if the servicer is the same before and after a refinancing, otherwise it is zero. The table also present summary statistics for other key variables, including the LTV ratio (in percentage terms) at the time of refinancing, FICO credit score of the borrower at the time of refinancing, interest rate (in percentage terms) on a loan before refinancing (*Previous rate),* interest rate on a loan after refinancing (*Rate after refinancing)*, and balance of a loan at the time of refinancing (in thousands of dollars). Panel A presents the statistics of the full sample, while Panel B presents the mean values for HARP refinances separated in the four LTV ranges (as of the time of refinancing).

Panel A: HARP and conforming refinances (All Sample)

	HARP refinances 2009-2012		Conforming refinances 2009-2012		Conforming refinances 2005-2009	
	Mean (1)	S.D (2)	Mean (3)	S.D (4)	Mean (5)	S.D (6)
LTV	99.74	22.38	80	0	80	0
FICO	749.75	44.31	759.82	40.81	737.06	47.89
Balance	242.20	96.49	264.2	127.1	234.5	92.1
Previous rate	6.07	0.58	5.69	0.74	6.30	0.83
Rate after refinancing	4.67	0.52	4.55	0.51	5.75	0.69
HARP-conforming refi spread	16.07	37.54	-	-	-	-
Conforming refi-purchase spread	-	-	2.83	29.09	-0.55	32.11
Same servicer refi	0.54	0.50	0.33	0.47	0.28	0.45

Table 4 [continued]:

Panel B: HARP refinances by LTV ratio at the time of refinancing

	80 < LTV ≤ 90	90 < LTV ≤ 105	105 < LTV ≤ 125	LTV > 125
	(1)	(2)	(3)	(4)
FICO	752.91	749.73	745.38	741.49
Balance	248.09	245.06	230.69	218.48
HARP-conforming refi spread	11.33	13.46	27.06	33.77
Same Servicer	0.51	0.50	0.62	0.78

Table 5:

HARP-Conforming Refi Spread, Same Servicer Refinances and the LTV Ratio

Column (1) and (2) of this table presents OLS regression results for a specification with the HARP-conforming refi spread (in basis points) as the dependent variable. The set of control variables includes the three dummy variables that indicate the HARP loan LTV range of (90, 105], (105, 125] and >125. The loans refinanced through HARP with the LTV range (80, 90] serve as the excluded category and have an average HARP-conforming refi spread of 11.33 basis points. In Columns (3) and (4) the dependent variable is the dummy variable, *Same Servicer*, which takes the value of one if the loan is refinanced by the lender servicing the legacy mortgage and is zero otherwise. The set of control variables includes the four dummy variables that indicate the HARP loan LTV range of (80,90], (90, 105], (105, 125] and >125. The conforming refinances with LTV equal to 80 serve as the excluded category (33% of these loans are refinanced by the same servicer). Column (2) and (4) add borrower controls including the current FICO score (and its square) of the borrower and the metropolitan statistical area (MSA) fixed effects corresponding to the location of the property, time fixed effects capturing the quarter/year time during which the loan was refinanced (Year-Quarter FEs), and the fixed effects corresponding to the identity of the lender refinancing the loan (Servicer FEs). Standard errors are included in the parentheses.

	Dependent variable: HARP-conforming refi spread		Dependent variable: Same servicer refinance	
	(1)	(2)	(3)	(4)
80<LTV≤90	-	-	0.19	0.18
			(0.00)	(0.05)
90 < LTV ≤ 105	2.13	1.48	0.19	0.19
	(0.13)	(0.44)	(0.00)	(0.06)
105 < LTV ≤ 125	15.73	10.98	0.31	0.29
	(0.18)	(2.54)	(0.00)	(0.08)
LTV > 125	22.43	15.77	0.46	0.39
	(0.22)	(3.06)	(0.00)	(0.10)
Borrower Controls	No	Yes	No	Yes
MSA FEs	No	Yes	No	Yes
Year-Quarter FEs	No	Yes	No	Yes
Servicer FEs	No	Yes	No	Yes
Observations	414,172	414,172	828,344	828,344
Adjusted R-squared	0.04	0.10	0.06	0.36

Table 6:

HARP-Conforming Refi Spread and the Previous Interest Rate

Panel A of this table presents OLS regression results for a specification with the guarantee fee adjusted HARP-conforming refi spread as the dependent variable and the interest rate of a loan prior to refinancing as a control variable. Column (1) presents the basic specification with no controls but the previous interest rate. Column (2) adds borrower controls including the current FICO score (and its square) of the borrower and the metropolitan statistical area (MSA) fixed effects corresponding to the location of the property. Column (3) adds time fixed effects capturing the quarter/year time during which the loan was refinanced. Column (4) adds the fixed effects corresponding to the identity of the lender refinancing the loan and clusters standard errors at the servicer level. Panel B of this table presents the results of a 2-stage least squares regression in which the mortgage rate of a loan prior to refinancing, *Previous rate*, is instrumented with the average 10-year Treasury rate corresponding to the month of origination of legacy mortgage. The first two columns show the first-stage results in which the previous mortgage rate is regressed on the 10-year Treasury rate. Column (1) corresponds to a basic specification without additional controls. Column (2) introduces *Other controls*, including the dummy variables for LTV ranges as in Tables 2 and 3, FICO, FICO squared, year-quarter fixed effects corresponding to the origination of legacy and HARP loan (Year-Quarter FEs), MSA fixed effects, and the servicer fixed effects corresponding to the identity of the servicer handling the loan (Servicer FEs). Columns (3)-(4) present the analogues second-stage results, whereby the dependent variable is the guarantee fee adjusted HARP-conforming refi spread and the control variable is the previous mortgage rate instrumented with 10-year Treasury. In Panel B the standard errors are clustered at the quarter/year level corresponding to the origination time of the legacy loan. Standard errors are included in the parentheses.

Panel A: HARP-conforming refi spread and the previous rate

	(1)	(2)	(3)	(4)
Previous rate	7.54	5.75	9.97	9.61
	(0.10)	(0.10)	(0.11)	(0.78)
90 < LTV ≤ 105		1.69	-0.29	-0.10
		(0.13)	(0.13)	(0.42)
105 < LTV ≤ 125		15.02	7.21	6.73
		(0.19)	(0.20)	(1.71)
LTV > 125		21.42	10.20	9.31
		(0.24)	(0.26)	(1.93)
Borrower Controls	No	Yes	Yes	Yes
MSA FEs	No	Yes	Yes	Yes
Year-Quarter FEs	No	No	Yes	Yes
Servicer FEs	No	No	No	Yes
Observations	414,172	414,172	414,172	414,172
Adjusted R-squared	0.01	0.05	0.10	0.11

Table 6 [continued]:

Panel B: Harp-conforming refi spread and previous interest rate instrumented with 10-year Treasury rate

	(1) Dependent variable: Previous rate (On the original loan)	(2) Dependent variable: Previous rate (On the original loan)	(3) Dependent Variable: HARP-Conforming Refi Spread	(4) Dependent Variable: HARP-Conforming Refi Spread
10-year Treasury	0.61	0.55	-	-
	(0.05)	(0.04)		
Previous rate instrumented with 10-year Treasury	-	-	4.30	10.91
			(0.43)	(0.92)
Other controls	No	Yes	No	Yes
Observations	414,172	414,172	414,172	414,172
Adjusted R-squared	0.45	0.50	0.01	0.11

Table 7:

Difference-in-Difference around the Change in the Program Rules

Column (1) and (2) of this table presents the OLS regression results for the specification with the guarantee fee adjusted HARP-conforming refi spread as the dependent variable and a dummy variable, 2013× HARP, equal to one if a HARP loan was refinanced in the first half of 2013 and equal to zero if it was refinanced in the second half of 2012. The sample period consists of HARP loans originated from Q3 2012 till Q2 2013. Column (1) presents the estimation results for the basic specification model with no additional controls. Column (2) introduces *Other controls*, including the dummy variables for LTV ranges as in Tables 2 and 3, FICO, FICO squared, year-quarter fixed effects corresponding to the origination of legacy and HARP loan, MSA fixed effects, and the servicer fixed effects corresponding to the identity of the servicer handling the loan. Column (3) and (4) present the OLS regression results (in the percentage terms) for the specification with the dummy taking value of one if a loans refinances in given month and zero otherwise. Once the loan refinances it is dropped from the estimation sample. The control variables include *2013* dummy that takes value of 1 if the loan is refinance in the first half of 2013 and equal to zero otherwise, dummy variable HARP that takes value of 1 if a loan is HARP eligible (as of July 2012) and is zero otherwise, and the interaction of these two variables *2013× HARP*. In Column (3) and (4) the sample consists of loans eligible for HARP and conforming refinancing, respectively, tracked from July 2012 till June 2013. The excluded category are mortgages that are eligible for confirming refinancing as of July 2012. Standard errors are included in the parentheses.

