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Lauren Lambie-Hanson
Supervision, Regulation, and Credit
Federal Reserve Bank of Philadelphia

Carolina Reid
University of California, Berkeley

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RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA
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Lauren Lambie-Hanson, Federal Reserve Bank of Philadelphia[1]
Carolina Reid, University of California, Berkeley

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Abstract

Despite falling interest rates and major federal policy intervention, many borrowers who could financially gain from refinancing have not done so. We investigate the rates at which, relative to prime borrowers, subprime borrowers seek and take out refinance loans, conditional on not experiencing mortgage default. We find that starting in 2009, subprime borrowers are about half as likely as prime borrowers to refinance, although they still shop for mortgage credit, indicating their interest in refinancing. The disparity in refinancing is driven in part by the tightened credit environment post-financial crisis, along with the fact that many subprime borrowers are ineligible for the Home Affordable Refinance Program (HARP), which is the major policy initiative designed to assist borrowers in refinancing their mortgages. We argue that these barriers to refinancing for subprime borrowers have long-term implications for social stratification and wealth building. These concerns are exacerbated by an additional finding of our work that refinance rates have been significantly lower for black and Hispanic borrowers, even after controlling for borrower credit status.

Keywords: mortgage refinancing, subprime, household finance
JEL Codes: D12, G21, J15

[1] Lauren Lambie-Hanson is a principal financial economist at the Federal Reserve Bank of Philadelphia; e-mail: lauren.lambie-hanson@phil.frb.org. Carolina Reid is an assistant professor of city and regional planning at the University of California, Berkeley, e-mail: c_reid@berkeley.edu.

Access to credit has long been a core public policy concern, given the important role that credit plays in stimulating economic growth, expanding access to homeownership, and smoothing consumption over the household life cycle. For many years, policymakers have prioritized the widening of the credit box to expand access to homeownership, and the 1990s and early 2000s were characterized by an increase in lending to borrowers who previously would have been denied a mortgage (Retsinas and Belsky 2002; Belsky, Herbert, and Molinsky 2014). The subprime boom and subsequent financial crisis, however, have prompted the pendulum to swing in the other direction, and lenders have significantly tightened their underwriting criteria in recent years (Laufer and Paciorek 2016; Bhutta 2015; Bai, Goodman, and Zhu 2016). Researchers at the Urban Institute have estimated that 5.2 million more mortgages would have been made between 2009 and 2014 if lenders had used the same credit standards as those used in 2001 (Bai, Goodman, and Zhu 2016). Borrowers with less than pristine credit records have largely been excluded from the mortgage market, with disproportionate impacts on black and Hispanic borrowers and neighborhoods (Bhutta 2015; Bhutta and Ringo 2016).

While much of the attention has focused on decreased access to credit for home purchase (Bhutta and Ringo 2016), this tightened credit environment has implications for the refinance market as well. In this paper, we explore access to refinance credit for subprime borrowers who remained current on their mortgage during the crisis, and who should, in theory, have benefited from being able to refinance their higher-priced mortgage, given the historically low interest rates. Focusing on the refinance market is critical, since mortgage refinancing is one of the main channels through which households manage the benefits and risks of homeownership, and it constitutes one of the mechanisms by which accommodative monetary policy affects households (Agarwal et al. 2015; Fuster and Willen 2010). Refinancing can lead to short-term, material financial gains for a household by saving on monthly interest payments (and, presumably, an increase in aggregate demand by boosting other types of spending) and can contribute to wealth gains by reducing the long-term costs of credit. Refinancing has also been found to mitigate the risk of default (Zhu et al. 2014; Laufer and Paciorek 2016; Keys et al. 2014).

Despite the importance of refinancing, comparatively little research has focused on the refinance behaviors of subprime borrowers in the wake of the financial crisis. A majority of studies that have examined the experiences of subprime borrowers have focused on heightened default risk and the uneven distribution of defaults by race and ethnicity linked to subprime

lending practices (Reid et al. forthcoming; Bayer, Ferreira, and Ross 2016; Rugh, Albright, and Massey 2015). However, a subprime borrower's ability to refinance into a lower-cost mortgage over time is fundamental to a credit allocation regime that relies on risk-based pricing to expand access to credit. Since risk is not perfectly priced at origination (with some borrowers charged at higher rates than their underlying risk), the ability of a subprime borrower to refinance into a lower-cost mortgage can help mitigate ex-ante information asymmetries. As lenders observe a borrower's repayment history over time, they should be able to recalibrate the borrower's risk profile and thus allocate and price refinance mortgages more effectively.

Whether subprime borrowers are actually able to refinance thus has important implications for the welfare benefits of risk-based pricing as a credit allocation policy. If subprime borrowers are able to refinance, then risk-based pricing could improve credit allocation and lead to positive externalities of homeownership by providing access to mortgage credit for those who would otherwise be excluded — without penalizing borrowers with higher interest costs over the long term (Collins, Belsky, and Case 2005). However, if subprime borrowers are unable to refinance, refinance too soon, or refinance into another higher-priced loan or riskier product, then risk-based pricing can exacerbate wealth inequalities. Indeed, the failure of subprime borrowers to refinance could have substantial long-term consequences for their ability to accumulate household wealth and on the racial wealth gap, given that a disproportionate share of subprime loans were made to Hispanic and black households (Bocian, Ernst, and Li 2008a; Courchane 2007; Courchane, Surette, and Zorn 2004a; Avery, Brevoort, and Canner 2006; Calem, Gillen, and Wachter 2004; Ding et al. 2008; and Newman and Wyly 2004). Theoretical and historical works have revealed the production of inequality through risk-based pricing and the data used to produce credit scores (Marron 2007; Fourcade and Healy 2013), yet few empirical studies have focused on the question of whether subprime borrowers are able to translate their initial loan access to homeownership into a prime product or whether they remain "stuck in subprime," paying more for credit over the long term.

In this paper, we fill this gap in the existing refinance literature by shedding light on the refinance behaviors of subprime households. Understanding the experiences of these borrowers is particularly salient for policymakers, given that the composition of prospective new homeowners in the United States is increasingly skewed toward borrowers who are more likely to have lower credit scores or thinner credit profiles, lower incomes, and less wealth than

homebuyers in the past (Bhutta and Ringo 2016; Avery, Brevoort, and Canner 2010; Brevoort, Grimm, and Kambara 2015). One of the key contributions of this paper is our focus on borrowers who *did not* default on their mortgage; these are the borrowers for whom refinancing would appear to have a benefit, particularly given historically low interest rates and for whom other mortgage policy tools (such as loan modifications) would not apply. While it is not unreasonable to expect that subprime borrowers would have a harder time refinancing than those with prime credit scores, if they are being disadvantaged because of the "stickiness" of credit scores over time and not a higher propensity to default, then there could be a role for policy intervention to improve refinance credit allocation.

