Unintended Consequences of Policy Interventions: Evidence from Home Affordable Refinance Program[*]

Xiaoye Tian[†] Chen Zheng[‡]

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Abstract

This paper studies the unintended consequences arising from program design, and how it augments the market power of incumbent lenders, in the context of a federal program called Home Affordable Refinance Program. We build a dynamic discrete choice model of refinance decision where the payoff is generated from a search and negotiation process. We estimate the model using data on program participation and pricing decision. The estimation exploits a significant change to the program design that gives variation in the competitive advantage of incumbent lenders under the program. In a counterfactual where the advantage granted by program design is shut down, we find that it leads to an average welfare improvement of $4,977, or 3.6% relative to the baseline. The insight from this study could apply to other policies whose implementation depends on intermediaries with incumbent advantage with respect to targeted agents.

Keywords: HARP, Program Design, Competition, Incumbent Advantage, Mortgage, Refinancing, Household Finance, Financial Crisis

JEL Classification Codes: E65, G21, L85

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[†]Department of Economics, University of Wisconsin-Madison, Madison, WI 53706, xtian37@wisc.edu

[‡]Department of Economics, University of Wisconsin-Madison, Madison, WI 53706, czheng37@wisc.edu

1 Introduction

During adverse economic conditions, the federal government launches large-scale stimulus programs to help financially distressed households and small business owners[1]. These initiatives, however, typically rely on financial intermediaries to implement in a market setting. In the consumer finance markets, a large body of the literature has studied various sources that give rise to market power, which could lead to an incomplete pass through of the benefits. Thus, the design of the program is crucial - ideally, it should create a competitive environment among financial intermediaries so that would maximize the share of gains that goes to targeted agents.

In this paper, we study the welfare implication associated with program design in the context of a federal stimulus program: Home Affordable Refinance Program (thereafter, HARP). It is an important program that tries to help households refinance their mortgage, but the program design unintentionally exacerbates the market power of incumbent lenders[2] by giving them a cost advantage, resulting in an uneven competitive field in the program. What is the impact of design flaw on program outcome such as take-up (refinance) rate and price? Absent of the design flaw, how would consumer welfare and default rate change?

Refinance is one of the main financial decisions U.S. households make since it is a direct channel through which they can benefit from decline in the cost of credit. By refinancing their mortgage, households get a reduction on their previous interest rate, which reduces their mortgage payment[3]. During the 2008 housing crisis, home value widely depreciated. The loss of home equity caused many households unable to refinance despite of the declining interest rate[4]. In a response to this situation, the government launched HARP. It removes equity constraint on refinance, thus allowing households with insufficient equity regain access to the refinance market. HARP was a very well intentioned program - opening up refinance market had the potential to influence household consumption, providing a much needed stimulus to the economy. Since the U.S. government provides insurance against mortgage default to investors, lower mortgage payment can also help to lower the overall default rate in the economy.

[1] For example, the Paycheck Protection Program (PPP) was launched during the early period of Covid-19. Back in the 2008 housing crisis, the federal government created the Making Home Affordable (MHA) Program.

[2] The incumbent lender refers to borrowers' current lender who they repay their existing mortgage.

[3] There are other forms of refinance, such as cash-out refinance where additional loan is taken out on property already owned. In this paper, we only focus on rate refinance since this is what HARP allows households to do.

[4] Lenders require a minimum home equity of 20% when households refinance their mortgage.

However, the program is not working as intended. Only less than a million households actually refinanced under HARP, while the government originally were targeting to reach up to 8 million (HARP Mid-Program Report).

Refinance, like other financial products, requires a lump-sum costs from the consumers. If the refinance option is not attractive, households would not refinance right away given the option value of waiting to get a better offer. The attractiveness of the offer depends on the extent to which mortgage lenders compete and pass through lower rates to consumers. However, the competitive playing field in HARP favored the incumbent lenders for at least two reasons. First, the refinance market is characterized by search frictions since households incur a cost to gather price quotes. This allows incumbent lenders to price discriminate based on borrower's outside options and/or search costs (Allen et al. (2019)). The second advantage of incumbent lenders arises from a feature of program design. In order to encourage participation of mortgage lenders, HARP protects incumbent lenders from much of the underwriting risk on newly refinanced loans[5], but refusing to extend this treatment to competing lenders. As a result, HARP created deep asymmetries in costs of refinancing between the incumbent lenders and their would-be competitors (Amromin and Kearns (2014)). Instead of promoting competition, the program unintentionally augmented the market power of incumbent lenders. In fact, market share of incumbent lenders increased to 68% under HARP compared to 28%-32% in the regular refinance sector (Agarwal et al. (2015)).

In order to quantify the welfare impact associated with program design, we need to separately identify the magnitude of search friction and program granted advantage. To that end, we develop an equilibrium model of mortgage refinancing and search decisions. In the model, households first decide whether or not to refinance in each period, which we model as a dynamic discrete choice problem. A refinancing decision requires a cost-benefit analysis for the mortgage borrowers. Refinancing costs include transaction costs[6] and search costs. Thus, households face the tradeoff between refinancing this period to get a lower interest rate by paying a lump-sum cost, versus the continuation value of waiting to get a better offer. We adopt the seach and negotiation framework introduced in Allen et al. (2019) to derive the payoff of

[5] We delay the discussion of the specifics of incumbenct underwriting advantage to Section 2 when we provide more institutional background.

[6] Transaction costs in a mortgage refinancing include applicaton fee, apprisal fee, and title search fee, etc.

refinance: If households choose to refinance, they first get an (free of search cost) initial quote from their incumbent lender. Based on their idiosyncratic search cost and outside option, they decide if they will accept the incumbent offer (i.e. not search) or search for another offer (by paying a search cost). The incumbent offer is derived from a monopoly pricing problem of the incumbent lender, taking into consideration that it has another chance to compete in the negotiation stage. The competing lenders only make an offer if the initial quote was rejected by the borrowers. We model the competition between the incumbent and competing lender in this stage as a Bertrand competition. Thus, in our model, borrower's refinance decision depends on the competitiveness of the lending market. If there is a limited competiton, then it will lead to an unattractive (i.e. high price) offer, which inhibits households from refinancing.

We estimate the model using Simulated Method of Moments (SMM) by matching model's prediction of refinance decision and price to the data. The data we use for this study comes from the U.S. single family loan level dataset, which contains detailed loan level information at origination. The HARP data, which is a subset of the main data, has a very neat feature - it allows us to link every HARP participant to their previous mortgage transaction[7]. Therefore, we can construct key variables for this study such as whether borrowers switch to other lenders as well as their interest rate saving under the program. The identification of the model leverages a change on the program rule regarding underwriting risks. During the first half of HARP, incumbent lenders enjoy asymmetric underwriting cost advantage compared to the competing lenders. This changed in the middle of the program when the government announced both the incumbent and competing lenders would face the same set of underwriting standard. This has a direct effect on the competitive advantage of incumbent HARP refinances. We use this variation to back out the degree of incumbent advantage granted by the program, the key parameter of the model.

Our estimates show that incumbent lenders have a markup three times higher than the competing lenders under HARP, coming from the advantage of both search and program granted advantage. The main source of the incumbency advantage is the program granted advantage, which accounts for 68% of the margin. Since the search decision depends on the

[7] We cannot do the same for the regular refinance market. That is, we are not able to link a regular refinance to its previous transaction because the original loan gets assigned a new identification number when it is prepaid.

offer from the competition stage, borrowers will choose to accept incumbent offer if they don't expect gain too much from searching. However, even if borrowers search, they will likely end up staying with their incumbent due to the program advantage. We find the incumbent is able to retain the household with a probability of 62%[8]. Therefore, HARP gives a significant competitive advantage to incumbent lenders that makes it very hard for competing lenders to compete for households.

In our counterfactual analysis, we first perform a decomposition exercise. We do so by simulating household refinance decision and the price they will get in an environment without search friction and without program advantage. In the baseline, the model predicts HARP refinance rate of 15% and average interest rate saving of 156 bps. If we shut down search, we find HARP refinance rate and saving would increase 4.4% and 9 bps, respectively. If we shut down program advantage, they would increase 8.2% and 33 bps, respectively. Thus, our model suggests the program advantage plays a bigger role. Absent of search friction, households may still stuck with their incumbent if they have no good outside option (from competing lender) to negotiate with the incumbent lender. Next, we quantify the welfare improvement with program advantage shut down at the beginning of the program. As more people are able to refinance and get a lower interest rate, we find that the overall default rate would decrease from 6.5% to 4.2%, a 35.5% reduction compared to the baseline. We also find on average, household could increase their life time saving from the program by $4,977, or 3.6% relative to the baseline. However, this masks important heterogeneity with a standard deviation of $3,597. This heterogeneity arises from dynamic selection in the refinance market: households who refinanced earlier are those with most incentives to do so. For example, households with higher previous mortgage payment, conditional on everything else, would refinance early to reduce their mortgage payment. These households are also probably the main target of the program. If HARP does not have the design flaw, more households could have refinanced and got a lower price from the program. Our analysis suggests that whether a program will work as intended or possibly have unintended consequences depends on how the program details interact with the incentives of participants in the relevant markets. In the context of HARP, even if the government fixed the design flaw in the middle of the program, it should have

[8]This is calculated as the households who accept incumbent offer divided by households who search.

been more careful when designing the programs from the beginning as it has a sizable welfare implication.

Our paper relates to several strands of literature. It is related to the literature that examines the importance of institutional frictions and financial intermediaries in effective implementation of stabilization programs, particularly in housing markets. Piskorski et al. (2010) and Agarwal et al. (2017a) study Home Affordable Modification Program (HAMP), another federal program that tries to help households modify their mortgage. They find that lender-specific factors, such as servicing capacity and cost structure, can affect the effectiveness of policy intervention. Also analyzing HARP, Abel and Fuster (2019) stuides the effect of HARP on household debt and spending. Both Agarwal et al. (2015) and Amromin and Kearns (2014) point out that the design flaw in HARP that increases the pricing power of HARP lenders, which lead to higher interest rates in mortgage markets compared to the regular refinance market. We add to this literature by quantifying the welfare loss associated with program design flaw via estimating a structural model. Our paper is also closely related to the studies exploring decision-making in the mortgage refinancing market (Keys et al. (2016), Agarwal et al. (2017b), Wong (2019), DeFusco and Mondragon (2020)). This literature focuses on borrower specific factors such as inattention or liquidity in explaining their refinancing decisions. While such borrower specific factors can also help account the muted response to HARP, our paper emphasizes the importance of financial intermediaries and the degree of market competition in explaining part of this shortfall. Similar to our paper, Ambokar and Samaee (2019a) and Ambokar and Samaee (2019b) also studies the role of search fricition in borrower's refinacing decision. Ours complement their paper by analyzing another sources of market power that comes from program design. Finally, our paper fits into the literature that examines the market power in consumer finance market. Previous literaure (Woodward and Hall (2012), Honka (2014), Scharfstein and Sunderam (2016), Allen et al. (2019), Agarwal et al. (2020)) has documented various sources that give rise to market power. We add evidence to this literature by studying the refinance market. Our paper is most closely related to Allen et al. (2019), who proposes a search and negotiation framework to quantify the magnitude of incumbenct advantage in Canadian mortgage market, but we extend their model to a dynamic discrete choice framework to study market with dynamic selection such as refinance.