	Dependent variable: HARP-conforming refi spread		Dependent variable: Whether a loan refinances in a given month	
	(1)	(2)	(3)	(4)
2013 × HARP	-8.11 (0.19)	-9.03 (3.25)	0.10 (0.06)	0.12 (0.06)
2013	-	-	0.10 (0.07)	0.21 (0.06)
HARP	-	-	-0.06 (0.04)	0.22 (0.05)
Other controls	No	Yes	No	Yes
Observations	164,144	146,144	1,181,839	1,181,839
Adjusted R-squared	0.01	0.10	0.01	0.01

Table 8:

Quantitative Life-Cycle Model: The Effect of HARP on Consumption and Welfare of Eligible Borrowers

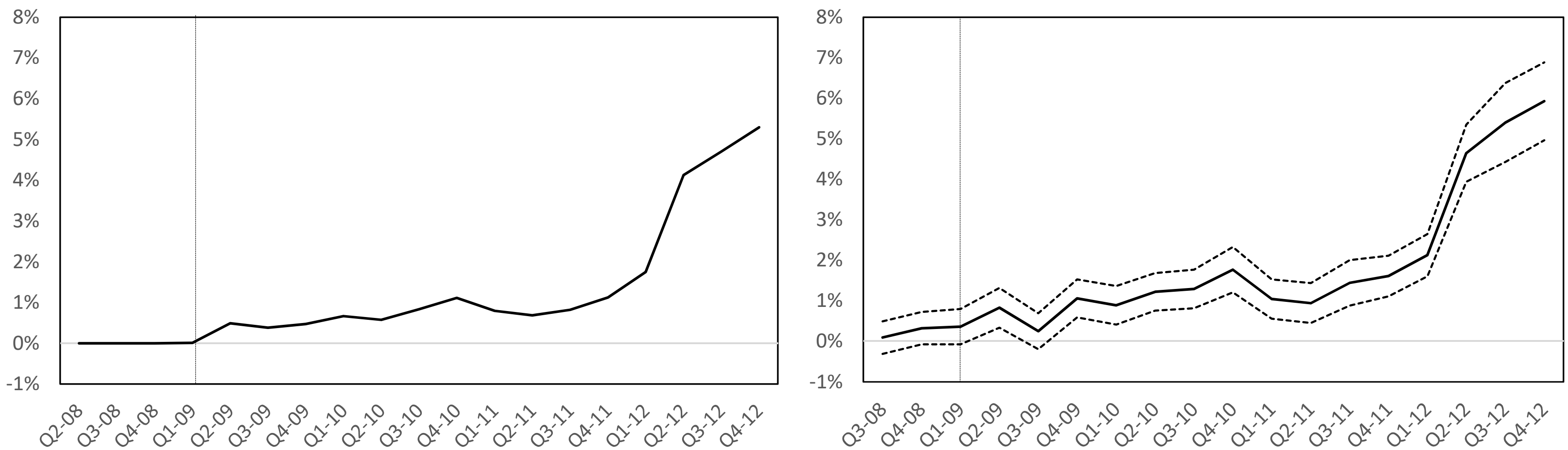
This table shows an annual increase in the household consumption in 1000s of dollars in the first 3 years of the program relative to the world without HARP (Panel A) and the welfare gains due to HARP to borrowers as a percentage of the borrower's lifetime utility (Panel B) in the cross-section of borrowers based on their current LTV and their pre-refinance mortgage rate. These results are calculated based on the model simulations from Section VI assuming the borrower can refinance to an average mortgage rate of 4.5% plus the monopolistic markups from Table 4B. Panel C shows additional welfare gains as a percentage of the borrower's lifetime utility that arise by eliminating the HARP interest rate markups.

	Pre-refinance mortgage rate			
	5.5%	6.0%	6.5%	7.0%
LTV	**Panel A:** Consumption response to HARP (annual average over 3-year period)			
(0.8, 0.9]	0.60	0.96	1.24	1.53
(0.9, 1.05)	0.64	1.09	1.61	1.91
[1.05,1.25)	1.03	1.37	1.85	2.31
> 1.25	1.12	1.76	2.38	2.87
	Panel B: Utility gain from HARP (% of lifetime utility)			
(0.8, 0.9]	0.37	0.47	0.66	0.79
(0.9, 1.05)	1.08	2.04	4.76	6.53
[1.05,1.25)	2.01	4.66	9.86	13.45
> 1.25	2.76	6.13	12.53	16.32
	Panel C: Utility gain from elimination of HARP markups (% of lifetime utility)			
(0.8, 0.9]	0.22	0.22	0.37	0.46
(0.9, 1.05)	0.30	0.30	0.54	0.61
[1.05,1.25)	0.57	0.55	0.98	1.07
> 1.25	0.85	0.83	1.33	1.50

Figure 1:

HARP and Refinancing Rate

Panel (a) of the figure shows the percentage of loans refinancing under HARP in the treatment group (eligible loans) in a given quarter. Panel (b) shows the estimated coefficients of interaction terms between quarterly time dummies and the treatment indicator (*HARP Eligible*) along with 99% confidence intervals for the specification where the dependent variable takes the value of one whether the loan refinances (through HARP or otherwise) in a given quarter and is zero otherwise. The refinanced loans exit the estimation sample. The specification is similar to one in Column (4) of Table 2A but where we replace the *After Q1 2009* dummy with a set of quarterly dummies (the excluded category includes observations from 2008:Q2). This specification allows us to investigate the quarter-by-quarter changes in the refinancing rate between the treatment and control group (relative to the level in 2008:Q2). The estimation period is 2008:Q3 to 2012:Q4.



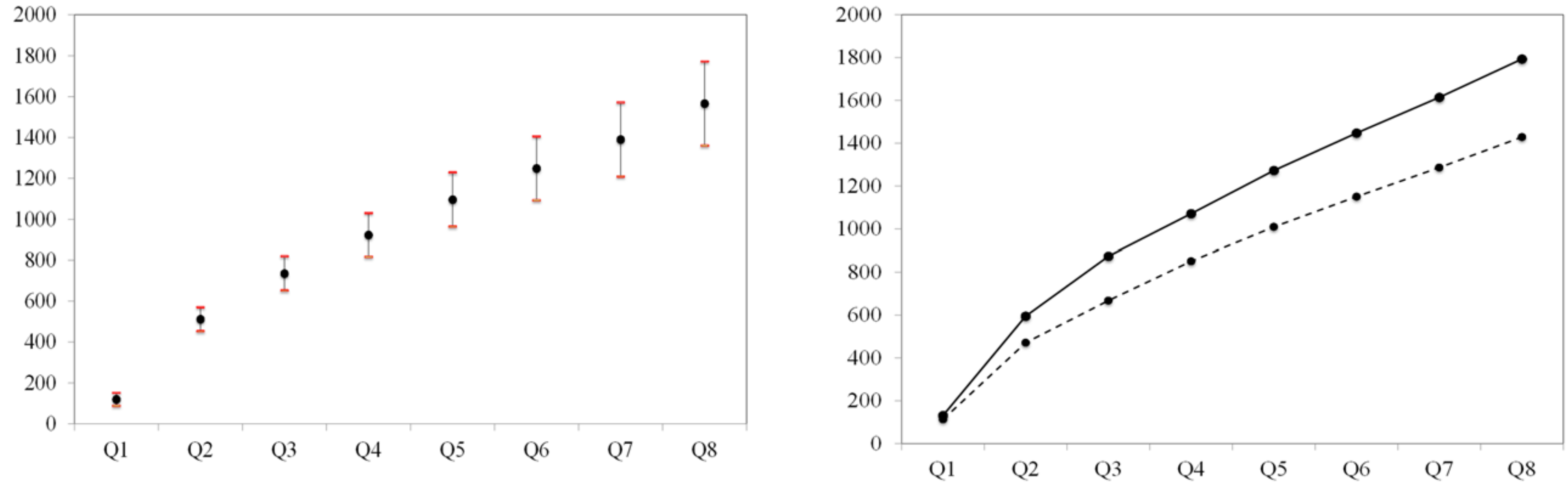
(a) Quarterly HARP refinancing rate in the treatment group

(b) Change in the refinancing rate between treatment and control group

Figure 2:

Cumulative Change in the Durable Spending (New Auto Financing) after the HARP Refinancing Date

Panel (a) shows the estimated cumulative change in the net amount of new auto financing (in dollars) along with 99% confidence intervals in the eight quarters following the HARP refinancing. These estimates are from a borrower level specification where the dependent variable is the net amount of new auto financing in dollars. We include a set of controls capturing borrower, loan, and regional characteristics and a set of quarterly time dummies that capture the three quarters preceding HARP refinancing and eight quarters following HARP refinancing date. Panel (b) plots the estimates for less indebted borrowers with below median LTV (dashed line) and more indebted borrowers with above median LTV (solid line). The average differences across these groups in Panels (b) are statistically significant at 1%.



(a) Cumulative change in the new car spending after HARP refinance

(b) New car spending among less/more indebted (below/above median LTV)

Figure 3:

Geographical Distribution of Zip Codes and HARP Eligible Share

This figure presents the geographic distribution of zip codes in our overall sample across the United States. In addition, the figure displays the fraction of loans in a zip code which are eligible for HARP (as of March 2009). As we observe, there is a significant variation in the *HARP Eligible* share across zip codes (ranging from just few percent of loans being eligible for the HARP program to more than 70%).