Specifically, we examine three questions related to the refinance experiences of subprime borrowers. First, what were the refinance experiences of subprime borrowers in the post-crisis lending market? Second, to what extent were subprime borrowers eligible for the federal Home Affordable Refinance Program (HARP)? Third, did subprime borrowers who were able to refinance their mortgage see welfare gains in the form of lower interest rates and lower monthly payments? To answer these questions, we rely on a monthly panel dataset that merges loan-level information on a random sample of first-lien mortgages from McDash Analytics with borrower credit data from Equifax, along with Home Mortgage Disclosure Act (HMDA) data on borrower race and ethnicity. This unique dataset allows us to observe a richer set of refinance behaviors and outcomes than did previous studies.

Our analysis provides insights into the constraints that subprime borrowers face in trying to refinance their mortgages. We find evidence that subprime borrowers who refinanced did so earlier in the life of their loans. While the common refrain in the media and some academic literature is that subprime borrowers refinanced early to avoid interest rate resets, we observe this behavior even among those with fixed-rate mortgages or those with adjustable-rate mortgages that were not set to experience an interest rate reset until years later. In hindsight, given that interest rates fell, it may have been more optimal for them to delay refinancing — although they could not have known that a priori. Rather than seeking interest rate reductions, at this time, subprime borrowers were predominantly refinancing to extract equity: 70 percent of subprime borrowers in our sample who refinanced in 2007–2009 took out cash. By extracting equity and pushing their loan-to-value (LTV) ratios higher, these borrowers may have been preventing themselves from future refinances as house prices fell.

Beginning in 2009, when rates began falling dramatically, many subprime borrowers remaining in their loans could have reduced their mortgage payments through refinancing but did not. There are two main explanations: Those who "wanted" to refinance simply did so early (prepayment "burnout" as it is referred to in the industry), or the borrowers sought mortgage credit but could not receive it in the tightened credit environment post-crisis. Although we believe both forces were at work, we show evidence that subprime borrowers continued to inquire with lenders for mortgage credit past 2009, but they were less likely than prime borrowers to receive loans. For subprime borrowers who remained current on their mortgage throughout the foreclosure crisis (thus demonstrating both the ability and willingness to repay their existing mortgage), we find significantly lower refinance rates than for borrowers with prime or super-prime credit scores, even after controlling for a wide range of factors that would influence credit access. We also find that black and Hispanic borrowers were less likely to refinance than white borrowers, regardless of whether they were subprime or prime when they purchased their homes. However, subprime borrowers who were able to refinance received similar mortgage payment reductions as prime borrowers, suggesting that refinancing can successfully lead to reductions in interest payments.

We also find that HARP did little to help subprime borrowers. HARP was the federal program to assist underwater borrowers who were not delinquent on their mortgages. (It targeted a different group of borrowers from the Home Affordable Modification Program, or HAMP, which was designed for borrowers in default.) HARP was structured in a way that excluded a majority of subprime, black, and Hispanic homeowners from its potential benefits. While the results in this paper are largely descriptive, they point to an underexamined area for housing finance policy and suggest several ways in which policymakers could improve refinance outcomes for subprime borrowers.

The paper proceeds as follows: First, we review the literature on borrower prepayment and refinancing, paying particular attention to studies that focus on differences in refinance behavior across borrower types. Second, we discuss the construction of our dataset and provide descriptive statistics for the samples used in this paper. We then present our empirical results, focusing on the three questions outlined previously. In the final section, we discuss and review the policy implications of our main findings and suggest avenues for future research.

1. Related Literature

The literature on borrower prepayment and refinancing is extensive, in part because of the importance of correctly modeling prepayments to effectively price mortgage securities (Green and LaCour-Little 1999; Agarwal, Driscoll, and Laibson 2013; Davidson and Levin 2014; Kau and Keenan 1995; Dickinson and Heuson 1994). However, a complete picture of refinance behavior and the reasons for suboptimal refinance decisions remains elusive. Data constraints can make it difficult to identify whether the prepayment is driven by borrower mobility (e.g., when a homeowner decides to sell his house) or by refinancing a new loan for the same property (LaCour-Little 1999). Borrowers also refinance for many reasons other than reducing interest rate payments; for example, a homeowner may refinance to adjust the amortization schedule of the loan (e.g., switching from a 30-year to a 15-year mortgage to pay off the loan more quickly), to increase liquidity through a cash-out refinance, or to switch from an adjustable-rate mortgage (ARM) to a fixed-rate mortgage (FRM) (Brady, Canner, and Maki 2000; Duca and Kumar 2014; LaCour-Little 1999).

Existing studies suggest that borrowers often fail to refinance even when economic theory would suggest that doing so would be financially beneficial. These failures can take on many different forms. For example, borrowers may fail to refinance even when interest rates have dropped significantly (Keys, Pope, and Pope 2016; Agarwal, Rosen, and Yao 2013). Keys, Pope, and Pope (2016) estimate that 20 percent of households in December 2010 had not refinanced their mortgages when it appeared profitable to do so. Moreover, they find that approximately 40 percent of the households identified as those that could have benefited from refinancing in December 2010 still had not refinanced their mortgages by the end of 2012, despite interest rates dropping even more. Conversely, borrowers may refinance when interest rates have actually increased or when the costs of refinancing exceed the benefits of lower interest payments (Goodstein 2014).[2]

Borrowers can also wait too long to refinance or refinance too soon (Agarwal, Rosen, and Yao 2013; Chang and Yavas 2009; Stanton 1995). For instance, Stanton (1995) finds that mortgage holders typically delay refinancing for more than a year beyond the optimal

[2] Although there is less evidence in the literature for this phenomenon, some researchers have shown that this is often driven by cash-out refinancing, in which borrowers are more concerned with consumption smoothing than with the long-term interest costs of the mortgage (Hurst and Stafford 2004; Pennington-Cross and Chomsisengphet 2007).

refinancing date; Agarwal, Rosen, and Yao (2013) find that at least half of borrowers refinance at rates that are at least 50 basis points higher than what would be optimal and that nearly 20 percent of borrowers wait six months too long to refinance.

Research has also identified systematic differences in who chooses to refinance and has shown that borrowers' characteristics are significant factors that drive prepayment behavior (LaCour-Little 1999).[3] Minority homeowners and those with lower levels of education and lower credit scores are the most likely to make refinancing mistakes (Chang and Yavas 2009; Amromin et al. 2011; Fuster and Willen 2010; Agarwal, Ben-David, and Yao 2014; Campbell and Cocco 2003; Peristiani 1997; Archer, Ling, and McGill 1996; Agarwal, Rosen, and Yao 2013; Goodstein 2014; Deng, Pavlov, and Yang 2005).[4]

Borrowers may fail to optimally refinance for a number of reasons, despite the availability of financing innovations that reduced the institutional barriers for refinancing.[5] Constraints related to underwriting criteria may limit a borrower's ability to refinance (Archer, Ling, and McGill 1996; Peristiani 1997; LaCour-Little 1999; Goodstein 2014). Collateral constraints and high loan-to-value ratios have consistently been shown to reduce the likelihood of refinancing (Brickman and Hendershott 2000; Goodstein 2014; Peristiani 1997; and Archer, Ling, and McGill 1996). When a borrower applies for a refinance loan, the lender will reappraise the property value and calculate the current LTV ratio. Homeowners with high LTV ratios may be completely rationed out of the refinance market. In recent years, these collateral constraints may be particularly important, given the dramatic housing price declines and the high percentage

[3] When the option to refinance is clearly a poor financial decision ("out of the money") or clearly beneficial ("in the money"), then borrower and loan characteristics are less important in predicting refinance behavior (LaCour-Little 1999).