The remainder of the paper is organized as follows. Section 2 provides some institutional background about HARP. Section 3 describes in detail the data source used for the analysis and then use the data to document some key patterns of the program feature. Section 4 presents the model. Section 5 discusses the estimation procedure and identification. Section 6 shows the estimation results. Section 7 performs counterfactual simulations. Section 8 concludes. Additional technical details and tables/figures can be found in the appendices.

2 Program Background

This section provides some background information about HARP. We start with a discussion of the U.S. mortgage market before and during the financial crisis when HARP was created by the government. Then we discuss the unintentional program design that gives the incumbent lender a huge advantage, which results in a lack of competition under HARP.

2.1 U.S. Mortgage Market

The U.S. mortgage market is organized into two segments, a primary and secondary market. The primary mortgage market is where borrowers and lenders meet and negotiate lending terms to create a mortgage transaction, while the secondary mortgage market trades mortgage loans and mortgage backed securities (MBS). The secondary mortgage market is dominated by the government sponsored enterprises (GSEs), Fannie Mae and Freddie Mac, which purchase the loans from the primary market. The sold mortgage ends up as a part of a package of the pools of mortgages that, so bundled, turn into securities sold to investors in the capital market (a.k.a. securitization). GSEs guarantee full payment of interest and principal to investors on behalf of lenders and in exchange charge lenders an upfront guarantee fee. Mortgage lenders that securitized loans through GSE typically retained mortgages' servicing right[9], which is the main source of revenue for mortgage lenders. Therefore, mortgage lenders are essentially the intermediaries between the households and the GSEs.

The majority of mortgage contracts that GSEs acquired from lenders is fixed rate and

[9]The role as a servicer includes collecting payments, advanced them to the MBS trustee, and engaged in a variety of loss mitigating actions on delinquent loans. The terms "servicer" and "lender" are usually used interchangeably.

amortize over long time periods, usually 15 or 30 years. 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 (i.e. refinancing). Therefore, mortgage borrowers can take advantage of declines in the general level of interest rates (cost of credit) by refinancing a loan. However, since the new mortgage needs to be underwritten, its availability depends critically on the borrower creditworthy and the borrower having enough equity in their home[10].

Although historically the market for mortgage refinancing functioned smoothly, it encountered strong headwinds during the Great Recession. As home prices dropped precipitously, many households found themselves with little or no equity in their homes. The phenomenon of owing more on the house that it is worth came to be known as being "underwater". Therefore, despite the interest rate on 30-year conventional mortgages fell from around 6.5% in 2007–08 to below 5% in 2009, many of the distressed borrowers who might have obtained substantial benefits from the fall in rates were unable to refinance their mortgages at the lower rates.

As a response, the federal government, working with Fannie Mae and Freddie Mac, developed HARP in 2009 to expand the set of borrowers who could refinance their loans. The goal is to help those borrowers regain access to the refinance market, which can lower their mortgage payments and thus reduce mortgage default rates. The program waived the maximum LTV cap of 80% in the regular refinance market and allowed eligible[11] borrowers with insufficient equity to refinance their mortgages by extending federal credit guarantee on those loans. Absent HARP, borrowers with a LTV ratio above 80% would not qualify for regular refinancing of their mortgages. However, the program only allows each household use once. Once a household refinance their mortgage under HARP, they cannot refinance under the program anymore.

2.2 Incumbent Program Advantage

While HARP was a very well intentioned program, its implementation ultimately relies on the participation of mortgage lenders in the market. However, during the inception of HARP,

[10] Traditionally, lenders require a LTV ratio no more than 80% for a refinance transaction, although the maximum they are willing to accept is 95% if the borrower is willing to pay mortgage insurance premium upfront.

[11] Other than the LTV ratio greater than 80%, the program also include some other requirements such as the borrowers cannot have delinquency record in previous 12 months. See www.makinghomeaffordable.gov/get-answers/Pages/program-HARP.aspx for more details.

the U.S. mortgage market was going through a tightening underwriting standard, presumbly because the large amount of poorly underwritten loans before the crisis. Specifically, there willingness to participate in HARP was undermined by ambiguities about the program's treatment of representations and warranties (R&W)[12]. 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 (Agarwal et al. (2015), Amromin and Kearns (2014)). In Figure 1(a), we plot the proportion of putback, calculated as the number of putback divided by the number of default loan. In Figure 1(b), we plot the default ratio by LTV group, calculated as the number of default devided by the total number of loans. These figures confirm that the industry description is consistent with the data.

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. The program degisn, while has a good intention of encouraging lender participation, unintentionally exacerbated the incumbenct advantage by giving them an additional cost advantage in underwriting.

With continuing communication between lenders and GSEs regarding R&W liability, FHFA addressed concerns about the open-ended nature of R&W violation reviews[13]. These changes went into effect in January 2013. Before the sunset provisionsnew policy, a new lender was

[12]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.

[13]The review 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.

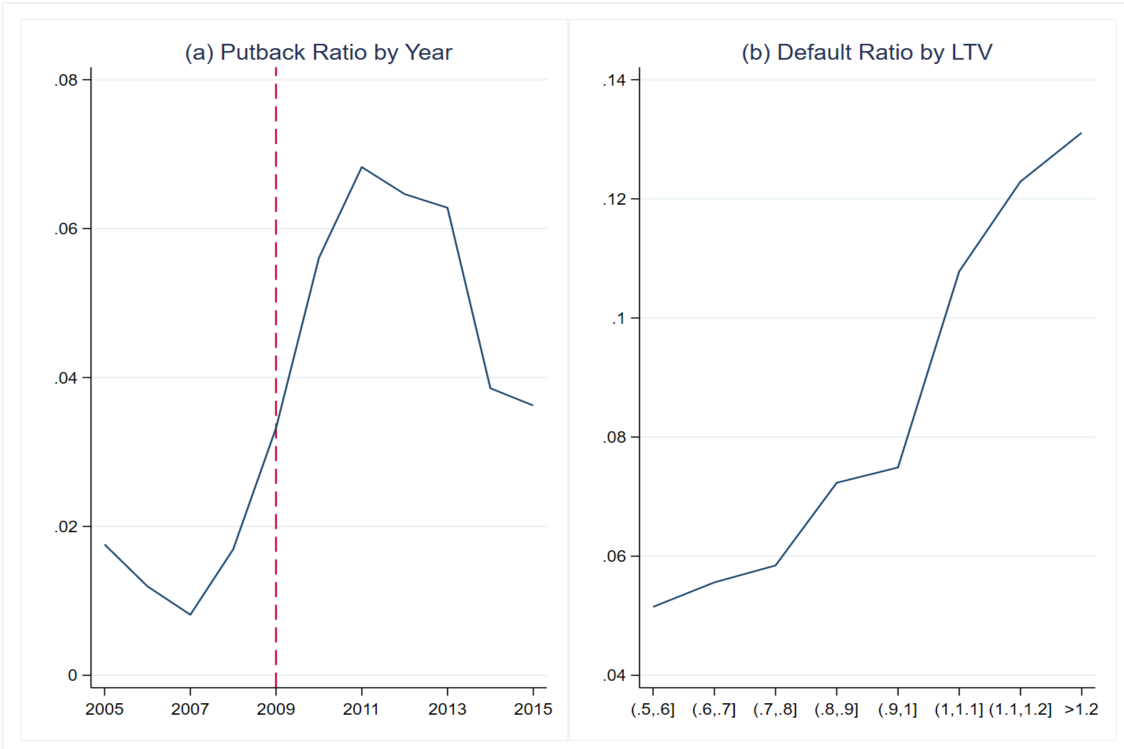

Figure 1: Tightening Underwriting Standard during HARP

Figure 1(a) shows the the put back risk became particularly pronounced when HARP was launched when mortgage investors and GSEs began conducting aggressive audits for possible R&W violations on every defaulted loan. Figure 1(b) then shows the risk of default was considered to be particularly high in the case of low-equity and underwater loans targeted by HARP, so mortgage lenders regarded R&W as a major liability in the program.

taking on an 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. More importantly, this was the same set of standard for both the incumbent and competing. The clarification of the R&W process have had a direct effect on the competitive advantage of same-lender HARP refinances (Agarwal et al. (2015)).

3 Data

In this section, we first describe in detail the data sources used for the analysis. It comes from three sources. The first is the single family loan-level data complied by GSEs. The second is the data for HARP, which is a separate data that GSEs publish in addition to their main data. The third is the housing price index which measures price movement of single-family houses. We then use the data to document some key patterns of the program feature.

3.1 Data Source

GSE Single Family Data GSEs started to publish the single family loan-level data to support the risk sharing and transparency encouraged by their regulator, Federal Housing and Finance Agency (FHFA). The data starts in 2000 and is updated quarterly. It consists of two parts: acquisition and performance. The acquisition file provides characteristics of loans that are acquired by GSEs at the loan origination level. Loan characteristics that we observe include credit score (FICO), LTV ratio, debt-to-income (DTI) ratio, loan amount, loan purpose (e.g., home purchase, no cash-out refinance, cash-out refinance), quarter of origination, property zip code and the name of lending institution. The performance file is a panel that provides monthly credit performance, which includes the monthly loan balance and delinquency status. The loan exits the performance file if it was terminated by the borrower via prepay/refinance or foreclosure.

HARP Data GSEs also publish a separate data that includes the acquisition and performance file for those who participated HARP. A crucial feature of this data is that it provide us a one-to-one mapping of HARP participants with their pre-HARP transaction. This allows us to identify the households who were refinanced under the program, as well as constructing the key variables of the analysis such as whether they refinanced with their incumbent lender and what is the interest rate reduction they get from HARP.

We combine the main GSEs data and HARP data to construct a panel of loan sequences. An loan sequence is the complete span of time a loan is active until it is terminated. For each sequence, we only observe updated and accurate information (FICO, LTV) at termination for those people who participated in HARP since we are able to match them with the unique loan-id. For all other loans (i.e. those who did not take HARP), we only observe if and when they terminated their mortgage due to either default or refinance, but not if they refinance with their incumbent and the interest rate reduction.

House Price Index In creating the loan sequence, we need to estimate current LTV, which determines if the household is eligible for the program and also the interest rate they will get. The numerator is strightforward, which is essentially just the loan balance which we observe in each period. To impute current house value in the denominator, we use the FHFA mean house price (HPI) at 3 digit zip level. This index measures average price changes in repeat sales or refinancing on the same properties. This information is obtained by reviewing repeat mortgage transactions on single-family properties whose mortgages were purchased or securitized by GSE. We start with house price at origination, and update it on a quarterly basis using our price indexes. Noise in the denominator can arise in different ways. For example, values for distressed properties are likely to be overstated because they probably were receiving lesser maintenance and repair-related investment, in which case current LTV could be underestimated. In Section 5, we discuss how mitigate this problem by providing an estimation of idiosyncratic housing shock.

3.2 Descriptive Analysis

Summary Statistics Table 1 reports the summary statistics for a number of variables of interest. Panel A is the main data. This sample contains people who purchase house before the crisis during 2003-2006. These are all purchase loan with 30-year fixed interest rate. Their LTV is on average 80%, or 20% down payment, which is the most common mortgage contract for purchase transaction. The mean of initial interest rate and loan size is 600 bps and $174,000, which imply the mean annual mortgage payment for those households is $12,000.