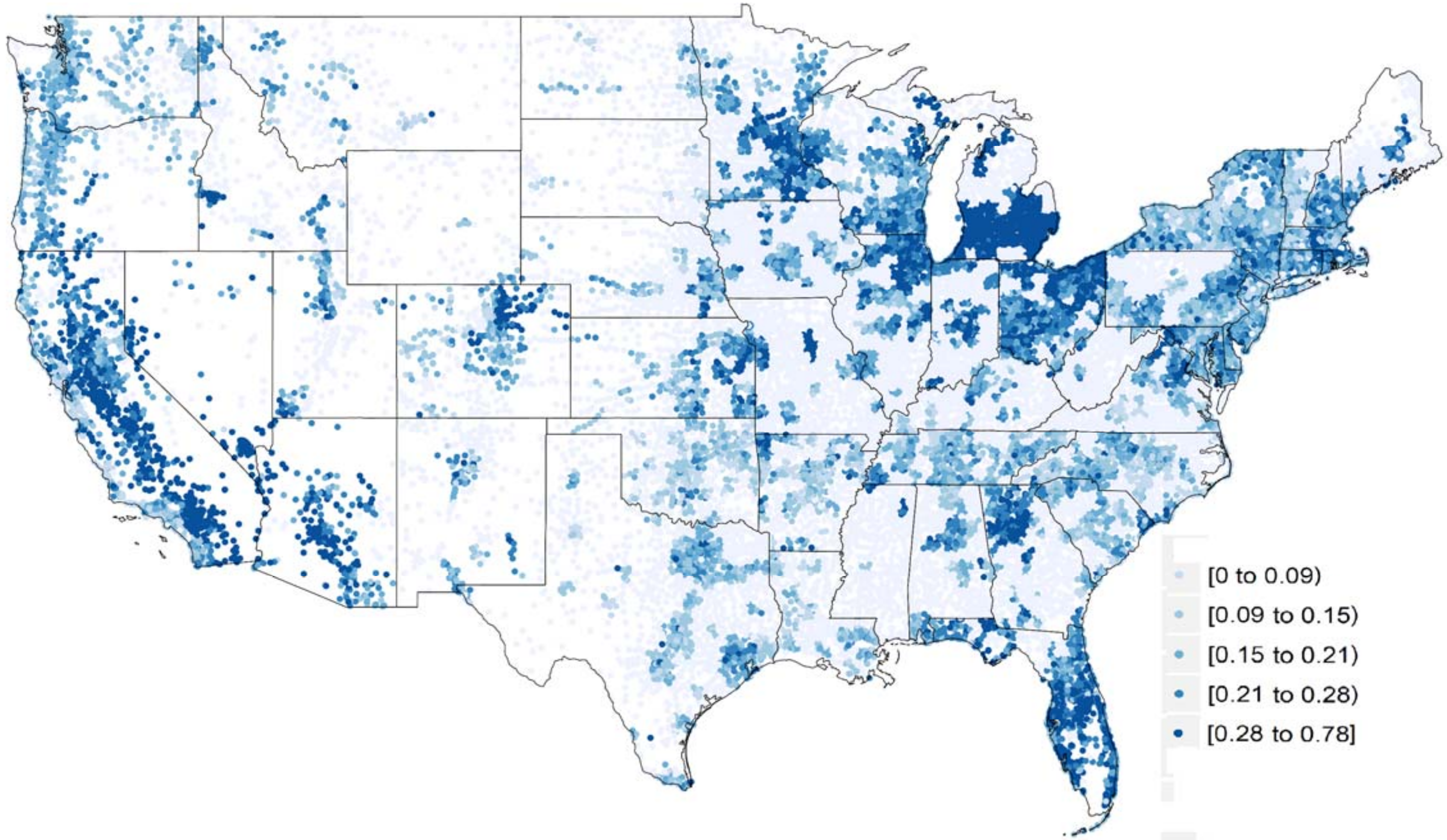
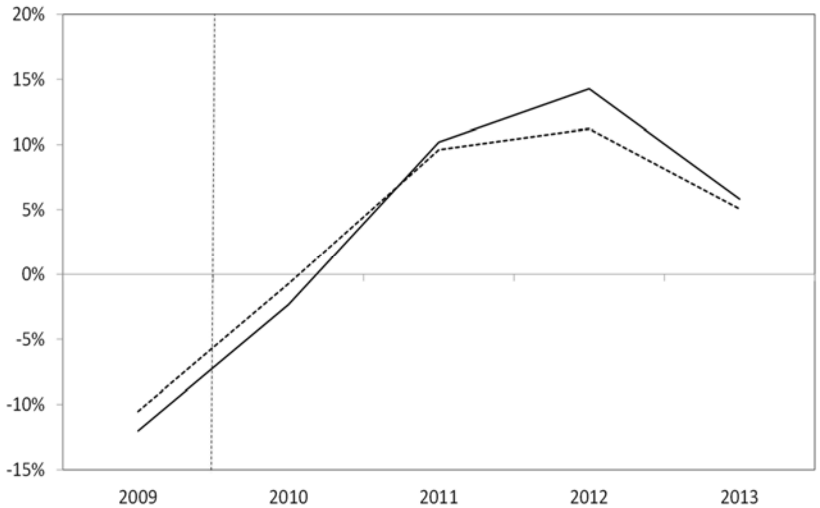


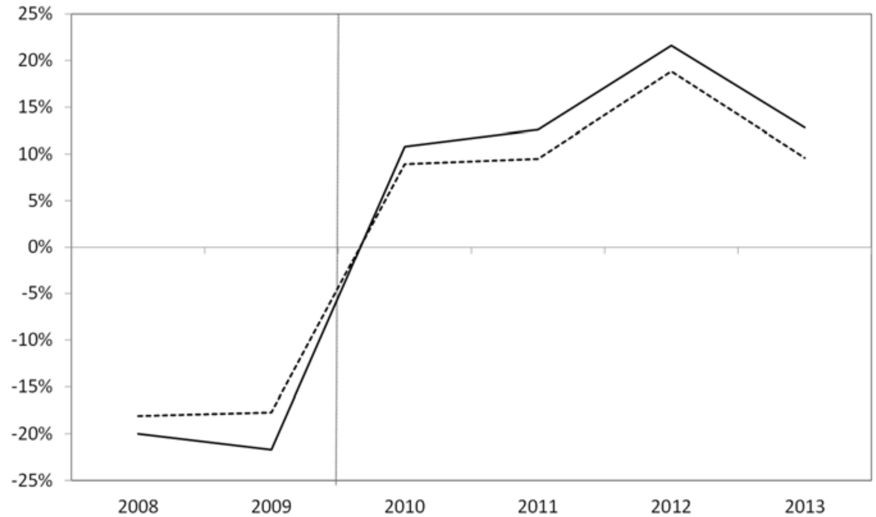
Figure 4:

Regional Evidence: Credit Card Spending, Auto Purchase, and House Price Growth in High and Low HARP Exposed Areas

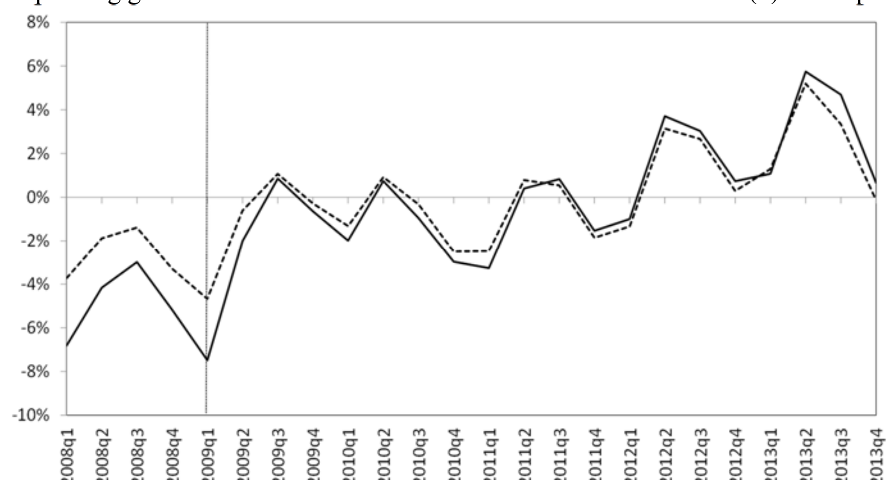
This figure shows the average credit card spending, auto purchase, and house price growth rates in the high HARP exposed (above median *Eligible Share*) and low HARP exposed (below median *Eligible Share*) zip codes. The high HARP exposed group is displayed in solid line and low HARP exposed group is displayed in dashed line. Zip code credit card spending growth is computed using proprietary data from U.S. Treasury. The auto purchase growth data come from Mian and Sufi (2010) (based on R.L. Polk & Company data). The house price growth is computed using CoreLogic zip-code level price indices.