[4] The picture looks slightly different when the focus is on cash-out refinancing, particularly during the U.S. mortgage boom between 1998 and 2005. During this time period, households that were younger, nonwhite, noncollege graduates, or financially illiterate about portfolio risk were more likely to have actively withdrawn housing equity using cash-out mortgage refinancing or traditional second mortgages (Duca and Kumar 2014). Green and LaCour-Little (1999) find that households headed by black consumers were more likely to prepay, after controlling for potential collateral value constraints; however, their data do not allow them to distinguish between rate and cash-out refinancing or distinguish prepayments due to homeowner mobility (selling the home).

[5] Bennett, Peach, and Peristiani (2001) argue that both the financial and nonfinancial costs to refinancing have declined over time because the mortgage application-and-approval process has been streamlined. They also suggest that technological advances have enabled lenders to more easily identify borrowers with interest rates above prevailing market rates, thereby disseminating information about refinancing opportunities more quickly and broadly than had occurred in the past.

of second-lien mortgages (Bond et al. 2013).[6] HARP, by raising the LTV ratio ceiling, was designed to remove collateral constraints to refinancing for eligible borrowers.

Credit constraints have also historically been an important barrier to refinancing (Peristiani 1997). Especially for subprime borrowers, a lower credit score may reduce the likelihood that a lender will approve a refinance application, particularly since lenders have tightened credit standards over the past few years. Weaker and more uncertain conditions in employment and housing markets may also lead lenders to scrutinize applications more carefully (Avery et al. 2011). Concerns about representation and warranty exposure[7] may have led some lenders to impose credit overlays (higher credit standards than required), restricting refinancing to lower-risk borrowers (Federal Housing Finance Agency 2013).

Loan characteristics and pricing will also influence the propensity to refinance. At origination, borrowers have the option to "pay points" up front (generally between 0.5 percent and 3 percent of the mortgage amount) to lower the interest rate. Evidence suggests that borrowers who pay points are less likely to refinance — and refinance later — than similarly situated borrowers who did not pay points (Agarwal, Ben-David, and Yao 2014; Chang and Yavas 2009), despite the fact that the decision to refinance should be driven by potential savings on the current interest rate and not on what was already spent to lower the rate. Fuster and Willen (2010) note that subprime borrowers were more likely to pay up-front "discount" points at closing for a given interest rate. Prepayment penalties, which were more prevalent among subprime loans, may also limit refinancing options (Cutts and Van Order 2005).

In addition to underwriting or loan criteria, borrowers may differ in terms of their financial knowledge and understanding of the costs and benefits of refinancing at any point in time. The decision to refinance is complex, involving not only financial calculations to determine whether it is "in the money" to refinance but also assumptions about the future, such as the homeowner's expectations about the direction of future interest rates and inflation, how long he

[6] In addition to the burden of overcoming collateral constraints to refinancing (most borrowers with a second loan have a higher LTV ratio), there are also legal barriers specific to refinancing a second mortgage (Bond et al. 2013). As of December 2012, 22 percent of homes with a mortgage had more than one mortgage lien (Bond et al. 2013).

[7] Representations and warranties are assurances that lenders make to investors (including Fannie Mae and Freddie Mac) about the quality of loans they originate; if the loan does not meet the criteria that the lender claimed it did, Fannie Mae or Freddie Mac may issue a request to the lender to repurchase the loan. (Although banks also make reps and warranties to private-label investors, there are meaningful distinctions between the capacity of the government-sponsored enterprises (GSEs) and private-label investors to put-back loans to the banks.)

intends to stay in his current home, and his future labor market prospects (Brady, Canner, and Maki 2000; Campbell and Cocco 2003). Even more financially sophisticated borrowers may not monitor mortgage rates closely and refinance when "they have a spare moment" rather than at the financially optimal time (Agarwal, Ben-David, and Yao 2014). Borrowers may also receive suboptimal advice about when to refinance. Agarwal et al. (2013) surveyed the refinancing recommendations offered by the top 25 leading books and websites and found that these information sources provided broad guidelines, including such advice as refinancing only if there was a fixed interest rate differential of 1.5 percent to 2 percent and if the borrower plans to stay in the house for at least three to five years.

Subprime borrowers, in particular, may have lower levels of financial knowledge and may fail to take the necessary actions to pursue refinancing (Agarwal, Rosen, and Yao 2013). Pre-crisis surveys of subprime borrowers found that they typically did not initiate a search for a mortgage loan, especially for a refinance or home equity loan (Courchane, Surette, and Zorn 2004b; Kim-Sung and Hermanson 2003). In some neighborhoods that were hard hit by the foreclosure crisis, borrowers may be wary of seeking a refinance loan or may not trust brokers, given the "push" marketing for subprime cash-out refinance loans during the subprime boom (Apgar, Calder, and Fauth 2004; Reid 2014). Reid (2014) also found that the process of obtaining a refinance loan can be time-consuming and confusing, leading borrowers to abandon their attempts to refinance.

In this paper, we build on these earlier studies to specifically focus on the experiences of subprime borrowers who purchased property during the housing boom, then compare their mortgage outcomes with borrowers with prime credit profiles. For borrowers who initially purchased their homes with a higher-priced or subprime loan, refinancing into a prime product after a period of successful payments or increased financial stability and security should promote significant welfare benefits. Yet, the previous studies suggest that there are many reasons that subprime borrowers may not take advantage of lower rates to change their loan terms. A better understanding of the specific barriers that subprime borrowers face in the refinance market is critical for contemporary debates bearing on access to credit and lending for lower-income and minority households.

2. Data

To investigate the differences in refinance behavior between subprime and prime borrowers, we use a dataset of loan-level mortgage performance data matched with the borrowers' credit file attributes. We capture mortgage characteristics and performance using Black Knight Financial Services' McDash Analytics data, containing U.S. prime and nonprime loans, some securitized and others held in portfolio. Our analysis focuses on borrowers who purchased their homes in 2006; in this year, the McDash data covered 81 percent of first-lien purchase mortgages.[8] In addition to providing information on the product type, lien type, property type, level of income documentation, and owner occupancy at origination, the McDash data include a monthly panel of current loan characteristics, including prepayment and delinquency status.