Panel B then reports the HARP program takers among those from panel A. We report the characteristics for HARP takers separately before and after the mid-HARP policy change on underwriting standards between incumbent and competing lenders which took place in 2013. First of all, FICO score for HARP takers actually increases from 730 to 750, presumably because HARP has a requirement that borrowers cannot have a missing mortgage payment in 12 consecutive months. However, LTV for those borrowers increased from 0.79 to 1, suggesting a loss of home equity for those households as a consequnce of the 2008 housing crisis. The (refinance) interest rate that households obtained from the program is 450 bps between 2009-2012, compared to 415 bps between 2013-2018, a period when the market interest rate (i.e. cost of credit) also decreased.

The next two rows show the degree of the incumbent advantage granted by the program. Market share is 68% for incumbent lender during the first half of HARP, compared to a

Table 1: Loan-Level Summary Statistics

Panel A: GSE Single Family Data, 2003-2006

	Mean	S.D.
FICO Score	730	50
LTV	0.79	0.09
Interest Rate (bps)	600	45
Loan Size (1,000$)	174	77
# of Observations	1,627,723	

Panel B: HARP Refinance, 2009-2018

	2009-2012		2013-2018	
	Mean	S.D.	Mean	S.D.
FICO Score	750	53	733	62
LTV	1.00	0.23	1.03	0.22
Interest Rate (bps)	450	61	415	54
Incumbent	0.68	0.42	0.38	0.45
Rate Reduction (bps)	154	63	196	61
Previous Rate (bps)	611	42	603	40
Previous Balance (1,000$)	225	94	192	86
# of Observations	113,095		60,902	

This table presents descriptive statistics for the data source used in this paper. Panel A shows the statistics for the parent data, which is the main GSE data that contains purchase loan from 2003-2006. Panel B then presents the HARP takers among those in Panel A. This is separated by those who participated HARP before the mid-HARP policy change on underwriting standards between the incumbent and competing lenders.

regular refinance market where the incumbent market share is 28% to 33% acrosss different years (Agarwal et al. (2015)). The market share becomes close to the regular sector level after the policy change in 2013. In terms of the interest rate reduction (refinance saving), we find on average households who refinance before the policy change saving 38 bps lower compared to households who refinanced after the policy change.

The last two rows show evidence of dynamic selection of refinance. On average, households who refinance early are those who have the most incentive to do so. On average, they have higher previous interest rate as well as higher balance. Overall, we see households took the program during the first half of the program on average have larger previous mortgage payment of $4,000. In Appendix A, we provide further details of the program by showing these statistics for each year.

Search Friction Previous literature has documented that borrowers with similar characteristics obtain mortgages with substantially different interest rates in the United States, and a leading explanation of this dispersion is consumer search. Is search friction also present in our data? To show this, one would show that two borrowers in the same market, at the same time, with the same characteristics, paid different mortgage rates. Following earlier literature, we and estimate the following specification:

$$r_{itm} = \alpha + \beta \cdot X_{itm} + \mu_t + \mu_m + \epsilon_{itm} \tag{1}$$

where r_{itm} represents the refinance rate of borrower i at time t in market m. X_{itm} includes borrower's characteristics, such as FICO score, LTV, mortgage balance, and previous interest rate. In order to compare borrowers in the same market, we condition on market fixed effects (three digit zip code), and on time (year-quarter) fixed effects, in order to compare borrowers at the same point in time.

The result is presented in Column 1 of Table 2. As expected, interest rate is positively correlated with the riskiness of the mortgage. However, conditional on the mortgage characterisitcs, a substantial amount of residual rate dispersion remain, as can be seen from Figure 2. A borrower at the 10th percentile of the distribution pays an interest rate that is 72 bps lower than that paid by the borrower at the 90th percentile of the distribution. We find a similar magnitude of price dispersion to those presented in Allen et al. (2014), who find that the standard deviation of residual retail mortgage spreads of 50 bps, compared with 45 bps in our data. Meanwhile, Gurun et al. (2016) find a coefficient of variation of 0.23 in their data on U.S. fixed rate mortgages, while ours is 0.29.

Table 2: Descriptive Analysis

	(1)	(2)
Sample:	HARP Loans	HARP Loans
Dep Var:	Int. Rate	Int. Rate
Incumbent		0.125^{***}
		(0.001)
Post		-0.145^{***}
		(0.001)
Post $\times$ Incumbent		-0.186^{***}
		(0.001)
log(FICO)	-0.426^{***}	-0.377^{***}
	(0.003)	(0.003)
LTV	0.213^{***}	0.196^{***}
	(0.001)	(0.001)
log(Balance)	0.066^{***}	0.076^{***}
	(0.000)	(0.000)
Prev. Rate	0.173^{***}	0.172^{***}
	(0.001)	(0.001)
Location FE	Yes	Yes
Year-Qtr FE	Yes	Yes
Observations	173,997	173,997
R-squared	0.71	0.74

This table reports the regression coefficients in descriptive analysis. Column 1 is the result for Equation (1) and Column 2 is the result for Equation (2). Both estimations use HARP loans (i.e. data from Panel B of Table 1) and the dependent variable is HARP refinance interest rate.

Mid-Program Change As described in Section 2.2, in an effort to encourage lender participation, the program rules imposed a lesser legal burden on existing (incumbent) servicers in the first part of the program. From January 2013 the program rules were changed significantly. To establish a direct connection between this rule change and the incumbent advantage, we run the following specification:

$$r_{itm} = \alpha + \beta \cdot X_{itm} + \gamma \cdot I_{itm} + \delta \cdot \text{Post}_{im} + \theta \cdot I_{itm} \times \text{Post}_{im} + \mu_m + \mu_t + \epsilon_{itm} \tag{2}$$

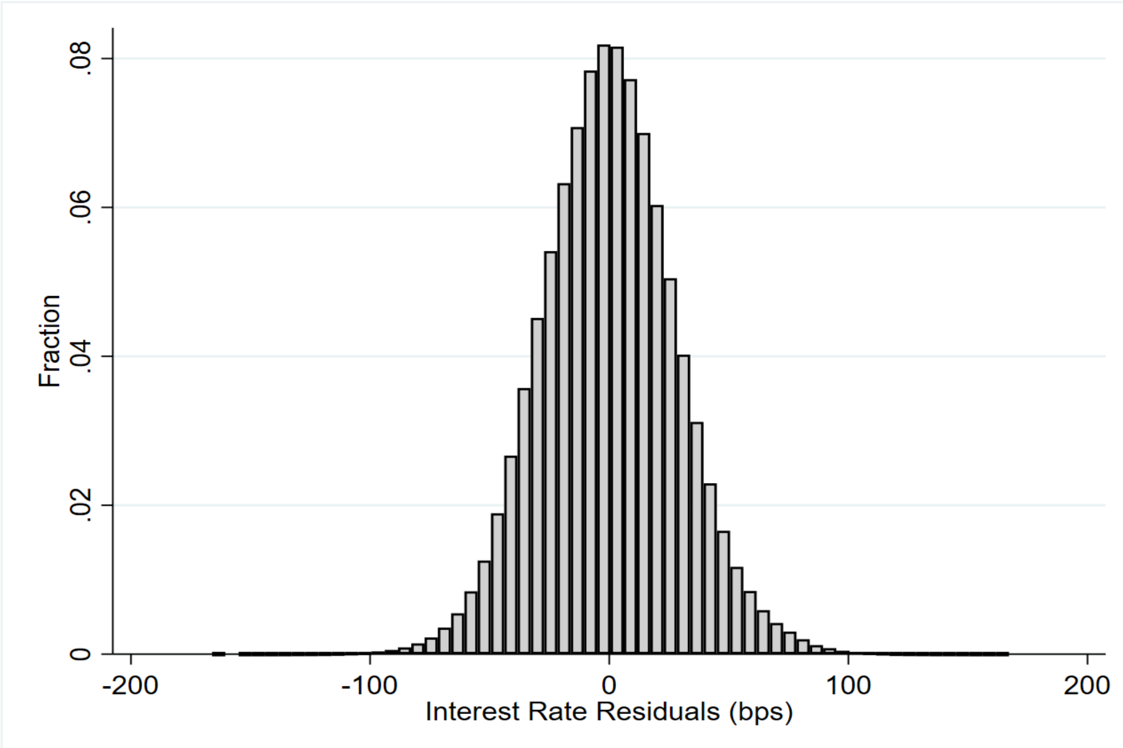

Figure 2: Interest Rate Residual

This figure plots the distribution of the residuals from Equation (1). The standard deviation is 45 bps and the coefficient of variation is 0.29.

where I_{itm} is a dummy variable that equals to 1 if the HARP refinance is originated from the incumbent lender, and Post_{im} is another dummy variable equals to 1 for loans refinanced during the second half of HARP (2013-2018) after the rule change regarding underwriting costs between incumbent and competing lenders.

Column 2 of Table 2 reports the results. During the first half of the program, borrowers with incumbent lenders on average pay 12.5 bps higher. After the policy change happended in the middle of the program, we find incumbent lenders now earn 6.1[14] bps lower, a reduction of 18.6 bps compared to the previous half of the program. While suggestive, we cannot make any causal inference based on these numbers since they could be a result of (dynamic) selection. For example, households with high search cost might select into incumbent lenders which could bias the results.

In sum, this section shows some key patterns from the program and how it changes before

[14] $(0.125 - 0.186)\times 100 = 6.1$ bps.

and after the policy change. We also document that search fricition is present in our data, and the mid-program change does have implication for incumbent advantage. However, in order to separately identify the magitude of each source (for the welfare analysis), as well as taking into consideration of (dynamic) selection, we provide a structural model, which we describe in the next section.

4 Model

In this section, we present our model. We take a stance that the ultimate refinance decision is on borrower and lenders' only role in the model is to offer price[15]. The demand model is a dynamic discrete choice model of refinancing decision, where the payoff is generated from the search and negotiation framework as in Allen et al. (2019). Households incur a lump-sum cost of refinance, which makes the refinance problem dynamic because they may hold on to a mortgage for quite a while. They face the tradeoff between refinancing this period to get a lower interest rate by paying a lump-sum cost, versus the continuation value of waiting to get a better offer.

On the supply side, there are two possible offers: incumbent offer and competitive offer. An offer is a combination of interest rate and product type, which can be either HARP or Regular depends on the LTV eligibility of households[16]. We assume the incumbent lender moves first and gives an initial offer, taking borrowers' search cost and outside option into account. This offer is free of search cost to the borrower if they decide to refinance. The competitive offer only appears if the incumbent offer is rejected by the borrower, in which case the incumbent will compete with competing lender a la Bertrand. Borrowers need to pay a search cost in order to find out the competitive offer. We discuss the demand in Section 4.1 and the supply in Section 4.2.

[15]That is, we assume it is always borrower who initiate the refinance process: if the benefit of refinance is greater than cost, then they will refinance. Lenders cannot "reject" a borrower other than offering an (expensive) offer that inhibits the borrowers from refinancing. Studying lender's incentive is also important because lenders are facing the cannibalization problem where it tries to replace their current cash flow. Their problem could also be dynamic as well, as in Allen and Li (2020). These are interesting extensions of our model which we leave for future investigation.