(a) Credit card spending growth



(b) Auto purchase growth

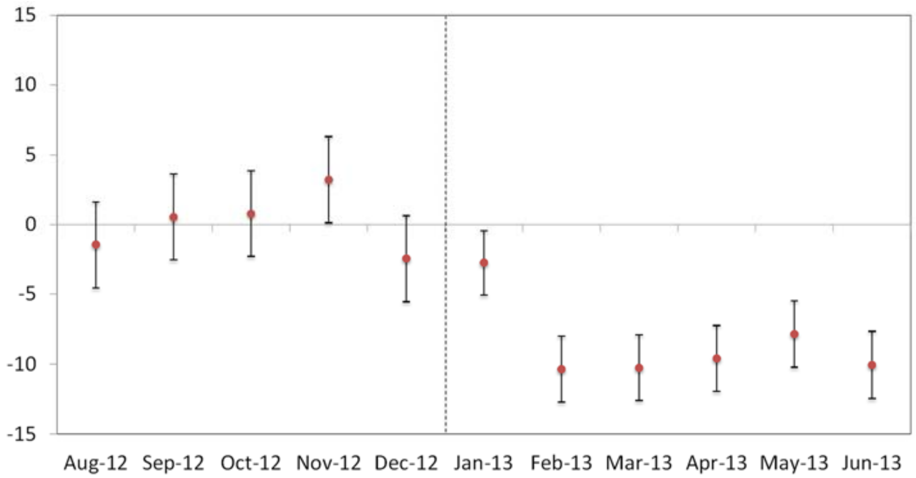


(c) House price growth

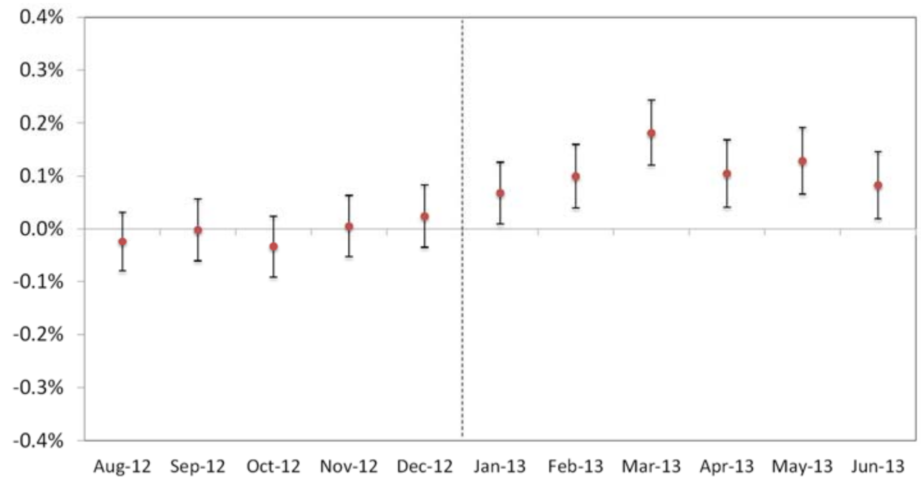
Figure 5:

Change in the Program Rules and the HARP-Conforming Refi Spread and Harp-Conforming Refinancing Rate

Panel (a) of this figure plots the estimated coefficients (based on OLS) for monthly fixed effects along with 99% confidence intervals around these estimates from a regression of HARP-conforming refi spread (in basis points) on a set of borrower and loan characteristics including current loan LTV ratios, borrower credit scores, servicer fixed effects, MSA fixed effects, previous rate, and monthly time fixed effects. The excluded category corresponds to HARP refinances that occurred during July 2012 so the plotted coefficients show the estimated change relative to the spread from this period. Panel (b) shows the corresponding results from the specification where now the dependent variable takes the value of one if the loan refinances in a given month and is zero otherwise. The plotted coefficients are the estimated interaction terms of time dummies with *HARP eligible* dummy. In panel (b) the base category are loans that are eligible for conforming refinances (loans with current LTV as of June 2012 less than 80). The displayed coefficients in panel (b) show the estimated change in the difference between refinancing rates of HARP and conforming loans (relative to the level in July 2012). The estimation period is from July 2012 till June 2013. As we observe the HARP spread and the difference between refinancing rates of HARP eligible and conforming loans generally persists at a stable level prior to the change in program rules in January 2013. Once the new rules are in place the spread declines sharply by about 10 basis points in 2013 and the HARP refinancing rate experiences a significant differential increase (by about 0.12% per quarter).



(a) Change in the HARP-conforming spread

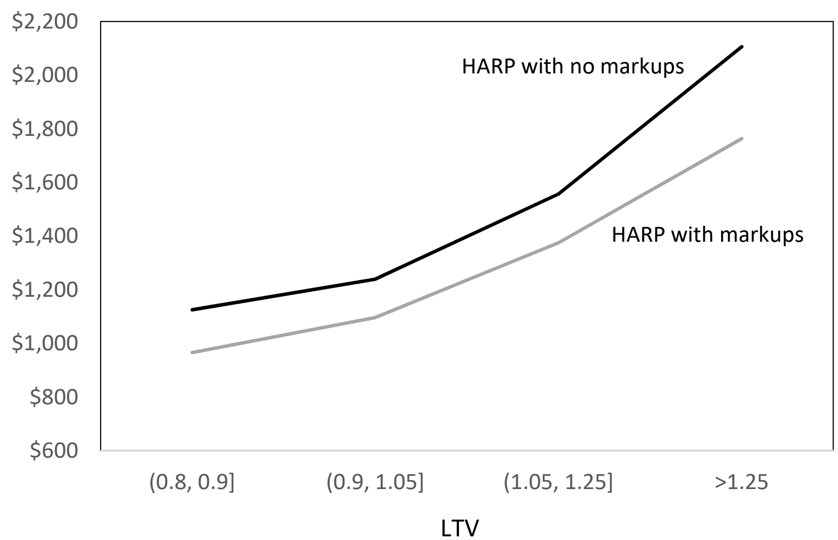


(b) Change in the refinancing rate

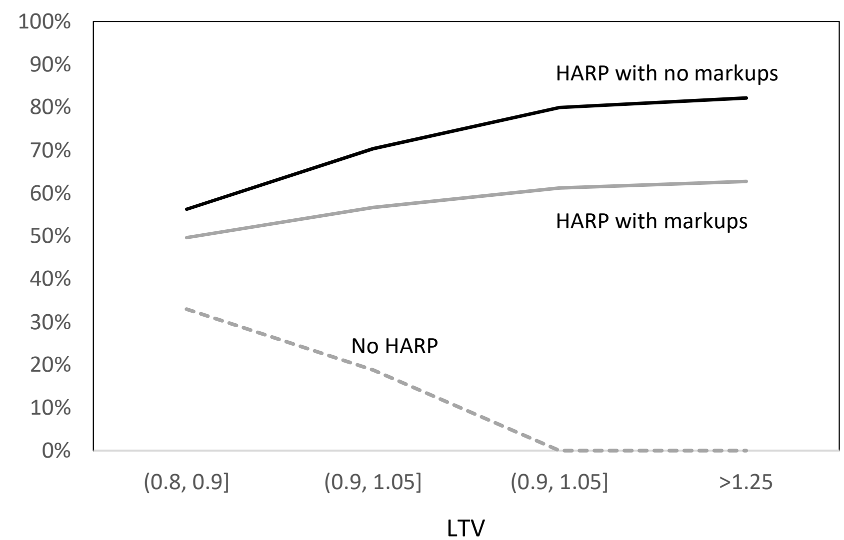
Figure 6:

Impact of HARP Markups on Consumption and the Refinancing Rate of Eligible Borrowers

Panel A of this figure shows an average increase in the borrower's annual consumption due to HARP during the first 3 years relative to the world without HARP in the cross-section of borrowers based on their current LTV. These results are calculated based on the model simulations from Section VI for the borrower with an average prior rate of about 6% who can refinance to an average rate of 4.5% plus the monopolistic markups from Table 4B in the case of HARP with markups. These rates correspond to the mean rates in in our sample for HARP borrowers. Panel B shows the percentage of borrowers who refinance their loans during the first three years based on the optimal refinancing function implied by our model from Section VI applied to a random sample of borrowers that were eligible for HARP as of its implementation date in March 2009. This sample amounts to more than 1.1 million conforming mortgages from a large secondary market participant, which is more than 15% of the entire population of eligible loans. Top black solid line shows the case in which borrowers can refinance (at no additional cost) to the benchmark conforming rate (with no guarantee fees). The middle solid gray line shows the case in which borrowers face the HARP guarantee fees. The bottom dashed gray line (in panel b) shows the case in which there is no HARP.



(a) Borrower's consumption increase due to HARP (annual in $)



(b) Refinancing rate among HARP eligible borrowers (in %)

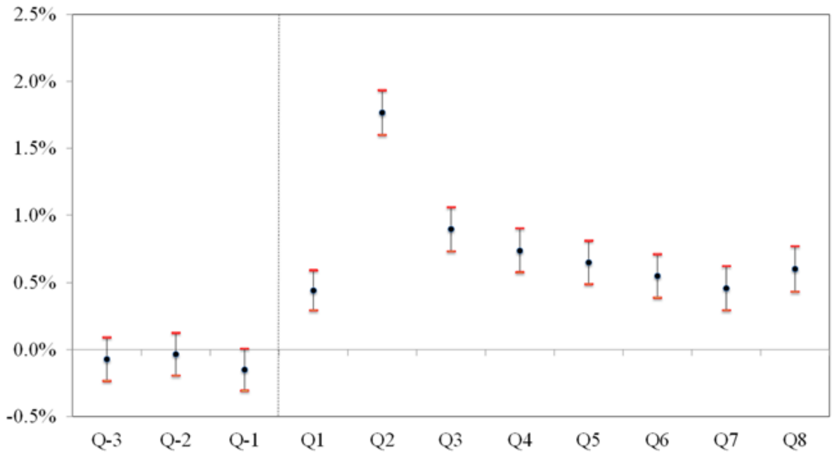
On-Line Appendix A:

Additional Empirical Analysis

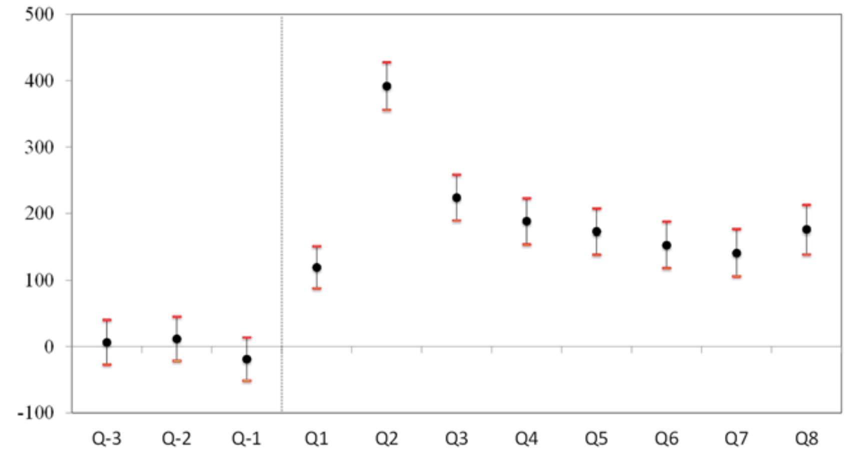
Appendix A.1:

Borrower-Level Evidence: Change in the Durable Spending (New Auto Financing) around the HARP Refinancing Date

Panel (a) of this figure plots the OLS estimates for quarterly time fixed effects (along with 99% confidence intervals) from the specification where the dependent variable takes the value of one if a new auto financing transaction takes place in a given quarter and is zero otherwise. In this specification we include a set of controls capturing borrower, loan, and regional characteristics and a set of (plotted) quarterly time dummies that capture the three quarters preceding HARP refinancing and eight quarters following HARP refinancing date. Panel (b) shows the corresponding results for the specification with the net amount of new auto financing (in dollars) as the dependent variable.



(a) Change in the probability of new auto financing



(b) Change in the net amount of new auto financing

Appendix A.2:

Robustness: The Impact of HARP on Refinancing Rate and Durable Consumption of Eligible Borrowers

Panel A of this table presents summary statistics of key variables in the pre-HARP period in the treatment and control groups formed in the random sample from the Black Knight Data and Analytics and Equifax database. The treatment group consists of a sample of GSE 30-year fixed-rate mortgages that have current LTV ratios greater than 80 as of March 2008. The control group consists of a sample of prime non-GSE 30-year fixed-rate mortgages that have current LTV ratios greater than 80 as of March 2008. Panel B of this table presents OLS estimates from regressions estimated on quarterly data (Q2 2008 till Q4 2012). The dependent variable takes the value of one in the quarter a given loan refinances and is zero otherwise (Columns 1 and 2), takes value of one if the new auto financing takes place in a given quarter and is zero otherwise (Column 3 and 4), is the net amount of new auto financing in dollars (Colum 5 and 6).The variable, *HARP Eligible*, takes the value of one if a loan belongs to the treatment group and is zero otherwise. The variable, *After Q1 2009,* takes the value of one for the quarters after Q1 2009 and is zero otherwise. Column (1, 3, 5) presents the basic specification with no other controls but a constant term, *HARP Eligible* dummy, *After Q1 2009* dummy, and the interaction term (*HARP Eligible) × After Q1 2009*). Column (2, 4, 6) add borrower controls and the location and origination time fixed effects. Estimates in Column (1)-(4) of Panel B are in percentage terms. Standard errors are in parenthesis.

Panel A: Summary statistics for HARP and Non-HARP eligible loans

	Treatment (HARP Eligible)		Control (Non-HARP Eligible)	
	Mean (1)	S.D (2)	Mean (3)	S.D (4)
LTV	90.4	15.3	93.2	12.7
FICO	733.8	73.1	720.8	81.0
Interest Rate	6.25	0.48	6.37	0.69
Balance	199,536	87,896	198,225	92,551
Number of Loans	1,113,898		178,548	

Panel B: The effect of HARP on refinancing rate and durable consumption

	Refinancing rate		Probability of new auto financing		Net amount of new auto financing	
	(1)	(2)	(3)	(4)	(5)	(6)
(HARP Eligible) × After Q1 2009	1.53	1.50	0.09	0.10	29.08	32.10
	(0.02)	(0.01)	(0.03)	(0.03)	(6.87)	(6.85)
Borrower Controls	No	Yes	No	Yes	No	Yes
Year-Quarter FEs	No	Yes	No	Yes	No	Yes
MSA FEs	No	Yes	No	Yes	No	Yes
Observations	17,157,481	17,157,481	19,194,535	19,194,535	19,194,535	19,194,535
Adjusted R-Square	0.005	0.043	0.001	0.001	0.001	0.001

Appendix A.3:

Borrower-Level Evidence: Change in the Durable Spending (New Auto Financing) and the Rate Reduction due to HARP

This table presents OLS estimates from the specification where the dependent variable is the average quarterly probability of new auto financing in percentage points (Column 1 and 2) and net dollar amount of new auto financing in dollars (Column 3 and 4) after the HARP refinancing date less the corresponding value prior to the HARP refinancing. The control variable *Rate Reduction* captures the difference between the legacy interest rate and rate on refinanced HARP loan (in percentage terms). Columns (1) and (3) present the estimation results for the basic specification with no additional controls. Columns (2) and (4) add borrower controls that include variables such as FICO credit score, LTV, interest rates and the fixed effects for the location (MSA) of the property (*MSA FEs*). Column (2) and (4) clusters standard errors at the MSA level. The estimation sample consists of a set of borrowers refinancing their loans thru HARP during Q2 2009 till Q4 2012 and tracked over the period of two years after their refinancing date. Standard errors are included in the parentheses.

	Probability of new auto financing		Net amount of new auto financing	
	(1)	(2)	(3)	(4)
Rate reduction	0.20	0.12	55.15	36.94
	(0.03)	(0.04)	(11.25)	(72.13)
Borrower Controls	No	Yes	No	Yes
MSA FEs	No	Yes	No	Yes
Year Quarter FEs	No	Yes	No	Yes
Servicer FEs	No	Yes	No	Yes
Observations	357,507	357,507	357,507	357,507
Adjusted R-squared	0.001	0.001	0.001	0.001

Appendix A.4:

Regional Evidence: Mortgage Rate Reduction, Program Refinancing Rate and the Fraction of Eligible Loans and Eligible Loans Serviced by High Cost Lenders in a Zip Code

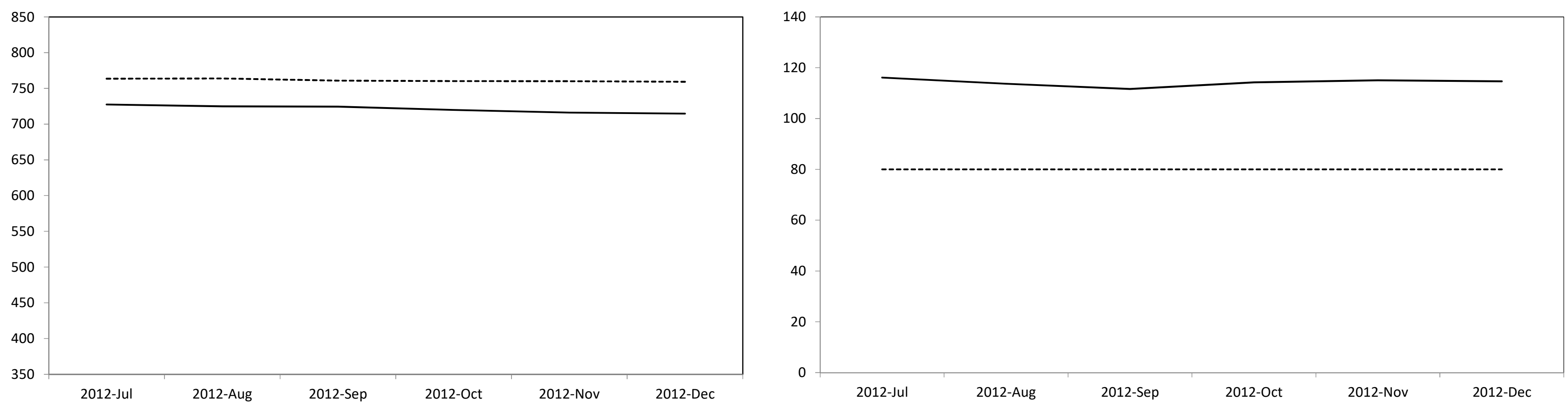
Column (1) and (2) of this table investigates the relation between the reduction in the average mortgage rate in a zip code due to HARP (in basis points) during first four years of the program and zip code level *Eligible Share* and *Eligible and High Cost Servicer Share*. *Eligible Share* is the fraction of loans in a zip code that are GSE and have current LTV ratios greater than 80 prior to the program implementation. *Eligible and High Cost Servicer Share* is the fraction of loans in a zip code that are GSE, have current LTV ratios greater than 80 and are serviced by high cost servicers prior to the program implementation. We also include a set of controls including the zip code average FICO credit score, LTV ratio, interest rate on mortgages along with the average zip code house price growth over the prior five years and state fixed effects. Column (1) presents the specification without *Eligible and High Cost Servicer Share* control, while Column (2) repeats this analysis, but includes this variable in the set of controls. Columns (3) and (4) provide the corresponding analysis for the fraction of loans in a zip code refinancing under HARP as the dependent variable. The servicer is classified as high cost if it is in the top quartile of servicers with the highest estimated fixed effects as displayed in Figure 5A. These high cost servicers account for over 60% of loans in our data. The analysis is based on a sample of 3,443 zip codes. Standard errors (based on the OLS estimates) are included in parentheses.