We focus our analysis on a sample of 60,000 borrowers with conventional, 30-year mortgages, drawn randomly from the McDash data; but we intentionally oversampled the subprime borrowers, which we define as those with credit scores below 620 at origination. We include borrowers with both fixed-rate mortgages and adjustable-rate mortgages that first reset five, seven, or 10 years after origination.[9]

We require that borrowers be owner-occupants (as identified in the McDash data underwriting fields), and we exclude borrowers who held two or more first-lien mortgages concurrently in 2006. These data are then matched to credit file attributes for each consumer by the credit bureau Equifax, in a dataset known as Credit Risk Insight^{TM} Servicing. Although the matching algorithm is proprietary, it incorporates such loan characteristics as the origination date, origination amount, payment history, and location of the consumer and of the property serving as collateral for the mortgage.[10] By linking the McDash data to the credit bureau records, we can observe whether the homeowner takes on a new mortgage loan at the time of prepayment. The credit bureau data also include information about other sources of consumer

[8] We calculate this coverage rate by comparing the 8.7 million first-lien purchase mortgage originations in the McDash data with the corresponding 10.8 million originations reported in Home Mortgage Disclosure Act (HMDA) data for 2006.

[9] We exclude mortgages that reset earlier than five years from our analysis because they were used by a relatively small number of borrowers with credit scores over 620.

[10] Bond et al. (2013) use similar procedures to match their data.

debt (e.g., for auto loans, credit cards, or student loans) and indicate if and when a borrower makes an inquiry for new mortgage credit.

For a borrower who refinances into a mortgage included in the McDash dataset, we also observe about 60 characteristics of the new loan, including its size, interest rate, and monthly payment. We supplement the panel dataset with additional data from CoreLogic on house prices at the zip code and county levels, beginning with the origination date and updated monthly. We use the CoreLogic data to estimate changes in the value of the properties over time, which enables us to estimate mark-to-market LTV ratios.[11] In addition, to consider basic demographic characteristics of the borrowers, we match our dataset with HMDA data, achieving a match rate of 67 percent. We match on origination date and amount, property location, lien type, loan type, and stated occupancy type. To guard against including false matches, we keep only McDash mortgages that match one, and only one, HMDA record, and we require that this HMDA record be uniquely matched to this single McDash loan. Because matching with HMDA data limits the sample, we present a majority of findings for the full subprime sample, using the matched HMDA data sample only to illuminate differences for black and Hispanic borrowers.

Our data are structured as a monthly panel, beginning six months before the borrower purchases his home in 2006 through six months after the purchase mortgage is terminated or May 2015, whichever comes first. We restrict our sample to borrowers whose 2006 purchase mortgages were still active (not paid off or terminated through foreclosure) as of July 2007, thereby ensuring a better match with the credit bureau data. We further restrict our analysis to the sample of conventional loan borrowers who remained current (or fewer than 60 days' delinquent) on their mortgages for our entire study period. Borrowers are often disqualified from refinancing if they have missed mortgage payments, and default rates are higher for subprime borrowers. In effect, we are limiting our analysis to those subprime borrowers who should be in the best position to refinance since they have demonstrated their willingness and ability to pay their mortgage during a period of unprecedented housing market volatility. While many other researchers have focused on the higher rates of default among subprime loans, along with the

[11] Mark-to-market LTVs are LTVs in which the denominator (value) is updated using a house price index to get an updated estimate of the borrower's debt versus equity. We also use median home values at the zip code level from Zillow. We find that, generally, CoreLogic offers a more complete panel of data for loans in particular geographies, but Zillow data can, in some instances, provide more comprehensive information for small geographies at particular points in time. We find that our results are robust to using either data source in our analysis.

underwriting practices that were prevalent during the subprime boom (Bocian et al. 2011; Anacker and Carr 2011; Rugh, Albright, and Massey 2015; Bayer, Ferreira, and Ross 2016; Reid et al. forthcoming), our focus here is on borrowers who received higher-priced loans as a result of risk-based pricing and who should (but may not) benefit from refinancing into a lower-cost product.

This dataset allows us to overcome some of the shortcomings in previous studies of refinancing (Goodstein 2014; Keys, Pope, and Pope 2016; Agarwal, Rosen, and Yao 2013). First, while most researchers are limited to modeling the likelihood of prepayment (which could include a homeowner selling his home), we are able to observe whether a prepayment results in the origination of a new loan, along with the characteristics of the refinance mortgage. Second, researchers rarely have access to data on total mortgage debt or other debts at the time of a refinance application. Not having this information leads to underestimates of credit constraints, especially for borrowers who were negatively affected by the financial crisis. The merged credit panel and mortgage data enable us to track household debt obligations longitudinally, thereby allowing us to model these constraints more effectively.[12] Third, with the credit panel data, we are able to observe whether a borrower makes a mortgage inquiry, allowing us to see if a borrower attempts to refinance and then fails or whether the borrower does not even attempt to do so despite the mortgage being "in the money" (and, therefore, suggesting that the barrier may be related to the borrower's trust or financial capability).[13]

Table 1 provides summary statistics related to the loans and borrowers in our sample, stratified by their FICO score at origination. Throughout the paper, we refer to four separate FICO buckets: subprime (FICO below 620), nonprime (FICO between 620 and 679), prime (FICO between 680 and 739), and super-prime (FICO equal to or above 740). Because our sample is limited to borrowers who did not default over our time period, the sample is skewed toward borrowers with higher credit scores: Nearly half the sample falls in the super-prime bucket. Still, 22 percent of borrowers in the sample have credit scores below 680.

[12] For example, Elul et al. (2010) found that using only data from Loan Performance and Lender Processing Services (also known as McDash) significantly underestimates total combined LTV ratio.

[13] The inquiry field in Equifax comes from two sources: a) inquiries from a known mortgage lender and b) what Equifax refers to as "potential" mortgage inquiries, which are made by a credit service company that typically aggregates credit reports from the three main credit bureaus for the mortgage lender to review.

The sample characteristics conform with a priori expectations. The first-lien mortgages taken out by subprime borrowers had lower loan amounts and smaller monthly payments than did those taken out by prime borrowers. Subprime borrowers also tended to put less money down at origination: 30 percent of borrowers with credit scores below 620 put less than 5 percent down at origination compared with only 13 percent of borrowers with a credit score over 740. Lower down payments put these borrowers at great risk of negative equity as house prices began falling across most of the nation in 2007, the year immediately after these borrowers purchased.[14] As the table shows, mark-to-market combined LTV ratios (measured at termination or at the end of the sample period) were significantly higher for subprime than for prime borrowers, suggesting that subprime borrowers may face higher collateral constraints to refinancing.[15]

Mortgage product features also differ across FICO buckets. In our sample of FRMs and 5/1, 7/1, and 10/1 ARMs,[16] a majority of borrowers have FRMs and a slightly larger percentage of prime and super-prime borrowers have ARMs. Consistent with risk-based pricing, we find that borrowers with lower credit scores pay higher interest rates on average, ranging from 40 basis points for those with an ARM to 30 basis points for those with a FRM. Prepayment penalties were more common among subprime borrowers, with this feature attached to 6 percent of the subprime borrowers' loans, whereas only 2 percent of borrowers with FICO scores over 740 had such a penalty. Subprime borrowers are also more likely to have private mortgage insurance, which could increase the cost of a refinance mortgage (Fuster and Willen 2010).