[16]For example, if a household has LTV below 80%, he is not eligible to participate HARP and thus can only take regular refinance. For notation simplicity, we omit product type subscript in presenting the model.

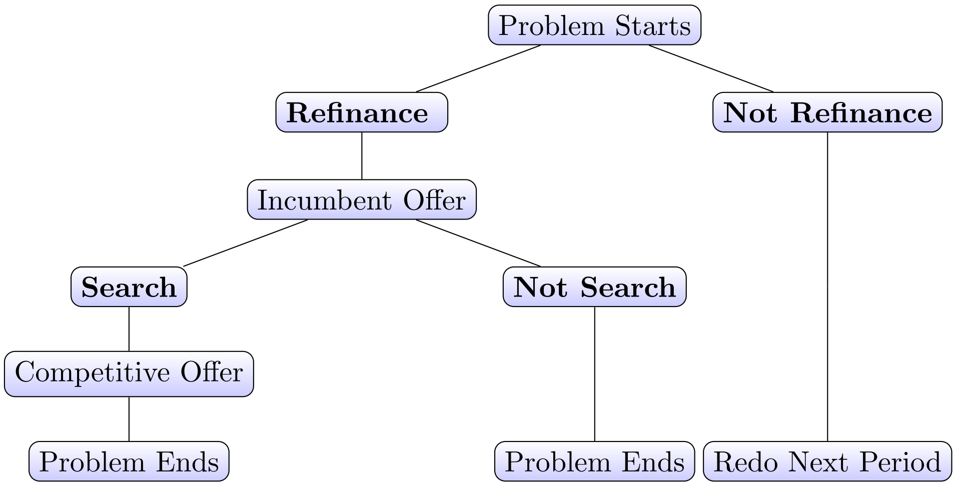

Figure 3: Timing of Borrower Decision

This figure shows the timing of the borrower decision. Borrowers first decide whether to refinance or not. If so, then they decide whether to accept their incumbent lender after getting a free quote, or pay a search cost to gain additional quotes. They have to accept the competitive offer once they decide to search. If they decide not to refinance, they will make the decision again next period.

4.1 Demand

Timing of Decision We start the discussion of the demand model by demonstrating the decision sequence of a borrower in Figure 3. Borrowers first decide whether to refinance or not. If not, they have the option of making the decision again next period. For those who decide to refinance, they need to decide whether to stay with their incumbent lender (i.e. not search), or pay a search cost to gain additional quotes. We assume there is no recall from borrowers. That means, they have to accept the competitive offer once it is revealed. Also, once borrowers decide to refinance, they cannot go back to the original mortgage anymore. The refinance decision is an absorbing state, meaning their problem ends and there is no more decision to make.

Refinance Decision We first lay out the dynamic refinance problem. The borrowers' state variables include some time invariant characteristics, which contains income, FICO, mortgage payment and mean search cost. These variables are only useful in determining the price they will get. For notation simplicity, we omit them in presenting the model. There are two time variant state variables, including LTV and current market rate. For example, borrowers might wait for LTV and/or market rate to decrease so they can get a better price. We summerzie the time variant state variables as $z = (LTV, c)$ and their transition is modeled as VAR(1).

A refinancing decision requires a cost-benefit analysis for the mortgage borrowers. Refinancing costs include transaction costs and search costs, while the benefit of refinancing comes from the flow of utilities throughout the life of the new mortgage contract. The borrowers compare the total expected payoff for a given choice when they make a refinancing decision. The value function can be written as

$$V(z) = \max\{V(z)^{\text{refi}}, V(z)^{\text{not refi}}\}$$

If the borrower decides not to refinance, they face the following Bellman Equation:

$$V(z)^{\text{not refi}} = y - m + \beta\mathbb{E}[V(z')]$$

The flow utility comes from per period consumption which equals to income (y) minus mortgage payment (m). The value of not refinancing is thus the sum of flow utility and a discounted expectation of continuation values of getting a chance to refinance in the future. If the borrower decides to refinance, then this is a absorbing state, so the borrower will achieve a value of

$$V(z)^{\text{refi}} = \bar{V}(z) - \mathbb{E}(\text{Refi Cost})$$

where $\bar{V}(z)$ the lifetime utility of refinancing. However, since refinance comes with a (expected) lump-sum cost, this needs to be subtracted from the refinance value.

Search Decision Conditional on refinancing, households need to decide if they will accept the incumbent offer (i.e. not search) or search for a competitive offer (by paying a search cost). Let us denote the incumbent offer as $r^I(z)$ and the competitive offer as $r^C(z)$, and the decision to search as s. Households will search $(s = 1)$ if the net gain from is greater than search cost:

$$\Delta U(z) = \mathbb{E}[U(r^C(z))] - U(r^I(z)) \geq \kappa\epsilon$$

where $U(.)$ is the discounted sum of future flow utility. The search cost consisits of two parts: κ is mean search cost, observed by both incumbent and competing lender, but unobserved to econometricians; ϵ is an *i.i.d.* shock, which is realized to households only when they are making the search decision. The incumbent lender won't observe ϵ when they make the initial offer, and ϵ won't matter in the competitive offer since the borrower has already paid a search cost.

Refinance Payoff We can now discuss the payoff from the refinancing decision, starting with $\bar{V}(z)$, the lifetime utility of refinancing. Since this is an absorbing state, it is the discounted present value of all future flow utility:

$$\bar{V}(z) = Pr(s=0)U(r^I(z)) + Pr(s=1)\mathbb{E}[U(r^C(z))]$$

In word, this says the lifetime utility of refinancing is a weighted average of incumbent offer and competitive offer. For the incumbent offer, there is no expectation since there is no uncertainty (from the borrower's point of view). For the competitive offer, the expectation is over the expected price since at this stage, borrower is uncertain about what price he will get if he decides to search (only knows the distribution).

On the other hand, refinancing costs include transaction costs and search costs. That is

$$\mathbb{E}(\text{Refi Cost}) = \phi + \kappa\mathbb{E}(\epsilon) \cdot Pr(s=1)$$

Households only pay search cost if they decide to search. However, ϕ is the transaction cost that has to be paid no matter the households search or not since they have already commit refinancing. We allow ϕ to be different across HARP and Regular[17].

4.2 Supply

On the supply side, we follow Allen et al. (2019) and assume incumbent moves first and offers an initial quote based on consumer's search cost and outside option. If that offer is rejected, incumbent will still have a chance in the negotiation stage, where it competetes a la Bertrand with the competing lender.

Profit Function Before discussing how each offer is determined, let us first define profti function. The profit is borrower specific (i.e. pricing based on borrower characterisitcs such

[17]In reality, HARP waived certain fees for borrowers such as appraisal fee and insurance fee.

as FICO, LTV), so we omit borrower subscript for notation simplicity. Following Fuster et al. (2013), the cash flow of charging an interest rate r is written as

$$\pi_{jt}(r) = PV(r - g - c_t) - P_{jt}$$

where j denotes either the incumbent lender or the competing lender. Since lenders are the intermediaries/servicers for GSEs, the revenue they earn from a transaction is essentially the present value (PV) of what they charge r minus g and c, where g is the guarantee fee paid to GSEs and c is the current coupon rate or cost of fund. The cost P_{jt} is different for incumbent and competing because incumbent lenders have an asymmetric cost under the program.

Incumbent Offer Now let's discuss how price is determined, starting with the incumbent offer first. After the incumbent sees a borrower who commits to refinance, the only private information is ϵ_{it}, so the incumbent is maximizing the expected profit from this stage, weighted by the probability if the borrower will search or not. That is:

$$\max_{r^I} Pr(s=0) \cdot \pi_{jt}(r^I) + Pr(s=1) \cdot \mathbb{E}\big[\Pi_I^s\big]$$

If the borrower does not search, the incumbent earns the profit with r^I. If the borrower does search, then the incumbent could still retain the borrower because the incumbent shows up again in the competition stage. Let us denote the expected profit from that stage as $\mathbb{E}\big[\Pi_I^c\big]$, which we delay until next subsection. Taking first order condition to the maximization problem renders:

$$r^I(z) = PV^{-1}\Big(\mathbb{E}\big[\Pi_I^c\big]\Big) + \frac{1 - F(\frac{\Delta U(z)}{\kappa})}{f(\frac{\Delta U(z)}{\kappa})}$$

where $F(.)$ is the CDF of ϵ. The first term here represents the price at which the incumbent lender is indifferent between two stages. This price increases with the expected profit of incumbent lender in the competition stage. Intuitively, if the incumbent's advantage is big enough to win in the competition stage, it will charge a higher price to the borrower in the initial stage to extract more surplus. The second term is a mark-up term, which increases with borrower's search cost and outside option. As the outside option gets poorer (based on their characteristics), the market power to incumbent lenders becomes larger.

Competitive Offer We now discuss the competitive offer[18], which only happens if the consumer rejects the initial offer from the incumbent, and also pays the search cost. This part can be thought of the negotiation stage in Allen et al. (2019) where consumer pays a cost to get a competing offer. In this stage, we assume each lender first observe a private *i.i.d.* shock (ω_{jt}). We model the price r^C from this stage as the outcome of an asymmetric Bertrand competition, which means the price makes the loser earns zero profit:

$$\pi_{-j}(r^C) - \omega_{-j} = 0$$

Incumbent will win in the competition stage if

$$P_I + \omega_I < P_C + \omega_C$$

Now we have the elements to define the expected profit from competitive offer for incumbent discussed in the previous subsection, that is:

$$\mathbb{E}\big[\Pi_I^c\big] = Pr(\text{I wins}) \cdot \mathbb{E}\big[\pi_I(r^C) - \omega_I | \text{I wins}\big]$$

which is the probability that the incumbent wins times the conditional profit. Of course, if the incumbent loses, it earns zero. Therefore, if the competitive field favors the incumbent, it still can win the borrower in the negotiation stage.

5 Estimation and Identification

We now discuss the estimation of the model presented in the previous section. We begin by discussing the model parametrization. Then we describe the Simulated Method of Momenets

[18] In practice, this stage is more complicated since we need to take care of the situation where the lender could also bid regular for households whose LTV is between 80% to 95%. The description of this part is more math cumbersome, so we leave the full discussion in Appendix C. The appendix also includes the detailed derivation, including the expectation of winning bid, the distribution of winning product, and each lender's winning probability.

(SMM) estimation procedure, followed by a discussion of how we identify the parameters. We put all the results that we estimate outside the model using data directly in Appendix B1-B3.

5.1 Parametrization

On demand side, the main element we need to estimate is the search cost distribution. Following previous literature (Alexandrov and Koulayev (2018), Ambokar and Samaee (2019a)), we assume the mean search cost κ follows lognormal distribution. The idiosyncratic search cost ϵ_{it} is assumed to have a uniform distribution:

$$\kappa_i \sim LN(\mu_\kappa, \sigma_\kappa)$$
$$\epsilon_{it} \sim U[2-\tau, \tau]$$

Another component of refinance cost is the transaction cost of refinance, ϕ. Like described earlier, we allow ϕ to be different across HARP and Regular, and we normalize $\phi_H = 0$ so we estimate the difference (Δ_ϕ) between HARP and Regular. In practice, households could also exit the sample because of default. Thus, to match data, we also need to estimate the (exogenous) probability that households will default[19] at the beginning of each period before maing refinance decision. The result is presented in Column 1 of Appendix B1.