	Dependent variable: Reduction in the average mortgage interest rate in a zip code due to HARP (in basis points)		Dependent variable: Fraction of loans in a zip code refinancing under HARP	
	(1)	(2)	(3)	(4)
Eligible Share	38.0 (0.01)	49.1 (0.03)	0.24 (0.01)	0.35 (0.01)
Eligible and High Cost Servicer Share	-	-17.4 (0.05)	-	-0.16 (0.03)
Zip Code Controls	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes
Adj. R-squared	0.70	0.71	0.68	0.69

Appendix A.5:

Evolution of Observables among HARP and Conforming Refinances prior to the Program Change

This figure tracks the evolution of average FICO credit scores (panel a) and LTV ratios (panel b) of borrowers at the time of loan refinancing among HARP and conforming refinance during the six months preceding the change in the program rules. The solid line represents HARP refinances while the dashed line shows the corresponding means for conforming refinances. The average LTV ratio for HARP refinances consistently remains about 30% above that for conforming refinances, with little relative change over time (by construction our benchmark conforming refinances have LTV ratios equal to 80 percent). We do not observe a substantial relative variation in the borrower credit scores between HARP and conforming refinances.



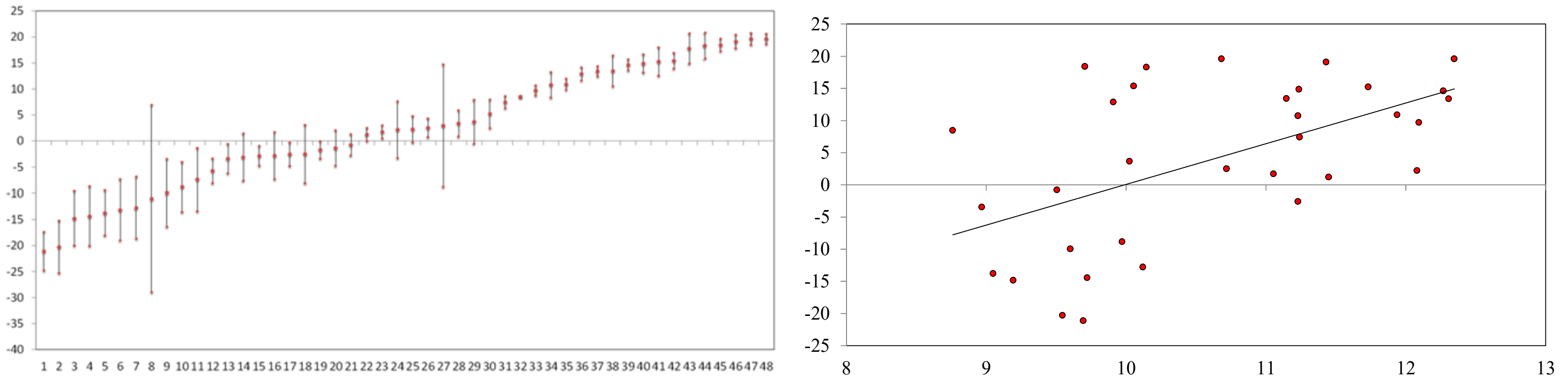
(a) FICO credit score

(b) LTV

Appendix A.6:

HARP-Conforming Spread across Lenders

Panel (a) of this figure plots the servicer fixed effects corresponding to the identity of HARP lender from the specification in Column (2) of Table 5, in which the dependent variable is the *HARP-conforming refi spread* along with 95% confidence intervals. Lender names have been anonymized. Panel (b) shows the relation between the lenders' fixed effects (y-axis) and their log asset size as of 2009 (x-axis). This figure is plotted only for the lenders for which we have asset size data collected from publicly available sources.



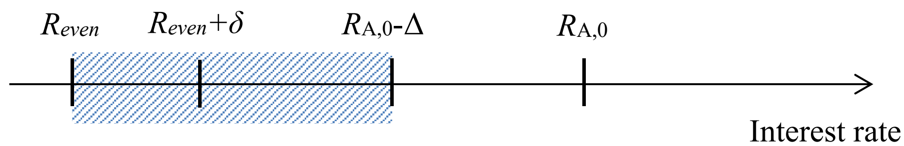
(a) Lenders' fixed effects

Lender's fixed effects and log asset size

On-Line Appendix B:

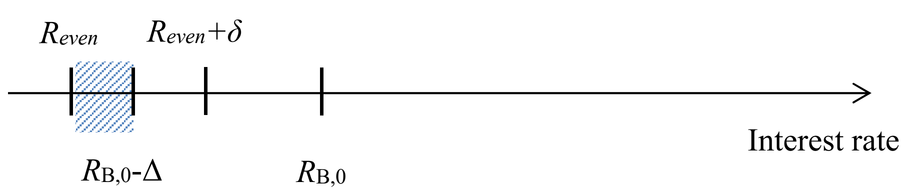
Variation in HARP-Conforming Refi Spread and Legacy Interest Rate

This appendix provides more discussion of our conjecture that the legacy interest rate on the mortgage prior to refinancing may be systematically related to the degree of pass-through under HARP. To see this argument further, consider the simple example where two similar HARP eligible borrowers (A and B) want to refinance their loans. The interest rates on their original loans (i.e., the legacy interest rates) are $R_{A,0}$ and $R_{B,0}$, such that $R_{A,0} > R_{B,0}$. Given the assumed similarity of borrower's risk characteristics, the difference in interest rates faced by the borrowers could reflect time variation in benchmark *risk-free* rates pinned down by the timing of when these borrowers obtained their original loans. We further assume that a borrower needs to obtain a reduction of the interest rate of at least Δ per year in order to refinance a loan (see Agarwal, Driscoll, and Laibson (2013) for an optimal rule for Δ). An existing lender requires an interest rate of R_{even} to break even on the new mortgage, given the borrower's risk characteristics. Since by assumption, borrowers A and B have identical risk profiles at the time of refinancing, they face the same breakeven rate. In a perfectly competitive market – proxied in our benchmark analysis by the conforming refinancing market -- the same R_{even} would apply to all lenders. However, suppose a new lender must charge a rate premium, δ, to compensate for higher underwriting costs due to higher put back risk (Section II). In this setting, what interest rates could be obtained by A and B on their respective loans? The diagram below sketches out the case for borrower A.



The shaded area represents the region of rates that satisfy the participation constraints of both the borrower and the lender. Although the existing lender can potentially charge $R_{A,0} - \Delta$, the presence of the outside option offered by the new lender effectively constrains the maximum rate offered by the existing lender to be $R_{even} + \delta$. This results in the existing lender being able to charge an interest rate above the expected cost and extracting some surplus from the borrower.

In the case of borrower B, the existing loan has a lower interest rate, although it is still higher than the rate on the newly refinanced loan. In the diagram below, a new lender is unable to offer a rate $R_{even}+\delta$ as this rate does not satisfy the borrower's participation constraint. However, because $(R_{B,0} - \Delta) < (R_{even} + \delta)$, the existing lender can still realize a markup over its expected cost of funding the loan, albeit smaller than in the case of Borrower A. This difference in the interest rates obtained by A and B occurs despite the fact that these borrowers have the same risk characteristics.



The discussion above assumes that the current lender (servicer) knows the borrower's participation constraint as well as the costs of other lenders. In reality the incumbent lender may be imperfectly informed about both the borrower's participation constraint as well as the refinancing cost structure of its competition (i.e., the incumbent lender may only know distributions of these factors). In such a scenario, the decision of the incumbent lender regarding the rate to be offered will reflect the trade-off between the expected profit in the case that the offer is accepted versus the risk of losing the borrower either due to violating the borrower participation constraint (offering insufficient reduction in rate) or due to other lenders being able to offer a lower rate (if their refinancing cost proves to be low enough).

It is not difficult to construct a simple market equilibrium model featuring such a tradeoff. In such equilibrium, consistent with the above discussion, the incumbent lender will still offer higher refinancing rates to borrowers with higher legacy rates and to borrowers for whom the expected cost of refinancing by other lenders is larger (and hence there is less competition). Moreover, fewer borrowers will end up refinancing their loans relative to the case when the incumbent servicer would offer its zero profit rates. These borrowers would be the ones with required reduction in rates higher than the one offered by the incumbent lender but lower than what is implied by a break-even rate. In addition, some loans will also be refinanced by other non-incumbent lenders (i.e., mortgages they can refinance at relatively low refinancing costs).

On-Line Appendix C:

Life-Cycle Model Solution Algorithm and Parametrization

C.1 Model Setup

Denote the terms of the mortgage contract at the beginning of period t that a household has obtained in some previous period by $(\bar{M}_t, \bar{r}_t^M)$. Further, denote the size of house owned at the beginning of t by $\bar{H}_t$ and the savings in risk-free debt by $\bar{L}_t$. To describe the decision problem of the household, it is useful to distinguish five cases.