Nonmortgage debt profiles for the different FICO groups reveal more similarities than differences, with a couple of exceptions. We find that subprime and nonprime borrowers — even those who have consistently paid their mortgage on time — are more likely than prime and super-prime borrowers to be past due on their nonmortgage debt. They are also more likely to have high levels (above $20,000) of auto debt. Finally, in the last panel, we provide the

[14] Subprime borrowers were about half as likely as nonprime, prime, or super-prime borrowers to use a piggyback mortgage, coupled with a lower LTV ratio first-lien mortgage. Instead, they took out higher-LTV ratio first-lien mortgages.

[15] Measuring combined LTV (CLTV) in this way is not a perfect assessment of collateral constraints in any given period. In our model, we control for contemporaneous mark-to-market, combined LTV.

[16] These refer to different types of ARM products and indicate the year in which the interest rate resets. A 5/1 mortgage, for example, is a mortgage that first resets five years after origination (the "5") and thereafter resets each year (the "1").

breakdowns for the matched HMDA sample. Black and Hispanic borrowers are overrepresented in the subprime and nonprime groups, as are single householders.

3. Empirical Results

Refinancing Outcomes for Subprime, Black, and Hispanic Borrowers

In this section, we explore the refinance experiences of subprime borrowers in the post-crisis lending market. We begin by providing descriptive statistics on the propensity to refinance, the reasons for refinancing, and the gap between a borrower's desire to refinance (as indicated by mortgage inquiry on the credit file) and his ability to do so. We then present a series of multinomial logit models to see whether observed differences in the subprime borrowers' refinance rates persist after controlling for the borrower, loan, and housing market characteristics.

Figure 1 presents cumulative refinance rates through May 2015 for each type of loan in our sample. Consistent with the studies previously described, we find that refinance rates are substantially lower among subprime borrowers. Forty-five percent of borrowers with FICO scores below 620 (subprime) refinanced by May 2015, compared with 53 percent of borrowers with scores over 740 (super-prime).[17] The difference is more pronounced for FRMs: 39 percent of subprime borrowers refinanced compared with 54 percent of super-prime borrowers. We also find that a significant share of subprime borrowers who refinanced did so in the initial two years of their loans, before interest rates had fallen much, meaning they likely gained less — in terms of lower interest rates — than did those who delayed refinancing for a few more years

Figure 2 shows that the motives for refinancing not only vary across borrower groups but also over time. We find that during the 2007–2008 period, nearly 70 percent of subprime borrowers were refinancing their mortgages into a cash-out mortgage compared with 45 percent of super-prime borrowers.[18] While refinancing to obtain an interest rate reduction becomes more important for all groups over time, it remains significantly lower for subprime than for prime and

[17] Subprime borrowers were also significantly less likely to prepay their mortgage; approximately 22 percent prepaid by May 2015, compared with 28 percent for borrowers with the highest FICO scores.

[18] A significant share of subprime borrowers had their closing costs capitalized in their refinance mortgage, which could lead to erroneously coding an interest rate refinance as a cash-out mortgage. We address this by imposing conditions on a large increase between the old and new origination amounts to avoid falsely coding a refinance mortgage as a cash-out.

super-prime borrowers, who also were more likely to use refinancing as an opportunity to shift into a 15-year loan or move from an adjustable into a FRM. These refinance decisions significantly reduce the overall cost of the loan and protect homeowners from future rate increases by locking in historically low interest rates.

In the literature, one common explanation for lower refinance rates among subprime and low-income homeowners is that lower refinance origination rates may reflect lower demand: If subprime homeowners are less financially knowledgeable, they may not be applying for a refinance mortgage at the same rate as prime or super-prime borrowers. One advantage of the credit score data is that we can observe whether a borrower makes an inquiry for a refinance mortgage, even if that mortgage is never originated. The inquiry is recorded at the time the borrower's credit report is pulled by lender, so a borrower who is discouraged by a lender early in the process and "walked away" would be unlikely to have an inquiry appear on his credit report. As a result, these inquiries should be seen as a lower-bound-measure on borrowers' interest in refinancing, particularly borrowers who are more likely to be discouraged from making formal applications (which we expect are more likely to be subprime borrowers).

Figure 3 presents the results of this analysis. In Panel A, we present the percentage of borrowers inquiring about new mortgage credit. We find that, in 2008, subprime and nonprime borrowers were significantly more likely to inquire about a new mortgage, compared with prime and super-prime borrowers, consistent with the data on higher rates of refinancing. However, after 2009, inquiries across borrower FICO groups converge over time — while, in general, super-prime and prime borrowers have slightly higher inquiry rates, differences across the four groups are relatively small and, in some cases, the trends are nearly identical. What does not converge is the ability of borrowers to translate inquiries into a new mortgage: In Panel B, we present the percentage of inquiries that result in a refinance mortgage within the next four months, as stratified by borrowers' FICO score. After 2009, super-prime borrowers who inquire about a new mortgage are consistently more likely to receive a refinance loan than are subprime or nonprime borrowers.

When comparing subprime and super-prime borrowers, these descriptive differences in refinance rates could be driven by differences in debt, collateral, or loan terms. For example, if subprime borrowers made smaller down payments or bought in neighborhoods with greater price declines, differences in refinance rates could be driven by differences in collateral constraints. To

account for observable characteristics that might drive differences in refinance originations, we specify a series of multinomial logit hazard models in which we account for the competing risks of refinancing and nonrefinance payoffs (generally coinciding with the sale of the collateral property) and include controls for borrower credit score and equity position, loan characteristics, and the presence of nonmortgage debt, along with state fixed effects and calendar-quarter dummies to account for changes in both the seasoning of the loans and broader, macroeconomic conditions. Super-prime borrowers — those with credit scores over 740 — are the omitted category.

Table 2 presents the average marginal effects for the first set of model specifications. In columns 1–3 of Table 2, we estimate regressions for the full sample, for the subsample of FRMs, and for 5/1 ARMs. In column 4, we limit our analysis to loans active between January 2009 and May 2015, the period in which interest rates were falling or holding steady at historically low levels. Focusing on this later time period also removes borrowers who refinanced early in their mortgage term, which may suggest alternative motives than an interest rate refinance.

The analysis reveals important differences in the refinance behavior of the subprime borrowers compared with prime and super-prime borrowers. In columns 1–2, we find that subprime borrowers are more likely to refinance than are prime borrowers, although the interaction terms indicate that this effect decreases over time. This initial higher propensity to refinance is driven by early refinance decisions made by subprime borrowers, confirming the descriptive results in Figure 1. Nonprime borrowers are less likely to refinance than are super-prime borrowers throughout the period of observation. Column 3, which focuses on 5/1 ARMs, provides less conclusive results, showing no significant differences between the refinance behavior of subprime and super-prime borrowers. In part, this may be due to the smaller sample size of this group and/or differences in refinance motivations for borrowers who took out ARMs in 2006.