We also need to estimate the transition process of LTV and current market interest rate, which we model as VAR(1). In estimating LTV, we are essentially estimating house price index (HPI) since we use it to calculate the denominator of LTV. Our HPI is at 3 digit zip code level, which is the finest geographical level of data we can get. Since LTV is very important in our analysis, one might worry that the mean HPI would not capture the fact that some households may continuously getting below/above average housing shock so we could have measurement problem in HARP eligibility. To mitigate this concern, we use the idea from Heckman selection model to estimate the idiosyncratic housing variance. We discuss the details of this estimation in Appendix B2.

On the supply side, we need to specify the putback cost, which is the main liability of lenders as we discussed in Section 2.2. To match the institutional feature that the putback

[19] That is, we do not model the default decision as a choice variable, following Ambokar and Samaee (2019a).

risk is uneven across incumbent and competing lenders, we specify the putback cost as

$$P_{jt} = P_{scale} \times p_{jt}$$

where p_{jt} is the putback probability estimated outside the model using data. We present the result in Appendix B3. P_{scale} is the scale parameter that transfers probability to monetary cost, which is the main structural parameter we back out using the model.

Next, we assume the cost shock ω_{jt} realized in the competition stage to have a T1EV distribution with mean F_j and scale parameter σ_ω. In practice, we normalize $F_I = 0$, so we estimate the difference of mean cost shock (Δ_F) between incumbent and competing lenders.

Finally, we specify the $PV(.)$ in the profit function. Since mortgage lender receives cash flow from servicing as long as the loan is still active, we specify $PV(.)$ as the expected duration of each mortgage. Duration is a function of observable characteristics. We present the result in Column 2 of Appendix B1.

5.2 SMM Estimation

The parameters to be estimated is summarized in Table 3. We use the Simulated Method of Momenets (SMM). Since this is a finite horizon problem, we solve the model using backward induction. Specifically, we solve value function and the associated policy function (refinance and search) for household at each possible state for 20 period. We also solve the distribution of offers that they can get at each refinance opportunity. Next, we simulate the path of each household's state variables which determines when they will refinance, and then the realized incumbent offer, search decision and offer from the competition stage. We use a random sample of 10,000 households from Panel A of Table 1.

We then match model's prediction of refinance decision and price to the data on program participation and pricing decision. Let D_i denotes model prediction on decisions which include HARP Incumbent (HI), HARP Competing (HC), Regular (R) or Wait (W), and let r_i denotes price conditional on taking HARP. The observed outcome from data is denoted as $\hat{D}_i$ and $\hat{r}_i$.

Table 3: SMM Estimation: Parameters

Notation	**Definition**
μ_κ	Mean of Logarithm of Mean Search Cost
σ_κ	Std-Dev of Logarithm of Mean Search Cost
τ	Boundary of Idiosyncratic Search Cost
Δ_ϕ	Difference of Transaction Cost
P_{scale}	Scale Parameter of Putback Cost
Δ_F	Difference of Mean of Idiosyncratic Cost Shock
σ_ω	Scale Parameter of Idiosyncratic Cost Shock

This table summarizes the parameters we seek to estimate from the emprirical model using the Simulated Method of Momenets (SMM) estimation.

The moment restrictions $g(\Theta)$, where Θ denotes the parameters to be estimated, are

$$E_i[X_i(\hat{D}_i - D_i)|\text{Post-2013}]$$

$$E_i[X_i(\hat{r}_i - r_i)|D_i \in \{HI, HC\}, \text{Post-2013}]$$

$$E_i[X_i(\hat{r}_i^2 - r_i^2)|D_i \in \{HI, HC\}, \text{Post-2013}]$$

where X_i includes borrower characteristics such as FICO, LTV and previous interest rate. We also use an auxiliary moment from HARP survey that 46% of households only consider one lender when they participated the program.

We adopt SMM estimator by minimizing the differences between model prediction and its data counterpart:

$$J(\Theta) = g(\Theta)'Wg(\Theta)$$

W is the weighting matrix, which is the inverse of standard error of each data moment.

5.3 Identification

The primary identification concern is to separately identify the seach cost and program advantage. The key sources of variation comes from the mid-HARP program change on the underwriting standard between incumbent and competing lenders. The conditional price from the incumbent before and after the policy change helps to pin down the level of the putback cost P_{scale}. The HARP survey about lender consideration is informative about the level/mean of search cost, so once μ_k and P_{scale} is pinned down, the difference between incumbent and competing are informative about the Δ_F. The difference in fixed cost Δ_ϕ is identified by the households who choose regular refinance but are eligible for HARP. Finally, the dispersion parameters such as σ_κ, τ and σ_ω can be identified from the second order statistics such as standard deviation of prices.

6 Results

The results of the SMM estimation is presented in Table 4. The parameter estimates are reported in Panel A while the model fit is reported in Panel B. To better interpret these estimates, we transfer everything into dollar term when discussing the results.

Table 4: SMM Estimation Results

Panel A: Parameter Estimates

μ_κ	σ_κ	τ	Δ_ϕ	P_{scale}	Δ_F	σ_ω
1.9227	1.0882	1.9883	20.4413	37.7153	0.0004	0.0161

Panel B: Model Fit

	Data Moments	Simulated Moments
HARP Take-up Rate	0.12	0.15
Incumbent Market Share (Pre 2013)	0.68	0.72
Incumbent Market Share (Post 2013)	0.38	0.41
Mean Incumbent Price (Pre 2013)	4.61	4.58
Mean Incumbent Price (Post 2013)	4.04	4.02
Mean Competing Price (Pre 2013)	4.46	4.42
Mean Competing Price (Post 2013)	4.06	4.11

Panel A of table reports the parameters estimated via SMM. Panel B shows the model fit by comparing the model predicted moments and data.

On the demand side, the estimated mean search cost is \$683. The results also suggests selection exists in the refinance market: searchers has an average search cost of \$654 versus \$1,614 of non-searchers, and people who refinaced earlier (pre-2013) has an average search cost of \$603 versus \$897 of those who refinanced later (post-2013). This evidence is in line with Ambokar and Samaee (2019a) that dynamic selection (on search cost) exists in the refinance market. In terms of transaction cost, we find that Regular refinance is about \$2,044 more costly than HARP[20]. This number is a reasonable since the difference between HARP and

[20] Although we normalize the transaction cost of HARP to 0, borrowers are not sure whether he will get a

Regular comes from appraisal fee and insurance premium. The magnitude of refinance cost from our estimation is also similar to Wong (2019), who reports an estimate of $2,100. It is a non-trivial cost for borrowers which could inhibit them from refinancing.

On the supply side, the average program advantage to the incumbent is 0.012 per dollar of loan[21]. This advantage is bigger for households that are more costly to originate since we allow putback probability to be a function of borrower characteristic. For example, the program advantage is higher for households with higer LTV and/or higher previous interest rate, who are probably the main target that the program tries to reach for.

In terms of the idiosyncratic cost shock, we find that mean cost shock between the incumbent and competing does not differ too much - only 0.0004 per dollar of loan. On the other hand, the scale parameter renders a standard deviation of 0.2 per dollar of loan. In the data, we find that the main competing lender observed are Fintech lenders such as Quicken Mortgage, who have a lower origination cost since their main business model is online. These firms also have a growing market share in the refinance market, as documented in Buchak et al. (2018) and Fuster et al. (2019). We find similar pattern in our case as we see their market share grows after the program rule levels off the competitive field in terms of putback risk.

With the estimates from search cost and program granted advantage, we now calculate the profit margins. Overall, the average profit margin for the incumbent lender under HARP is 0.016 per dollar of loan. That is is almost three times more than the competing lenders, which is 0.006 per dollar of loan. The incumbent profit margin is larger for non-searchers (0.018) than searchers (0.015) since the margin of the initial offer contains both search cost and program advantage. The main source of the incumbency advantage is the program granted advantage, which accounts for 68% of the margin on average across all households. Since the search decision depends on the offer from the competition stage, borrowers will choose to accept incumbent offer if they don't expect gain too much from searching. However, even if borrowers search, they will likely end up staying with their incumbent due to the program advantage. We find the incumbent is able to retain the household with a probability of 62%[22]. This is a larger

HARP or Regular refinance when he makes refinance decision so he still needs to take this into consideration.

[21]We first calculate the differences in putback probability between incumbent and competing lenders for each loan using the results from Appendix B3, and multiply the difference with the estimated putback scale from the structural estimation.

[22]This is calculated as the households who accept incumbent offer divided by households who search.

magnitude compared to Allen et al. (2019), who reports an estimate of 51% in the Canadian mortgage market. Therefore, HARP gives a significant competitive advantage to incumbent lenders that makes it very hard for competing lenders to compete for households.

Finally, Panel B of Table 4 shows the model fit. Our model is able to reproduce the low take up rate of the program, and it also captures some key patterns in the data, such as the price difference and incumbent market share before and after the mid-HARP policy change on underwriting standards between incumbent and competing lenders. Overall, the model provides a close enough fit to the data that we are comfortable using it to assess the counterfactual effects of shutting down the program granted advantage to the incumbent lenders.

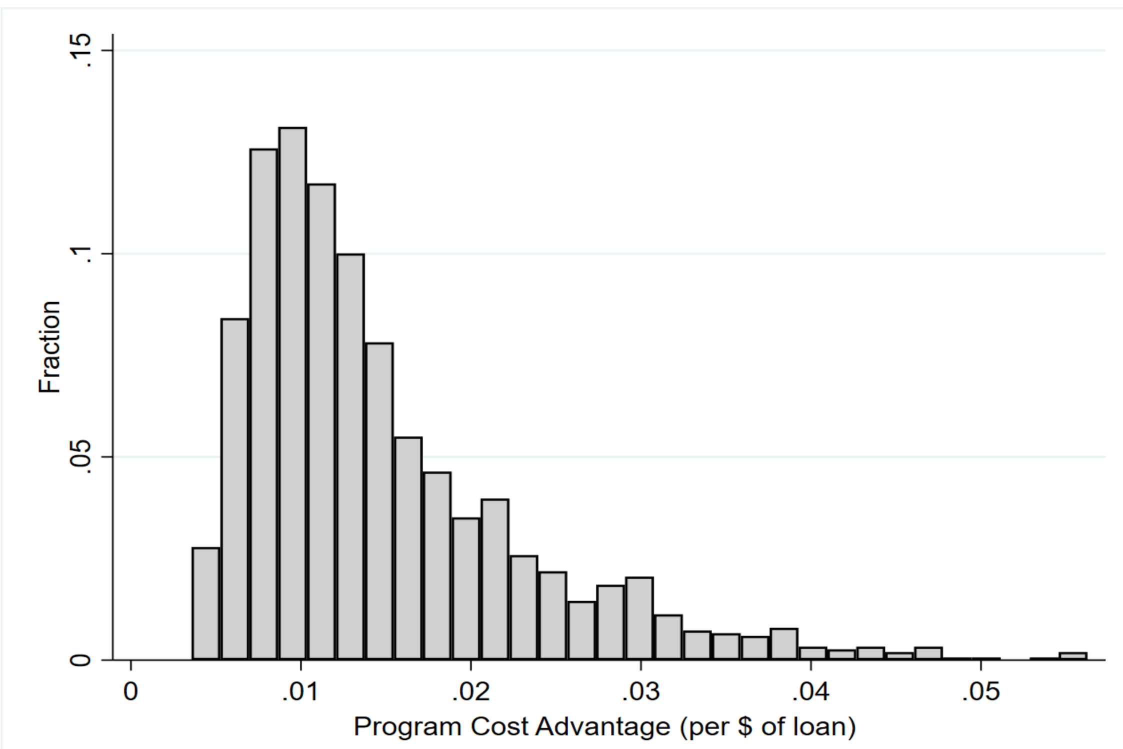

Figure 4: Incumbent Cost Advantage under HARP

This figure shows the estimated cost advantage to the incumbent under HARP. We first calculate the differences in putback probability between incumbent and competing lenders for each loan using the results from Appendix B3, and multiply the difference with the estimated putback scale from the structural estimation.