The household always has the option of staying in the current house and keeping the same mortgage terms, while either staying on the fixed amortization schedule or prepaying part of the mortgage balance. The mortgage debt for next period then has to satisfy $M_t \leq (1-\delta_H)\bar{M}_t$, and the rate for next period is $\bar{r}_{t+1}^M = \bar{r}_t^M$. The other choices are consumption C_t and savings L_t. The budget constraint is

$$Y_t + (1 + r_{t-1})\bar{L}_t - (1 + (1 - \tau_I)\bar{r}_t^M)\,\bar{M}_t = C_t + L_t + M_t. \tag{4}$$

The second option is to stay in the current house, but refinance the mortgage at the market rate, such that $\bar{r}_{t+1}^M = r_t + \varsigma$. In this case, the closing fee needs to be paid and the down payment requirement is enforced, i.e. $M_t \leq (1-\delta_H)P_t\bar{H}_t$,. The budget constraint is

$$Y_t + (1 + r_{t-1})\bar{L}_t - (1 + (1 - \tau_I)\bar{r}_t^M)\,\bar{M}_t = C_t + L_t - (1 - \nu)M_t. \tag{5}$$

The third option is to buy a new house and obtain a new mortgage at the market rate, such that $\bar{r}_{t+1}^M = r_t + \varsigma$. In this case, the closing fee needs to be paid and the down payment requirement is enforced with respect to the value of the new house, i.e. $M_t \leq (1-\delta_H)P_t\bar{H}_t$. The budget constraint is

$$Y_t + (1 + r_{t-1})\bar{L}_t + (1-\rho)P_t\bar{H}_t - (1 + (1 - \tau_I)\bar{r}_t^M)\,\bar{M}_t = C_t + L_t + P_tH_t - (1 - \nu)M_t. \tag{6}$$

Finally, the household can choose to default on its mortgage. In this case, the mortgage debt is erased, the house is seized by the mortgage lenders, and the household has to rent for its remaining life. Further, the household incurs a one-time additive utility penalty that is an increasing function of household wealth $\Delta(W_t)$. The budget constraint is

$$Y_t + (1 + r_{t-1})L_{t-1} = C_t + L_t + \alpha P_t H_t, \tag{7}$$

where α is the rent-to-price ratio.

C.2 Dynamic Program

We can define the liquid wealth of a household (assuming a hypothetical sale of its house) as

$$W_t = (1-\rho)P_t\bar{H}_t + (1 + r_{t-1})\bar{L}_t - (1 + (1 - \tau_I)\bar{r}_t^M)\bar{M}_t.$$

Denote by $V_{a_t}^S(W_t, \bar{H}_t, \bar{M}_t, \bar{r}_t^M;\, Z_t)$ the value function of a household with age a_t conditional on the decision to stay and keep the same mortgage or prepay part of the balance (options 1 or 2), by $V_{a_t}^{SR}(W_t, \bar{H}_t;\ Z_t)$ the value function conditional on the decision to stay and refinance (option 3), and by $V_{a_t}^{B}(W_t;\ Z_t)$ the value function conditional on the decision to sell the current house and buy a new one (option 4).

To model default, denote by $V_{a_t}^{R}(W_t;\ Z_t)$ the value function of a renting household with savings W_t. Renting households solve

$$V_{a_t}^{R}(W_t;\ Z_t) = \lambda_{a_{t+1}} \left\{ \max_{C_t, L_t, H_t} u(C_t, H_t) + \ \beta E_t\left[V_{a_{t+1}}^{R}(W_{t+1};\ Z_{t+1})\right] \right\} + \left(1 - \lambda_{a_{t+1}}\right) B(W_t)$$

subject to

$$W_t + Y_t = C_t + L_t + \alpha P_t H_t$$
$$W_{t+1} = (1 + r_t) L_t.$$

This implies that the optimization problem of a household conditional on the decision to default this period is given by

$$V_{a_t}^{D}(W_t^D;\ Z_t) = V_{a_t}^{R}(W_t^D;\ Z_t) - \lambda_{a_{t+1}} \Delta(W_t).$$

where we defined wealth after default as

$$W_t^D = (1 + r_{t-1}) \bar{L}_t.$$

The value function of a household who has not previously defaulted is then

$$V_{a_t}(W_t, \bar{H}_t, \bar{M}_t, \bar{r}_t^M;\ Z_t) = \max\{V_{a_t}^{S}(W_t, \bar{H}_t, \bar{M}_t, \bar{r}_t^M;\ Z_t), V_{a_t}^{SR}(W_t, \bar{H}_t;\ Z_t), V_{a_t}^{B}(W_t;\ Z_t), V_{a_t}^{D}(W_t^D;\ Z_t)\}.$$

We will now define the optimization problems conditional on the different discrete decision options.

For households who stay and keep the same mortgage rate we get

$$V_{a_t}^{S}(W_t, \bar{H}_t, \bar{M}_t, \bar{r}_t^M;\ Z_t) = \lambda_{\alpha_{t+1}} \left\{ \max_{C_t, L_t, M_t} u(C_t, \bar{H}_t) + \beta E_t\left[V_{a_{t+1}}(W_{t+1}, \bar{H}_t, M_t, \bar{r}_t^M;\ Z_{t+1})\right] \right\}$$
$$+ \left(1 - \lambda_{a_{t+1}}\right) B(W_t)$$

subject to

$$M_t \leq (1 - \delta_M) \bar{M}_t$$
$$W_t + Y_t + p P_t \bar{H}_t = C_t + L_t + P_t \bar{H}_t - M_t,$$
$$W_{t+1} = (1 - \rho) P_{t+1} \bar{H}_t + (1 + r_t) L_t - (1 + (1 - \tau_I) \bar{r}_t^M) M_t.$$

For households who stay and refinance we get

$V_{a_t}^{SR}(W_t, \bar{H}_t;\ Z_t) = \lambda_{a_{t+1}} \left\{ \max_{C_t, L_t, M_t} u(C_t, \bar{H}_t) + \beta E_t\left[V_{a_{t+1}}(W_{t+1}, \bar{H}_t, M_t, r_t + \varsigma;\ Z_{t+1})\right] \right\} + \big(1 - \lambda_{a_{t+1}}\big) B(W_t)$

subject to

$$M_t \leq (1 - \delta_H) P_t \bar{H}_t$$
$$W_t + Y_t + \rho P_t \bar{H}_t = C_t + L_t + P_t \bar{H}_t - (1 - v) M_t,$$
$$W_{t+1} = (1 - \rho) P_{t+1} \bar{H}_t + (1 + r_t) L_t - (1 + (1 - \tau_I)(r_t + \varsigma)) M_t.$$

For households that buy a new house we get

$$V_{a_t}^{B}(W_t;\ Z_t) = \lambda_{\alpha_{t+1}} \left\{ \max_{C_t, L_t, M_t H_t} u(C_t, H_t) + \beta E_t\left[V_{a_{t+1}}(W_{t+1}, H_t, M_t, r_t + \varsigma;\ Z_{t+1})\right] \right\} + \big(1 - \lambda_{a_{t+1}}\big) B(W_t)$$

subject to

$$M_t \leq (1 - \delta_H) P_t H_t$$
$$W_t + Y_t = C_t + L_t + P_t H_t - (1 - v) M_t,$$
$$W_{t+1} = (1 - \rho) P_{t+1} H_t + (1 + r_t) L_t - (1 + (1 - \tau_I)(r_t + \varsigma)) M_t.$$

Our assumptions on utility functions and stochastic processes allow us to define a transformed stationary optimization problem by normalizing choice variables and value functions by trend income. To do so, we first define transformed choice variables $c_t = C_t/\bar{Y}_t$, $l_t = L_t/\bar{Y}_t$ and $m_t = M_t/\bar{Y}_t$, and state variables $w_t = W_t/\bar{Y}_t$ and $\bar{m}_t = \bar{M}_t/\bar{Y}_t$. We further define housing choice and state variables in terms of expenditure at the trend house price as

$$h_t = \frac{\bar{P}\bar{Y}_t H_t}{\bar{Y}_t} = \bar{P} H_t, \bar{h}_t = \frac{\bar{P}\bar{Y}_t \bar{H}_t}{\bar{Y}_t} = \bar{P}\bar{H}_t.$$

We can then write transformed optimization problems that define value functions

$$v_{a_t}^{j}(\cdot; r_t) = \frac{V_{a_t}^{j}(\cdot; r_t)}{(\bar{Y}_t \bar{P}^{-\chi})^{1-\gamma}},$$

for *j* = R (renting), D (defaulting), S (staying), SR (staying and refinancing), B (buying), respectively.

First, for renting households the transformed problem is

$$v_{a_t}^{R}(w_t; Z_t) = \lambda_{a_{t+1}} \left\{ \max_{c_t, l_t, h_t} \frac{\left(c_t^{1-\chi} h_t^{\chi}\right)^{1-\gamma}}{1-\gamma} + \beta E_t\left[e^{(1-\gamma)g} v_{a_{t+1}}^{R}(w_{t+1};\ Z_{t+1})\right] \right\} + \big(1 - \lambda_{a_{t+1}}\big) \bar{B} \frac{w_t^{1-\gamma}}{1-\gamma}$$

subject to

$$w_t + \tilde{Y}_t^A exp(f(a_t) + \eta_t) = c_t + l_t + \alpha h_t,$$
$$w_{t+1} = e^{-g}(1 + r_t)l_t,$$

and therefore the problem of a defaulting household is

$$v_{a_t}^D\left(w_{a_t}^D; r_t\right) = v_{a_t}^R\left(w_{a_t}^D; r_t\right) - \lambda_{a_{t+1}}\kappa \frac{w_t^{1-\gamma}}{1-\gamma}.$$