In column 4, which models refinancing post-January 2009, we find that subprime borrowers were 0.86 percentage point and nonprime borrowers 0.76 percentage point less likely to refinance each month than were super-prime borrowers. In other words, at the same time that interest rates were falling to historically low rates, subprime and nonprime borrowers were not taking advantage of these shifts in the mortgage market. Given an overall average monthly refinance rate of 1 percent, this amounts to subprime borrowers being over 80 percent less likely

than super-prime borrowers to refinance.[19] In the descriptive statistics without controls, the relationship between credit score and refinancing is monotonically positive during this period: Nonprime borrowers were about one-third less likely than prime borrowers to refinance, and super-prime borrowers were twice as likely to refinance. However, after controlling for mortgage interest type and other loan characteristics, the amount of equity the borrower has in the home, the amount of other outstanding debts, and the amount he stands to save if he refinances, the key difference in refinancing is between super-prime borrowers and those with lower credit scores. We conducted several robustness checks, and these results hold across alternate model specifications.[20]

The models also confirm a priori expectations about barriers to refinancing. Collateral constraints are an important factor in explaining the borrower's propensity to refinance: Higher LTV ratios have a strong negative effect on the likelihood that a borrower refinances, regardless of product type or time period. Not surprisingly, loans with prepayment penalties and/or lower loan balances are less likely to be refinanced. The models also reveal that many borrowers may be abiding by the "rule of thumb" to refinance when interest rates fall more than 1.5 percent (Agarwal, Driscoll, and Laibson 2013); we observe higher average marginal effects for loans that have an interest rate of more than 1 percent over the contemporaneous prevailing rate.

We also find important interactions between the borrowers' other debts and their ability to refinance a home mortgage. Borrowers who were past due in the previous 12 months on any consumer credit accounts — including auto debt, credit card debt, student loan debt, or mortgage debt — are less likely to refinance than are those who have stayed current on all their accounts. We also find that the amount of debt matters: Borrowers with lower balances on their credit card (e.g., less than $10,000) are more likely to refinance than are those without a balance on their credit card. For these groups, having more debt might signal better unobserved credit conditions, since it means that other parties are extending credit to the borrowers. It may also be a sign of

[19] In the models displayed, we quantify these savings as the difference between the borrower's contemporaneous interest rate and the prevailing 30-year mortgage rate, controlling also for the size of the loan. In alternative specifications, we instead control for the likely change in the borrower's payments and find very similar results.

[20] Robustness checks include treating right-censored loans differently (coding transferred and vanished loans as a separate outcome, or omitting these loans from the analysis entirely), which we find still generates similar results. Results are also similar if we control for the expected change in monthly payments (in log dollars) instead of the change in interest rates, if we restrict the sample to loans in which the borrower would save at least $100 per month, or if we focus on high-balance loans (those with balances > $100,000). The results of robustness checks are available from the authors upon request.

higher consumption as driven by higher income or more stable employment. However, borrowers with more than $10,000 of outstanding credit card debt or more than $40,000 in student loan debt are less likely to refinance their mortgage.[21]

In Table 3, we present a similar series of models using the HMDA sample,[22] this time stratifying the sample by FICO bucket and including controls for the race/ethnicity of the borrower and whether there was a coborrower on the loan. These models reveal interesting patterns in refinance behavior. While collateral constraints and the drivers for refinancing (e.g., interest rate conditions) matter for all FICO groups, prime and super-prime borrowers appear to be more sensitive to the financial benefits and costs of refinancing: Prepayment penalties have a larger average marginal effect for prime and super-prime borrowers as do lower interest rates and higher loan amounts. Being "past due" on other credit accounts also has a larger dampening effect for super-prime borrowers.

However, we also find that the borrowers' race and ethnicity play a role in their propensity to refinance. Black subprime borrowers were 0.37 percentage point and Hispanic subprime borrowers 0.40 percentage point less likely to refinance each month than were non-Hispanic white borrowers. We observe this same effect for all the FICO groups. Among super-prime borrowers, the propensity to refinance is lower for black, Hispanic, and Asian subgroups (compared with non-Hispanic white borrowers). As we discuss in the conclusion, these persistent differences by race and ethnicity, even within FICO categories, deserve further research and policy attention.

Overall, these models present an interesting puzzle: Subprime borrowers who are interested in obtaining a refinance mortgage (as indicated by mortgage inquiries) and who should, in theory, benefit from refinancing (since they are paying off a higher-cost loan) but are less likely to do so, even after controlling for a wide range of factors. Overall, we find that the

[21] Most credit bureau data on credit/bank cards cannot distinguish between consumers carrying balances from one billing cycle to another or paying off the balance each cycle. One reason that having bank card debt of more than $10,000 may be a negative predictor of refinancing is that $10,000 is a large amount of money for most consumers to charge each month and pay off in full. Borrowers who have balances this high are probably more likely to be carrying over some of that debt from prior billing cycles.

[22] We also estimated this same stratified model on the full sample and find no significant differences in the direction or value of the coefficients for control variables. This analysis is available from the authors upon request. Note that the combined number of observations in Table 3 is 55 percent of the number of observations in the final column of Table 2, rather than 67 percent, as our match rate would suggest. We exclude some matched observations because race, ethnicity, and sex of borrowers are not reported in HMDA for all loans.

largest barrier for subprime borrowers is the tightened credit environment post-2009. Figure 4 shows this in stark relief: After 2009, the distribution of FICO scores for conventional refinance mortgages jumps significantly, with more than 50 percent of conventional refinance mortgages having credit scores of above 740 — analogous to our super-prime category. Although there is some variation over time, only a small share — approximately 5 percent — of refinance mortgages go to borrowers with credit scores under 640.

Returning to our sample of 2006 purchasers, only 27 percent of subprime-at-purchase borrowers who still had their purchase loan and had not defaulted on it had improved their FICO score to over 680 by January 2009, and only 9 percent had a FICO score of 740 or higher. Indeed, when we narrow our focus to subprime borrowers who improved their credit score into prime or super-prime buckets over time, we find that the gap in refinance rates narrows considerably. While it may not be surprising that subprime borrowers have a more difficult time refinancing, there are two important factors to keep in mind. First, had it not been for the extremely tightened credit environment, these borrowers likely would have been able to access a refinance mortgage. Second, this analysis points to the "stickiness" of a borrower's credit rating over time; while these borrowers demonstrated their ability and willingness to repay their mortgage, this information does not necessarily translate into a higher credit score over time.

HARP: Policy Tailored to Prime Borrowers

Our second question relates to the role of HARP in helping subprime borrowers refinance, given that it was the federal government's largest initiative to remove refinancing constraints, particularly those related to collateral constraints. HARP facilitated 3.4 million refinances between 2009 and the first quarter of 2016 (Federal Housing Finance Agency 2016): Borrowers who refinanced under HARP saw, on average, a 20 percent reduction in their monthly mortgage payments (Agarwal et al. 2015). Since subprime and nonprime borrowers were more likely than prime and super-prime borrowers to put less down at origination and to have higher mark-to-market LTV ratios (Table 1), HARP could have had a measurable impact on these borrowers' ability to refinance.