7 Counterfactuals

In this section, we use the estimates from the previous section to perform counterfacutal analysis. We first perform a decomposition analysis to separately show the effect of search friction and program advantage on market outcome such as take-up (refinance) rate and price. Then, we quantify the welfare implication in terms of consumer surplus and default rate in a case where the program does not have design flaw from the beginning.

7.1 Decomposition

What will the program outcome look like if we eliminate the incumbent advantage in the program? To answer this question, we simulate an envirnment where we eliminate search friction and program granted advantage. The results is presented in Figure 5. In the baseline, the model predicts HARP refinance rate (extensive margin) of 15% and average interest rate saving (intensive margin) of 156 bps. If we shut down both advantages (Neither), we find HARP refinance rate and saving would increase 13.7% and 42 bps, respectively. Both are pretty sizable increase compared to the baseline model. However, since there remains to be transaction cost as well as putback liability for mortgage lenders, many households would still choose not refinance.

To show the impact of each source of incumbency advantage on market outcome, we separately shut down search friction and program granted advantage. If we shut down search (No Search), we find HARP refinance rate and saving would increase 4.4% and 9 bps, respectively. If we shut down program advantage (No Advantage), they would increase 8.2% and 33 bps, respectively. Thus, our model suggests the program advantage plays a bigger role. This is because households will be stuck with their incumbent if they have no good outside option to negotiate with the incumbent lender. Thus, absent of competition, getting rid of search friction won't help much since there is no incentive for the incumbent lender to offer a competitive rate. In reality, there is probably nothing too much government can do about (completely) eliminating search friction, either. On the other hand, they can clearly do a lot about program design. Thus, this is what we will focus in the next subsection.

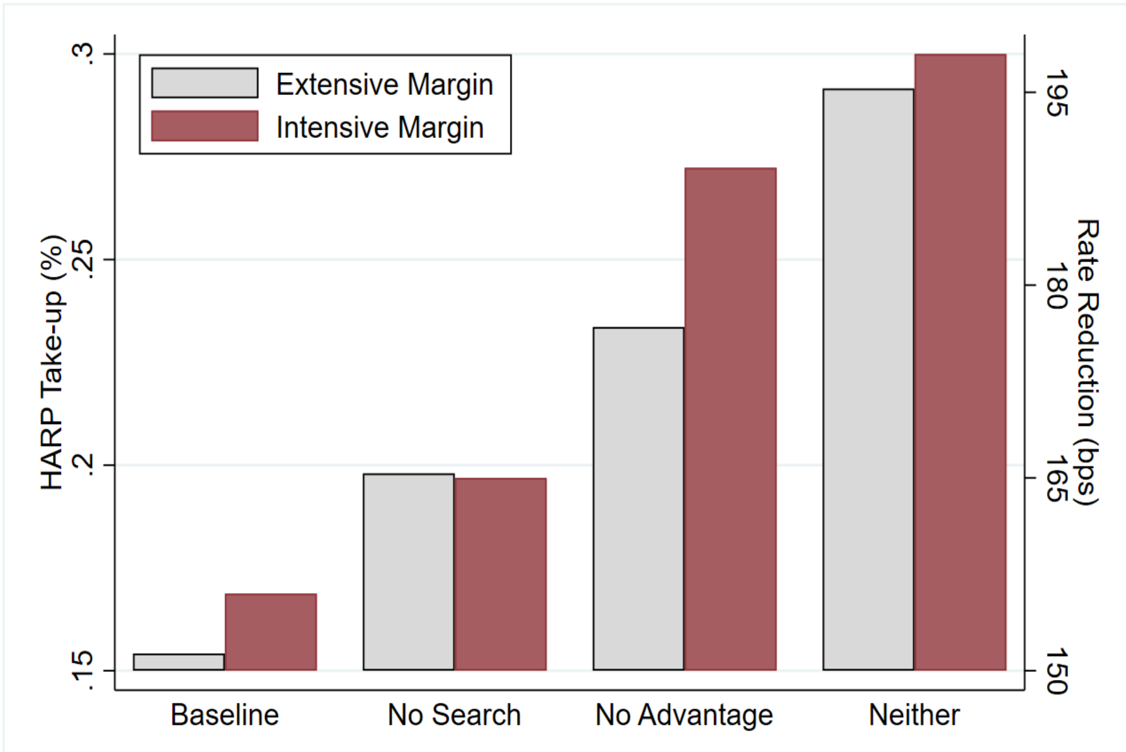

Figure 5: Decomposition: Extensive and Intensive Margin

This figure plots the baseline model prediction of HARP refinance rate (extensive margin) and average interest rate saving (intensive margin). In a decomposition analysis, we separately shut down search friction (No Search) and program granted advantage (No Advantage) to show the impact of each source of incumbency advantage on market outcome.

7.2 Welfare Implication of Program Design

We now quantify the welfare improvement with program advantage shut down at the beginning of the program. As more people are able to refinance and get a lower interest rate, we find that the overall default rate would decrease from 6.5% to 4.2%, a 35.5% reduction compared to the baseline[23]. The decrease in default is pretty meaningful, as a lower default rate is good for the government since it provides credit guarantee on these mortgages. If the loan gets default, government needs to defray the cost to MBS investors. It is also good for economics stability, as lower default means lower foreclosure. Foreclosure events can impose significant negative economic and social externalities on homeowners, on communities, and, because of the serial correlation of neighboring real estate prices, on the housing market in general (Levitin and

[23]Following the literature, default is defined as having at least two missing payments since 24 months of loan origination. We obtain these numbers by simulating the default probability of households according to our estimation of default probability in Appendix B1.

Twomey (2011)).

Next, we turn to consumer surplus, defined as the life time saving (utility gain) from refinancing. We find on average, household could increase their life time saving from the program by \$4,977, or 3.6% relative to the baseline, if the program does not have the design flaw at the beginning. However, this masks important heterogeneity. The standard deviation is \$3,597 and the welfare increase ranges from less than \$2,000 to more than \$14,000. Figure 6 draws the distribution of welfare increase, where the top panel splits by previous mortgage payment, and the bottom split by search cost. We define high/low payment (search) as those households with previous mortgage payment (search cost) larger/lower than the median value. On average, borrowers with higher previous mortgage payment enjoy a increase of \$6,521, which is two times larger than those with lower previous payment. Similarly, borrowers with low search cost on average have higher welfare increase than those with high search cost. This heterogeneity arises from dynamic selection in the refinance market. Intuitively, households who refinanced earlier are those with most incentives to do so. Households with higher previous mortgage payment, conditional on everything else, would refinance early to reduce their mortgage payment. These households are also probably the main target of the program. The result from search cost are more subtle because search cost is unobserved to policy makers. However, our results do suggest that households with lower search cost will refinance earlier, in line with the results from Ambokar and Samaee (2019a). If search cost is correlated with other borrower characteristics (such as income), then it would have welfare implication as well.

In sum, our analysis suggests that if HARP does not have the design flaw from the beginning, more households could have refinanced and got a lower price from the program. This would lower the overall mortgage default rate as well as increase consumer welfare. Thus, the design of the program is very important. In the context of HARP, the original intention is to encourage participation from incumbent lenders, but it unintentionally augments their market power, which ended up inhibiting refinancing. Even if the government fixed the design flaw in the middle of the program, it should have been more careful when designing the programs from the beginning as it has sizable welfare implication, as we discussed in this subsection.

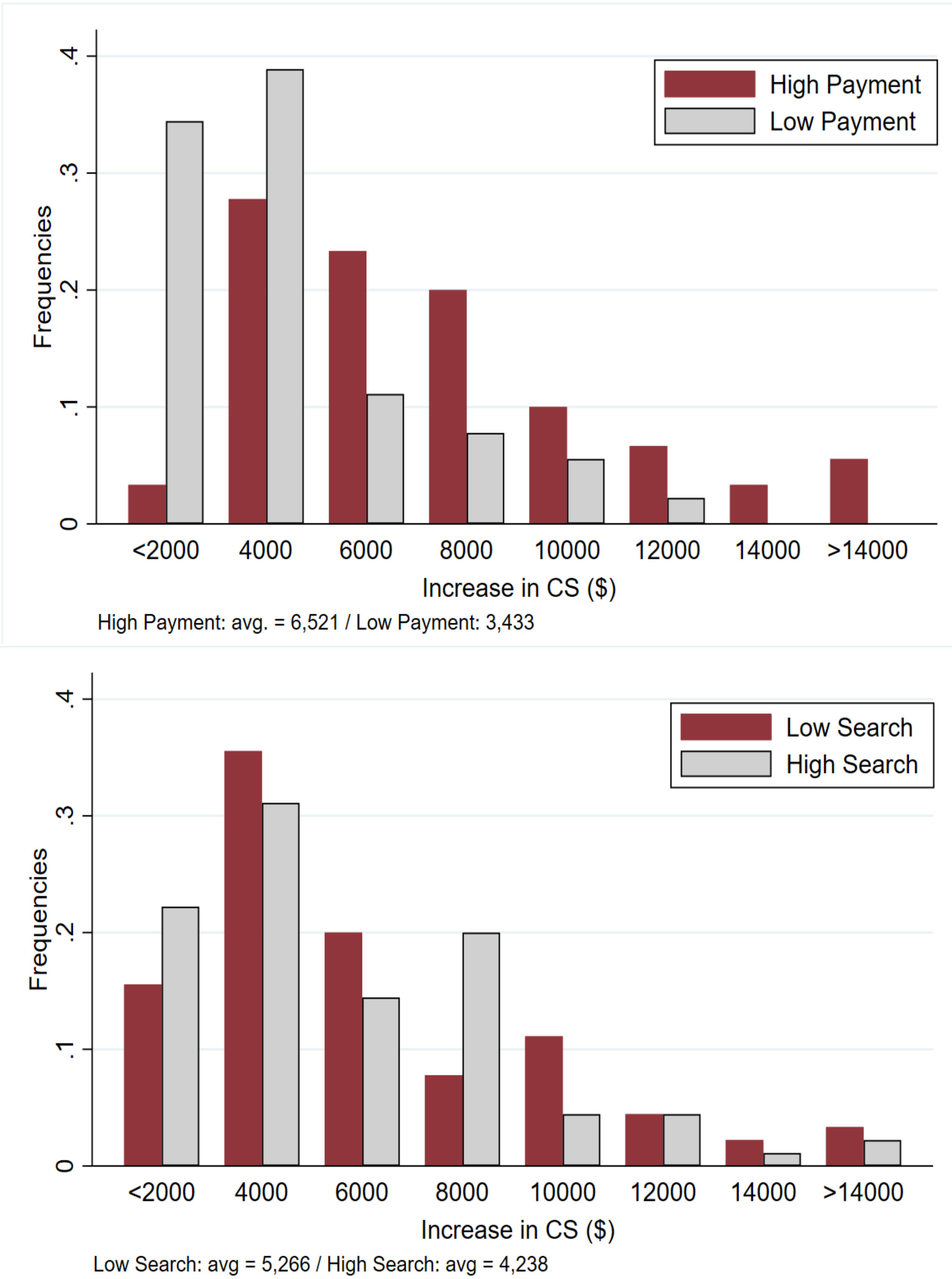

Figure 6: Distribution of Welfare Improvement

This figure plots the distribution of welfare increase if we shut down incumbent program advantage from the beginning. The top panel splits by previous mortgage payment, and the bottom split by search cost. High/Low refers to the groups that lies above/below the median.