For households who stay and keep the same mortgage rate we get

$$v_{a_t}^S\left(w_t, \bar{h}_t, \bar{m}_t, \bar{r}_t^M; Z_t\right) = \lambda_{a_{t+1}} \left\{ \max_{c_t, l_t, m_t} \frac{\left(c_t^{1-\chi} h_t^{\chi}\right)^{1-\gamma}}{1-\gamma} + \beta E_t\left[e^{(1-\gamma)g} v_{a_{t+1}}(w_{t+1}, \bar{h}_{t+1}, \bar{m}_{t+1}, \bar{r}_t^M;\ Z_{t+1})\right] \right\} +$$
$$\left(1 - \lambda_{a_{t+1}}\right)\bar{B} \frac{w_t^{1-\gamma}}{1-\gamma}$$

subject to

$$m_t \leq (1 - \delta_M)\bar{m}_t$$
$$w_t + \tilde{Y}_t^A exp(f(a_t) + \eta_t) + p\bar{h}_t = c_t + l_t + \tilde{P}_t^A \bar{h}_t - m_t,$$
$$w_{t+1} = e^{-g}((1 - \rho)\tilde{P}_{t+1}^A h_t + (1 + r_t)l_t - (1 + (1 - \tau_I)\bar{r}_t^M)m_t)$$
$$\bar{h}_{t+1} = e^{-g}\bar{h}_t$$
$$\bar{m}_{t+1} = e^{-g}m_t.$$

For households who stay and refinance we get

$$v_{a_t}^{SR}\left(w_t, \bar{h}_t; Z_t\right) = \lambda_{a_{t+1}} \left\{ \max_{c_t, l_t, m_t} \frac{\left(c_t^{1-\chi} h_t^{\chi}\right)^{1-\gamma}}{1-\gamma} + \beta E_t\left[e^{(1-\gamma)g} v_{a_{t+1}}\left(w_{t+1}, \bar{h}_{t+1}, \bar{m}_{t+1}, r_t^M;\ Z_{t+1}\right)\right] \right\}$$
$$+\left(1 - \lambda_{a_{t+1}}\right)\bar{B} \frac{w_t^{1-\gamma}}{1-\gamma}$$

subject to

$$m_t \leq (1 - \delta)\tilde{P}_t^A \bar{h}_t$$
$$w_t + \tilde{Y}_t^A exp(f(a_t) + \eta_t) + \rho\tilde{P}_t^A \bar{h}_t = c_t + l_t + \tilde{P}_t^A \bar{h}_t - (1 - v)m_t,$$
$$w_{t+1} = e^{-g}((1 - p)\tilde{P}_t^A \bar{h}_t + (1 + r_t)l_t - (1 + (1 - \tau_I)r_t^M)m_t)$$
$$\bar{h}_{t+1} = e^{-g}\bar{h}_t$$
$$\bar{m}_{t+1} = e^{-g}m_t.$$

For households that buy a new house we get

$$v_{a_t}^B(w_t; Z_t) = \lambda_{a_{t+1}} \left\{ \frac{\max\limits_{c_t, l_t, m_t, h_t} \quad \left(c_t^{1-\chi} h_t^{\chi}\right)^{1-\gamma}}{1-\gamma} + \beta E_t\left[e^{(1-\gamma)g} v_{a_{t+1}}\left(w_{t+1}, \bar{h}_{t+1}, \bar{m}_{t+1}, r_t^M;\ Z_{t+1}\right)\right] \right\}$$

$$+\frac{(1-\lambda_{a_{t+1}})\bar{B}\left(w_t^{1-\gamma}\right)}{1-\gamma}$$

subject to

$$m_t \leq (1-\delta)\tilde{P}_t^A \bar{h}_t$$
$$w_t + \tilde{Y}_t^A exp(f(a_t)+\eta_t) = c_t + l_t + \tilde{P}_t^A h_t - (1-v)m_t,$$
$$w_{t+1} = e^{-g}((1-\rho)\tilde{P}_t^A h_t + (1+r_t)l_t - (1+(1-\tau_I)r_t^M)m_t)$$
$$\bar{h}_{t+1} = e^{-g}h_t$$
$$\bar{m}_{t+1} = e^{-g}m_t.$$

C3. Model Solution and Simulation

The dynamic program specified in Section C2 above can be solved recursively starting in period T, where

$v_{a_T}^j(w_T, \cdot) = \bar{B}\frac{w_T^{1-\gamma}}{1-\gamma}$, since $\lambda_{a_T} = 0$.

To compute the value functions $v_{a_T}^j(w_T, \cdot)$ for $j = R, SR, S, B$ in practice, we discretize the continuous state variables $(w_t, \bar{h}_t, \bar{m}_t, \bar{r}_t^M)$ with 20 grid points each. The spacing of the grid points is chosen with the goal of the simulation exercises in mind such that the points are denser around the median household in the estimation sample. The three aggregate exogenous shocks are discretized as a multi-variate Markov-chain with 2 nodes each for the aggregate income and house price shocks, and 5 nodes for the risk free interest rate (implying that the aggregate state of the economy can take on 20 different values). The inputs for the discretization are obtained by estimating a VAR on the relevant data counterparts (see Section C4 below. The idiosyncratic income shock is discretized using the Rouwenhorst method using 2 nodes. For the endogenous state variables, we use multi-variate linear interpolation to compute the continuation value in case the next period state variables lie between grid points.

For the results in Table 8 and Figure 6, we simulate a sample of 200,000 borrowers for three years. The borrowers are heterogeneous by initial LTV and prior interest rate, centered on the median borrower in the estimation sample. We simulate the optimal borrower decisions based on the policy functions obtained from solving the model. The simulation assumes a fixed sequence of aggregate shocks, chosen to reflect the aggregate state of the economy around the time of the introduction of HARP. Borrowers' idiosyncratic income evolves stochastically based on the parameters that govern the income process in the model.

C4. Model Parameters and Calibration

The housing related parameters are set to common values in the literature on housing markets that represent long-run estimates. The transaction cost for selling a house as a fraction of the house value, ρ = 10%, contains the actual cost of selling such as realtor's fees and the cost of moving for homeowners. The maintenance share ψ = 2% is the fraction of the house value that homeowners have to spend annually to offset depreciation. The rent-to-price ratio is set to α = 6% (see e.g. Davis, Lehnert, and Martin (2008)). Mortgage-related parameters are also set to standard values. The home equity requirement is set to δ = 20%, reflecting the 80% maximum LTV at origination for conforming mortgages. The refinancing cost is set to ν = 3% of the mortgage balance, including fees and commission. The mortgage spread of ζ = 3% is computed as the average difference between the 30-year fixed mortgage rate reported by Freddie Mac and the yield on the 1-year treasury bill over the period from 1971 to 2015, to reflect both a term and a credit premium. For the amortization rate we set δ_M = 3.7% to target an effective duration of 15 years of the mortgages in the model, given optimal refinancing. As marginal tax rate for the mortgage interest rate deduction, we use 25%.

We set the growth rate of GDP per capita and house prices g to 2%, the long-term average for the US. The standard deviation of idiosyncratic income shocks is set to 21% and the persistence to 0.9, in line with empirical estimates of residual earnings at the household level. We calibrate the remaining preference parameters to match data moments from the 2010 Survey of Consumer Finances (SFC). We pick the discount factor $\beta = 94\%$ to match the average net worth to income ratio of home owners of young homeowners. We choose a coefficient of relative risk aversion of $\gamma = 5$ to target average leverage of home owners, and we choose the weight on housing in the utility function to be χ = 0.15 to match the average house value to income ratio. Finally, we choose the bequest parameter to match the average wealth to income ratio among older households (age 65 and greater).

Table C.1: Model Parameters

Parameter	Value
Housing	
Housing maintenance ψ	0.02
Sale transaction cost ρ	0.10
Rent-to-price ratio α	0.06
Mortgages	
Annual amortization δ_M	0.037
Refinancing cost ν	0.03
Home equity requirement δ	0.20
Mortgage spread ζ	0.03
Tax rate for MID τ	0.25
Preferences and Income	
Risk aversion γ	5
Discount factor β	0.94
Weight on housing χ	0.15
Bequest strength $\bar{B}$	3
Utility penalty κ	10
Growth rate g	0.02
Idiosyncratic income risk σ_η	0.21
Idiosyncratic income persistence ρ^η	0.90

To determine the coefficients of the VAR for the exogenous state variables, we estimate a VAR on the following series (all annual 1954-2016):

1. GDP per capita, adjusted for inflation using the implicit GDP deflator. We take the logarithm of this series and HP filter it with parameter 100 to remove the trend.
2. The price index constructed from private residential fixed investment (BEA). We take the logarithm of this series and HP filter it with parameter 100 to remove the trend.

3. The one-year treasury constant maturity rate, adjusted for inflation by subtracting the growth rate of the GDP deflator.

The table below shows unconditional means and standard deviations and the estimated coefficient matrix from the VAR.

Table C.2: VAR estimation

Variable	Mean	Std.dev.	$\tilde{Y}_{t-1}^{A}$	$\tilde{P}_{t-1}^{A}$	r_{t-1}
$\tilde{Y}_{t}^{A}$	0.000	0.0321	0.604	0.308	-0.135
$\tilde{P}_{t}^{A}$	0.000	0.0459	-0.185	0.836	0.117
r_t	0.019	0.0255	0.000	-0.215	0.834
Constants	--	--	0.000	0.005	0.003

Figure C.1: Model fit of age profiles for household balance sheet positions

This figure plots life-cycle profiles of wealth-to-income and house value-to-income ratios for model versus data. Even though we are not explicitly targeting life-cycle moments, the model produces a good fit for wealth-to-income ratios and house value-to-income ratios over the life cycle.