However, we find that a focus on subprime borrowers reveals the ways in which HARP's program design reinforced credit barriers to reinforcing, in effect replicating the "dual mortgage market" that institutionally separated subprime from prime mortgage markets (Apgar and Calder

2005). Figure 5 illustrates the barriers to HARP eligibility, divided by both FICO bucket and the borrowers' race/ethnicity. HARP was available only to borrowers whose loans were owned by Fannie Mae and Freddie Mac, which limited HARP's reach for subprime borrowers; borrowers with lower FICO scores were less likely to hold a mortgage in a government-sponsored enterprise (GSE) pool since a larger share of conventional subprime loans originated in 2006 were sold into private-label securities. As of March 2009 when HARP was initially announced, 20 percent of subprime borrowers in our sample held loans that were not backed by a GSE (instead usually having private-label securitized loans). These borrowers were immediately excluded from HARP.[23] In contrast, only 15 percent of super-prime borrowers in our sample had non-GSE mortgages. These differences are even starker for black and Hispanic subprime borrowers: 40 percent of subprime black and 42 percent of subprime Hispanic borrowers were ineligible for HARP solely because the program limited its reach to GSE loans.

The second HARP eligibility criterion that disproportionately affected subprime borrowers was a borrower's need to be current on his loan payments (missing no more than one payment in the prior 12 months and no payments in the past six months). While we limited our analysis to borrowers who had not defaulted (which we defined as fewer than 60 days' delinquent), subprime borrowers were more likely to miss one payment here and there over time, meaning that they were ineligible for HARP, even if they sustained regular payments of their mortgage over many years. When we impose the HARP requirement on being current on loan payments on our sample, we exclude an additional 9 percent of subprime borrowers from HARP eligibility. In comparison, only 4 percent of nonprime borrowers, 2 percent of prime borrowers, and 1 percent of super-prime borrowers would be disqualified because of occasional missed payments.

Finally, HARP included equity threshold restrictions that changed over time. In the initial version of HARP, active from March to June 2009, borrowers' CLTV ratios had to be above 80 percent but below 105 percent. Beginning in July 2009, the upper bound was relaxed to 125 percent; starting in late October 2011, borrowers simply needed to have CLTV ratios greater than 80 percent. Applying HARP's initial narrow range of acceptable CLTV ratios excluded an additional 19 percent of subprime borrowers in our sample from eligibility, similar to the 18–19

[23] In this discussion, we focus on conforming-loan borrowers who had combined LTV ratios greater than 80 percent, since this was the minimum LTV ratio requirement for HARP loans.

percent of nonprime, prime, and super-prime borrowers who were too deeply underwater to participate. After the CLTV restriction was loosened to 125 percent, about 12 percent more borrowers in each FICO group became eligible.

However, by the time the upper CLTV threshold was eliminated in October 2011, 30 percent of the active conforming subprime loans were not owned by the GSEs, and, therefore, the subprime borrowers were ineligible (as opposed to 23 percent of the prime borrowers). This analysis suggests that, while relaxing the maximum acceptable CLTV ratio to accommodate borrowers who were more deeply underwater helped more prime and subprime borrowers qualify for HARP, by the time the maximum CLTV threshold was removed, a large share of conforming-loan borrowers, particularly subprime borrowers, were ineligible because their loans were not owned by Fannie Mae or Freddie Mac. In addition, news stories have highlighted that borrowers have been thwarted in their efforts to refinance under HARP by bank overlays or other restrictions, even when, in theory, they meet the eligibility requirements under HARP (Bernard 2012; Green 2012).

Does Refinancing Benefit Subprime Borrowers?

In the previous sections, we have shown that subprime borrowers are less likely to be able to refinance their mortgages, even after controlling for a variety of borrower and loan characteristics. But an equally important question is whether they benefit from refinancing and are able to convert their higher-cost loans into loans that carry lower interest rates. Because we are able to observe the terms of the refinance mortgage, we also can see whether refinancing contributes to welfare gains in the form of lower interest rates and/or lower monthly payments, or whether subprime borrowers refinance into another higher-cost product.

In Figure 6, we present the average monthly payment change for borrowers who undertook a rate refinance on their FRM as stratified by the credit score at origination.[24] We present results at the 25th, 50th, and 75th percentiles. We find that most borrowers who refinance see material benefits from taking on a new mortgage, on average reducing their monthly payments by at least 10 percent. This finding points to the benefits of refinancing from a public policy perspective: Homeowners in our sample who refinanced between 2007 and 2009 saved an

[24] We exclude borrowers who refinanced into a 15-year loan term.

average of $1,290 in interest payments each year, whereas those who refinanced between 2010 and 2013 saved an average of $4,050. These large savings can be diverted to other household needs or to long-term asset building.

However, we also find important differences in the benefits of refinancing between subprime and prime borrowers. First, borrowers who refinanced early in the life of the loan (2007–2009) saw, on average, smaller declines in their monthly payments than did those who refinanced between 2010 and 2013. This was driven by changes in interest rates that could not have been foreseen by the borrowers who chose to refinance earlier after purchase. Second, on average, higher FICO borrowers see relatively larger reductions in their monthly payments, particularly during the 2007–2009 period. However, the differences were not as large as we anticipated a priori: For borrowers who refinanced at the 50th percentile during the 2010–2013 period, the benefits of refinancing were distributed relatively evenly across FICO groups.

We also find some evidence that even subprime borrowers who never defaulted still pay a "subprime tax" because they are still more likely than prime borrowers to pay a higher interest rate after refinancing. However, the differences are small — on the order of 10 basis points. This suggests that risk-based pricing can be welfare enhancing and may be a more equitable form of credit allocation than creating a hard line between the decision to accept or deny a loan. Subprime borrowers who are able to refinance receive material benefits because their interest rates decrease closer to prime levels. Yet, regulators should carefully monitor potential abuses in risk-based pricing practices since other studies have showed racial inequalities in the pricing of mortgage loans above and beyond a borrower's credit profile (Courchane 2007; Ding et al. 2011; Bocian, Ernst, and Li 2008b).

4. Conclusion and Discussion

In this paper, we focus on the refinance experiences of subprime borrowers to better understand whether they are able to transition into a prime mortgage or whether they remain stuck in subprime. While risk-based pricing has potential benefits in terms of broadening access to credit for borrowers with lower credit scores, the presence of information asymmetries at origination (as well as the potential for discrimination or predatory lending practices) have led to concerns that many subprime borrowers present prime market risks (Carr and Schuetz 2001). Refinancing offers an opportunity to recalibrate those risks. As argued by An and Bostic (2009),

moving subprime households into lower-cost mortgages can reduce their vulnerability to default and increase the potential asset-building benefits of homeownership.