8 Conclusions

In this paper, we use HARP as a case study to quantify the welfare implication associated with program design. HARP was a very well intentioned program that tries to help underwater households to refinance their mortgage. However, the design of the program unintentionally exacerbates the market power of incumbent lenders, which ends up inhibiting refinance from borrowers. It also allows the incumbent lenders to extract surplus from borrowers who decide to refinance, resulting in a lower interest rate reduction.

We develop an equilibrium model of mortgage refinancing and search decisions. We then estimate the model by exploiting a significant change to the program design that gives exogenous variation in the competitive advantage of incumbent lenders under the program. Our estimates shows that HARP gives a significant competitive advantage to incumbent lenders that makes it very hard for competing lenders to compete for households. Without this design flaw, we find that it leads to an average welfare improvement of $4,977, or 3.6% relative to the baseline. The effect is heterogenous since the refiance market is characterized by dynamic selection: households who refinanced earlier are those with most incentives to do so. If HARP does not have the design flaw, more households could have refinanced and got a lower price from the program.

The main takeaway from our analysis is the importance of understanding institutional detail when designing policies. Whether a program will work as intended or possibly have unintended consequences depends on how the details of that policy interact with the incentives of important participants. While borrower-specific factors such as inattenion and inertia may also help account for the muted response, our evidence suggests that provisions limiting the competitive advantage of incumbent lenders with respect to their existing borrowers should be an active consideration when designing stimuls polices such as HARP. This insight from this paper could also apply to other policies whose implementation depends on intermediaries with incumbenct advantage with respect to targeted agents.

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Appendix A: Program Overview

Figure 7 presents further details of HARP. The top left panel shows the average take-up rate of the program is only about 5% during its operation over 10 years, suggesting a large number of eligible[24] households was not able to benefit from the program. Second, while incumbent lenders are able to retain a market share of 28% to 33% in the traditional refinance sector (Agarwal et al. (2015)), the top right panel shows the incumbent market share is particularly high during the first half of the program. The bottom left panel shows that the people who took the program tend have relatively lower LTV, suggesting the program is not able to reach those household who need it most, i.e. those heavily underwater households. Last but not least, the bottom right panel shows big difference in interest rate reduction, suggesting heterogeneous benefit from participating the program.

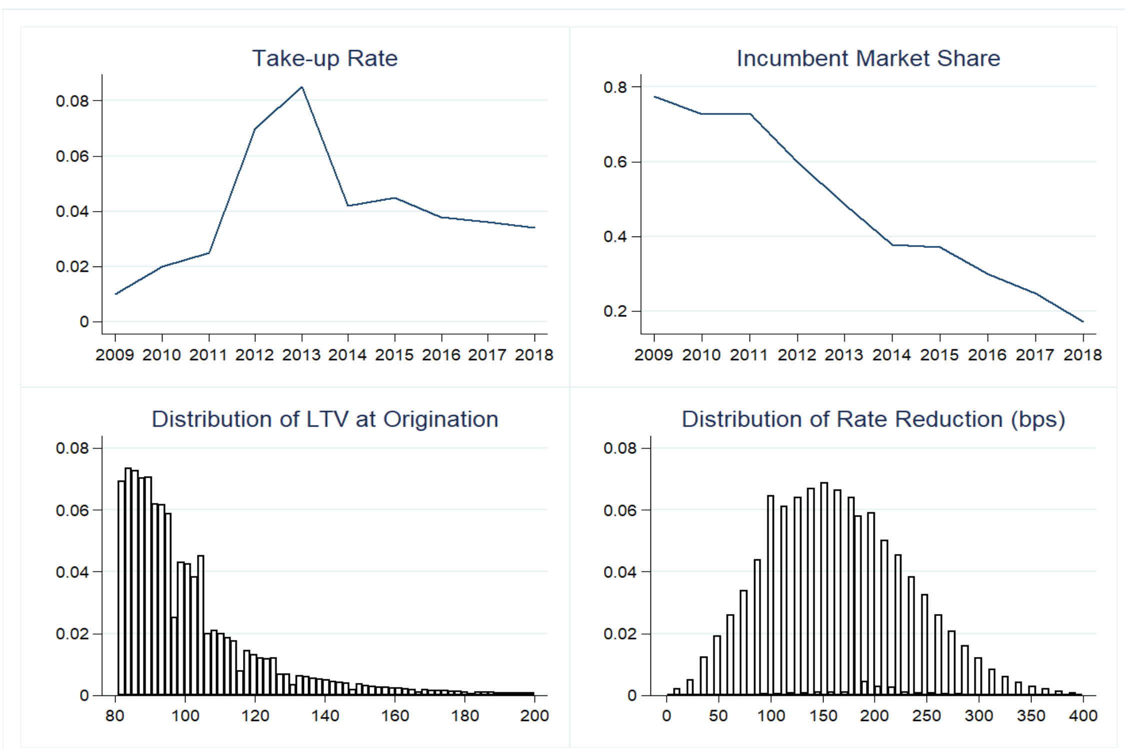

Figure 7: HARP Feature

This figure plots some features of HARP, including program take-up rate, incumbent market share, distribution of LTV at origination and distribution of interest rate reduction.

[24]We include a household as eligible if his/her LTV is above 80% according to our estimated house value using quarterly three digit zip code level house price index from FHFA.

Appendix B: Outside Model Estimation

In Appendix B, we describe some of the parameters that we estimate directly using the data (i.e. without solving the model). These parameters include default probability (B1), expected duration (B1), idiosyncratic housing shock (B2), and putback probability (B3).

B1. Default and Expected Duration

In practice, people could also exit the sample because of default. Therefore, we estimate the (exogenous) probability that households will default using a loglogistic survival model. Default shock is realized before households make refinance decision at the beginning of each period. The result is presented in Column 1 of Table 5.

Since mortgage lender receives cash flow from servicing as long as the loan is still active, we specify $PV(.)$ in the profit function as the expected duration of each mortgage. We specify the expected duration as a function of observable characteristics using a lognormal model. The result is presented in Column 2 of Table 5.

Table 5: Default and Mean Duration

	(1)	(2)
	Default Probability: Loglogistic	Mean Duration: Lognormal
log(FICO)	-0.0035	-0.0010
	(-232.77)	(-272.13)
LTV	1.3332	0.1681
	(179.73)	(213.36)
Interest Rate	0.4252	-0.6063
	(330.84)	(-318.13)
log(Balance)	0.0003	-0.0001
	(179.98)	(-193.32)
Market FE	Yes	Yes
Year FE	Yes	Yes
Observations	6,283,926	6,283,926

Column (1) reports the results of default probability using a loglogistic survival model, while Column (2) reports the results of expected duration using a lognormal model. Both of them are functions of observed mortgage characteristics at origination. t-statistics is reported in parentheses. We use all available GSE refinance loan for both estimation.

B2. Idiosyncratic Housing Shock

Since LTV is very important in our analysis, one might worry that the mean HPI (at 3 digit zip code level) would not capture the fact that some households may continuously getting below/above average housing shock so we could have measurement problem in HARP eligibility. To mitigate this concern, we use the idea from Heckman selection model to estimate the idiosyncratic housing variance. Specifically, we model the house value (HV) of borrower i in market m at time t as:

$$log(HV_{imt}) = \beta_0 + \beta_1 log(HV_{im0}) + \beta_2(log(HPI_{mt}) - log(HPI_{m0})) + \beta_3 Z_{mt} + \xi_{imt}$$

This is the outcome equation where the dependent variable is the observed house price, and the sample contains all households who refinanced under HARP between 2009-2015. Essentially, we model the house value as the mean HPI change plus some idiosyncratic housing shock ξ_{imt}. We assume

$$\xi_{imt} \sim N(0, \sigma^2)$$

We also add addtional controls (Z_{mt}) such as local change of unemployment and income which could also affect house price, as well as individual refinance decision.

We model the refinance decision, d_{imt}, as:

$$d_{imt} = \alpha_0 + \alpha_1 log(HV_{im0}) + \alpha_2(log(HPI_{mt}) - log(HPI_{m0})) + \alpha_3 Z_{mt} + \alpha_4 X_{imt} + \mu_t + \mu_m + \epsilon_{imt}$$

This is the selection equation, where the dependent variable is whether a household refinanced under HARP, and the sample contains all eligible households between 2009-2015. This stage contains individual level variables (X_i: FICO, LTV, previous interest rate) that affect their refinance decision but should not affect the house value (exclusion restriction).

The variance term, σ^2, in the outcome equation is the main variable of interest we seek to estimate from the model. The result of the estimation is presented in Table 6, and the estimation suggests that there is a sizable idiosyncratic dispersion of housing shock (0.1781).

Table 6: Idiosyncratic Housing Shock

	(1)	(2)
	First Stage HARP Refinance	Second Stage House Value
log(FICO)	0.1775***	
	(.0026)	
Prev. Rate	0.3477***	
	(.0004)	
Income	−0.0727***	
	(.0007)	
log(Balance)	0.9646***	
	(.0026)	
log(HV_0)	−0.3933***	1.0152***
	(.0025)	(.0001)
log(ΔHV_t)	−1.1615***	0.9546***
	(.0017)	(.0004)
%ΔUnemployment	0.0011***	−0.0009***
	(.0000)	(.0000)
%ΔIncome	0.2843***	0.0084***
	(.0001)	(.0000)
ρ	-0.0698	
σ^2	0.1781	
Observations	25,434,856	1,022,914

This table report the results from a Heckman twostep selection model. The first stage is the selection equation, where the dependent variable is whether a household refinanced under HARP, and the sample contains all active households between 2009-2015. The second stage is the outcome equation where the dependent variable is the observed house price, and the sample contains all households who refinanced under HARP between 2009-2015. The main variable of interest is the variance term, σ^2, in the outcome equation.

B3. Putback Probability

The putback probability is estimated using a logit regression of putback on whether a loan is originated with the incumbent lender, conditional on all other observed characteristics as well as market and year-quarter fixed effect, using default loans from 2009-2012 and 2013-2018:

$$Putback_{itm} = \alpha + \beta X_i + \gamma Incumbent_i + \mu_t + \mu_m + \epsilon_{itm}$$

The key variable of interest is γ, and Column (1) and (2) report the result. We do find incumbent originated loan is on average 1.8% less likely to be putback compared to the competing lenders from 2009-2012, in line with the institutional background. The coefficients from Column 2 is not statistically significant, when the rule is leveled off between incumbent and competing lenders. To rule out unobserved characteristics of selection into incumbent that could also affect default, in Column (3) we estimate a logit regression of default on incumbent (and other controls) and find the coefficient on incumbent not statistically significant.

Table 7: Logit Model of Putback and Default

	(1)	(2)	(3)
Sample:	Default Loans 2009-2012	Default Loans 2013-2018	All Loans 2009-2012
Dep Var:	Putback	Putback	Default
Incumbent	-0.252^{***}	-0.082	0.111
	(0.017)	(0.092)	(0.134)
log(FICO)	-2.071^{***}	-1.338^{***}	-6.344^{***}
	(0.349)	(0.380)	(0.062)
LTV	1.303^{***}	0.831^{***}	1.453^{***}
	(0.276)	(0.313)	(0.036)
log(Balance)	0.419^{***}	0.277^{***}	0.013
	(0.093)	(0.105)	(0.017)
Prev. Rate	0.284^{***}	0.306^{***}	0.296^{***}
	(0.082)	(0.091)	(0.014)
Location FE	Yes	Yes	Yes
Yr-Qtr FE	Yes	Yes	Yes
Observations	48,125	29,907	650,543
R-squared	0.08	0.05	0.10

Note: Column (1) and (2) estimate a logit regression of putback on whether a loan is originated with the incumbent lender, conditional on all other observed characteristics as well as market and year-quarter fixed effect, using default loans from 2009-2012 and 2013-2018, respectively. To rule out unobserved characteristics of selection into incumbent that could also affect default, in Column (3) we estimate a logit regression of default on incumbent (and other controls) and find the coefficient on incumbent not statistically significant.

Appendix C: Full Model of Competitive Offer

In Appendix C, we describe the full model of competitive offer, including the expectation of winning bid, the distribution of winning product, and each lender's winning probability. The derivation relies largely on the result from Brannman and Froeb (2000). In reality, because lenders can offer both Regular and HARP for households whose LTV is between 0.8 and 0.95, given the households also pay an upfront insurance premium. Incumbent lenders do not have the program advantage in the regular refinance. Thus, in the competitive offer, lenders need to first decide which product to bid. We assume each lender is only allowed one single bid which consists of price r and product type k. There are 3 cases we need to consider: LTV > 0.8 (Regular Only), LTV < 0.95 (HARP Only), LTV $\in (0.8, 0.95]$ (HARP and Regular).

Regular Only

The simplest case is where the borrower's LTV is less than 0.8, which means that only regular refinance can be made. In this case, the incumbent does not have putback advantage, so lenders in this auction are symmetric in terms of their distribution of lending cost. Thus, the lender with the lowest realization of ω_{ijt}^{R} will win with winning bid

$$\omega_{(2)} + P_t^R + g_t + c_t$$

where $\omega_{(2)}$ is the second lowest realization of cost shocks with expectation $-\sigma \log(C+1) - \sigma(C+1)\log\left(1 - \frac{1}{C+1}\right)$, where C is the number of competing lenders.

HARP Only

The second case is where the borrower's LTV is greater than 0.95, so lenders cannot offer regular refinance. The difference between this case and the previous case is that the incumbent lender has cost advantages over competing lenders. To caputure this asymmetry in costs, define an effective cost shock as

$$\tilde{\omega}_{ijt}^{H} = \omega_{ijt}^{H} - \Delta \cdot 1\{j \text{ is the incumbent of } i\}$$

The probability that the incumbent wins the competition is

$$p_{it}(h) = \frac{\exp(\Delta/\sigma)}{\exp(\Delta/\sigma) + C}$$

and every competing lender wins with probability

$$p_{it}(c) = \frac{1}{\exp(\Delta/\sigma) + C}$$

Conditional on the incumbent winning the auction, the winning bid is

$$\tilde{\omega}_{(2)|h} + P_t^H + g_t + c_t$$

where $\tilde{\omega}_{(2)|h}$ is the second-lowest effective cost shock conditional on the incumbent wins, and its expectation is $-\sigma \log[C + \exp(-\Delta/\sigma)] - \log(1 - p_{it}(h))/p_{it}(h)$.

Conditional on a competing lender winning the auction, the expected winning bid is

$$\tilde{\omega}_{(2)|c} + P_t^H + g_t + c_t$$

where $\tilde{\omega}_{(2)|h}$ is the second-lowest effective cost shock conditional on the incumbent wins, and its expectation is $-\sigma \log[C + \exp(-\Delta/\sigma)] - \log(1 - p_{it}(c))/p_{it}(c)$.

HARP and Regular

The most complicated case is when borrower's LTV lie between $(0.8, 0.95]$. In this case, each lender bids its more profitable mortgage product after observing product specific cost shocks ω_{ijt}^k. The presence of two "product types", HARP or Regular, seems to complicate the auction. But it can be easily turned into a homogeneous good auction by defining an *effective* cost shock:

$$\tilde{\omega}_{ijt}^k = \omega_{ijt}^k + P_{ijt}^k + \phi^k(z_{it})$$

This effective cost shock completely absorbs both the cost differences and taste differences between HARP and Regular refinances. Thus, we can view HARP and Regular as the same type of products but with different means of shocks. The level of *effective* cost shocks determines which type of refinance that each lender choose to bid, and the identity of the winning lender.

Let's first look at the problem of choosing the refinance type within a lender. It follows that a lender's choice of refinance type k depends on which type has the lowest effective cost shock. Define the minimum of HARP and Regular effective cost shock of lender j as $\tilde{\omega}^B_{ijt} = \min\{\tilde{\omega}^R_{ijt}, \tilde{\omega}^H_{ijt}\}$. It turns out $\tilde{\omega}^B_{ijt}$ also follows a (min) Gumbel distribution with scale σ and location parameter η_{ijt} given by:

$$\eta_{ijt} = -\sigma \log \left[\sum_k \exp \left(-(P^k_{ijt} + \phi^k(z_{it}))/\sigma - \gamma \right) \right]$$

Thus the probability that lender j bid type k is given by

$$p^k_{ijt} \equiv \frac{\exp \left(-(P^k_{ijt} + \phi^k(z_{it}))/\sigma - \gamma \right)}{\sum_{k'} \exp \left(-(P^{k'}_{ijt} + \phi^{k'}(z_{it}))/\sigma - \gamma \right)}$$

Note that every lender shares the same distribution of $\tilde{\omega}^B$ *except* for the incumbent, since the incumbent has a lower expected put-back cost P^H_{ijt}. So η_{ijt} only takes on two values, η_{iht} for the incumbent lender and η_{ict} for each competing lender. Similarly, the probability of bidding type k, p^k_{ijt}, also takes on only two values, p^k_{iht} and p^k_{ict}.

In the auction, the lender with the lowest $\tilde{\omega}^B$ wins. It follows that the incumbent has a higher probability of winning than the competing lenders. Specifically, if there are C competing lenders (i.e. $C+1$ participating lenders), the incumbent h wins with probability

$$p_{it}(h) = \frac{\exp(-\eta_{iht}/\sigma)}{\exp(-\eta_{iht}/\sigma) + C\exp(-\eta_{ict}/\sigma)}$$

and every competing lender wins with probability

$$p_{it}(c) = \frac{1}{\exp(-\eta_{iht}/\sigma) + C\exp(-\eta_{ict}/\sigma)}$$

Derivation of the winning bid comes from two indifference conditions: (1) the second most efficient lender is indifferent between lending and not lending[25]; and (2) the borrower is indif-

[25]Because we assume the borrower commits to refinance.

ferent between taking offer from the second most efficient lender and the winning lender. Again there are essentially two types of lender: incumbent (h) and competing (c), so the winning price depends on which type of lender wins and what type of refinance it offers.

1. Conditional on the incumbent wins the auction with refinance type HARP, the expected winning price is: ($\tilde{\omega}_{(2)|h}$ is the second lowest effective cost shock *conditional on* the incumbent h wins[26]).

$$p_{ict}^{H}\left(\tilde{\omega}_{(2)|h}-\phi^{H}+g_t+c_t\right)+\left(1-p_{ict}^{H}\right)\left[U^{-1}\left(\phi^{H}-\phi_{it}^{R}\right)+\left(\tilde{\omega}_{(2)|h}-\phi_{it}^{R}+g_t+c_t\right)\right]$$

2. Conditional on the incumbent wins the auction with refinance type Regular, the expected winning price is

$$p_{ict}^{H}\left[U^{-1}\left(\phi_{it}^{R}-\phi^{H}\right)+\left(\tilde{\omega}_{(2)|h}-\phi^{H}+g_t+c_t\right)\right]+\left(1-p_{ict}^{H}\right)\left(\tilde{\omega}_{(2)|h}-\phi_{it}^{R}+g_t+c_t\right)$$

3. Conditional on a competing lender wins the auction with refinance type HARP, the expected winning price is: ($\tilde{\omega}_{(2)|c}$ is the second lowest effective cost shock *conditional on* a competing lender wins, and $\tilde{p}_{it}(h)$ is the probability that the incumbent h has the second lowest effective cost shock[27]).

$$\begin{aligned}&\left[\tilde{p}_{it}(h)p_{iht}^{H}+\left(1-\tilde{p}_{it}(h)\right)p_{ict}^{H}\right]\left(\tilde{\omega}_{(2)|c}-\phi^{H}+g_t+c_t\right)\\&+\left[\tilde{p}_{it}(h)\left(1-p_{iht}^{H}\right)+\left(1-\tilde{p}_{it}(h)\right)\left(1-p_{ict}^{H}\right)\right]\left[U^{-1}\left(\phi^{H}-\phi_{it}^{R}\right)+\left(\tilde{\omega}_{(2)|c}-\phi_{it}^{R}+g_t+c_t\right)\right]\end{aligned}$$

4. Conditional on a competing lender wins the auction with refinance type Regular, the expected winning price is:

$$\begin{aligned}&\left[\tilde{p}_{it}(h)p_{iht}^{H}+\left(1-\tilde{p}_{it}(h)\right)p_{ict}^{H}\right]\left[U^{-1}\left(\phi_{it}^{R}-\phi^{H}\right)+\left(\tilde{\omega}_{(2)|c}-\phi^{H}+g_t+c_t\right)\right]\\&+\left[\tilde{p}_{it}(h)\left(1-p_{iht}^{H}\right)+\left(1-\tilde{p}_{it}(h)\right)\left(1-p_{ict}^{H}\right)\right]\left(\tilde{\omega}_{(2)|c}-\phi_{it}^{R}+g_t+c_t\right)\end{aligned}$$

[26] The expectation of $\tilde{\omega}_{(2)|h}$ is $-\sigma\log\left[\sum_j\exp\left(-\eta_{ijt}/\sigma\right)\right]+\sigma\gamma-\sigma\log\left(1-p_{it}(h)\right)/p_{it}(h)$.

[27] The expectation of $\tilde{\omega}_{(2)|c}$ is $-\sigma\log\left[\sum_j\exp\left(-\eta_{ijt}/\sigma\right)\right]+\sigma\gamma-\sigma\log\left(1-p_{it}(c)\right)/p_{it}(c)$.