However, we find that, in the wake of the financial crisis, subprime borrowers faced numerous constraints that limited their ability to refinance and take advantage of historically low interest rates post-2009. We focus on a specific population: subprime borrowers who bought at the height of the subprime lending boom and who did not become seriously delinquent on their mortgage. On average, these borrowers were paying interest rates of 6.5 percent to 6.8 percent on their mortgage at a time when the average interest rate for a 30-year FRM fluctuated between 3.6 percent and 4.7 percent. Yet, a greater share of these borrowers failed to refinance compared with borrowers who held prime or super-prime credit scores. The reasons for these lower refinance rates are complex, but they suggest possible avenues for public policy intervention.

The first relates to the potential for financial education to increase borrower knowledge of the risks and benefits of refinancing. We find that in comparison with prime and super-prime borrowers, subprime borrowers were more likely to borrow using cash-out refinance loans – 70 percent of subprime borrowers who refinanced in 2007–2009 chose cash-out mortgages versus 43 percent of super-prime borrowers. Cash-out refinances have been linked to higher rates of default (Goodman 2017). By increasing their indebtedness just as house prices were falling, the borrowers then locked themselves out of rate refinances when interest rates fell.

Although house price and interest rate trajectories were not possible for these borrowers to anticipate when they borrowed with cash-out refinances, perhaps borrower education could have helped them better understand their precarious position, should credit conditions tighten — as we observed occurring in 2009. In addition, to the extent that equity withdrawals were being used to pay down other debts, credit counseling and/or consumer disclosures at the time of the refinance decision might also help borrowers identify alternative payment options and evaluate the relative costs and benefits of cash-out refinancing (Collins 2014). Research into the effects of post-purchase counseling and/or at the time of refinance could also help to identify whether financial education or improved information could improve welfare outcomes. The continued, unexplained lower rates of refinancing among black and Hispanic borrowers, even among those with higher FICO scores, also suggest the need for more research that can tease out whether these are linked to lower levels of financial knowledge, distrust of financial institutions, or lack of access to banks or mortgage lenders in their communities.

The second policy area relates to the negative impacts of a tightened credit market and a return to lending only to the highest credit groups. Not only does this limit who has access to homeownership, but we show that it also limits the ability of subprime borrowers to refinance into a lower-cost product, despite remaining current on their mortgage and demonstrating both a willingness and ability to repay their mortgage debt. The tightened credit environment has significant negative welfare effects for these borrowers: Not only have they missed out being able to access historically low interest rates, but other research has suggested that the impact of credit score thresholds on access to credit persists up to four years later (Laufer and Paciorek 2016).

While few would advocate a return to the underwriting standards prevalent during the subprime boom, failing to address the consequences of the extremely tightened mortgage market will only exacerbate wealth inequalities, especially for black and Hispanic borrowers who were more likely to receive a higher-priced mortgage. The potential magnitude of refinancing on the wealth gap is large. Homeowners in our sample who refinanced between 2007 and 2009 saved an average of $1,290 in interest payments each year, whereas those who refinanced between 2010 and 2013 saved an average of $4,050. Over the course of 10 years, this could result in a $40,000 equity gap for those who were unable to refinance.

Rather than removing the barriers to refinancing, we also find that the federal HARP initiative failed to reach subprime borrowers. A significant share of subprime borrowers was ineligible for HARP, in large part because many subprime loans were held in private-label securities as opposed to securitized by the GSEs. In effect, HARP amplified the negative effects of the dual mortgage market on subprime borrowers by reinforcing institutional differences as to who could be reached through public policies. In addition, while HARP did not set a minimum credit score and removed caps on LTV ratios in the later years of the program, many lenders continued to impose their own restrictive credit score, appraisal, or maximum LTV thresholds, limiting HARP's impact, even for subprime borrowers who were eligible. While HARP is set to end in fall 2017, both Fannie Mae and Freddie Mac have announced streamlining refinance programs to reach borrowers who remain underwater on their mortgage (Lerner 2017). As our research shows, the focus on loans held by the GSEs is likely to continue being at a disadvantage for subprime borrowers who have not yet refinanced on their mortgage.

Third, our research points to the need to better understand the welfare effects of risk-based pricing, and, for policymakers who are working on housing finance reform, to specifically consider the best ways to overcome refinance barriers for subprime borrowers, in addition to ensuring access to purchase mortgages for underserved populations. The importance of subprime lending is only going to grow over time because a majority of new households going forward are expected to be Hispanic or nonwhite — groups that have lower credit scores, less wealth, and lower incomes than their non-Hispanic white counterparts. On the positive side, we show that subprime borrowers who are able to refinance see significant reductions in their interest rates and monthly payments. While there is some evidence that they continue to pay a "subprime tax" — benefiting the less-than-prime borrowers who also refinance — this tax is small, suggesting that risk-based pricing can be welfare enhancing when the borrower is given an opportunity to refinance his mortgage into a prime product after a couple of years.

However, we show that lower rates of refinancing could hurt subprime borrowers over the long term. Parsing out policy options is not easy; there needs to be a careful balancing of benefits, risks, and the effects on mortgage pricing when expanding the credit box and/or making it easier for subprime borrowers to refinance into a lower-cost product over time. One option would be to develop a streamlined refinance product for the conventional market.[25] However, this option would require careful estimation of increased default risk because refinancing may mask any underlying borrower distress (Caplin, Cororaton, and Tracy 2015).

Another proposed solution is to develop a FRM product that automatically adjusts downward when rates decline (Campbell 2013; Keys, Pope, and Pope 2014). Although this approach would increase the overall costs of mortgage lending, as Keys, Pope, and Pope (2016) point out, it could have potential equity benefits. In the current system, higher wealth and creditworthy homeowners who use their refinance option when rates decline are subsidized by those households who fail to do so. Additional research could shed light on the welfare costs and benefits of this type of product. ARMs could also provide an avenue for households to benefit from lower interest rates without having to take the step of refinancing, but these products need to be weighed against the risk of ARMs, particularly for less financially sophisticated borrowers

[25] In addition to the new streamline programs at Fannie Mae and Freddie Mac, the Federal Housing Administration (FHA) offers a streamlined refinance, which essentially modifies an existing FHA loan into a lower interest rate and extended loan term without the need for a new credit check or income verification.

(Agarwal et al. 2015). Our findings also suggest that the GSEs have a significant role to play in reaching out to subprime borrowers and other underserved populations to attenuate the costs of a dual mortgage market system. Increasing the competition for subprime (and other nonprime) borrowers from prime mortgage market participants, such as the GSEs, is likely to lead to more equitable outcomes overall (An and Bostic 2009; Courchane, Surette, and Zorn 2004a).

Finally, our research points to the value of research that parses out the experiences of subprime and other underserved populations. As others (Fuster and Willen 2010; Agarwal, Ben-David, and Yao 2014) have also shown, borrowers with lower credit scores do not respond in the same way to policy shifts as do borrowers with higher credit profiles, and the reasons for this still pose empirical questions. A better understanding of the constraints and risks facing subprime borrowers — and how those vary by income, race/ethnicity, or other characteristics — could improve the effectiveness of mortgage market interventions and lead to better outcomes for borrowers who have historically been underserved by conventional lenders.

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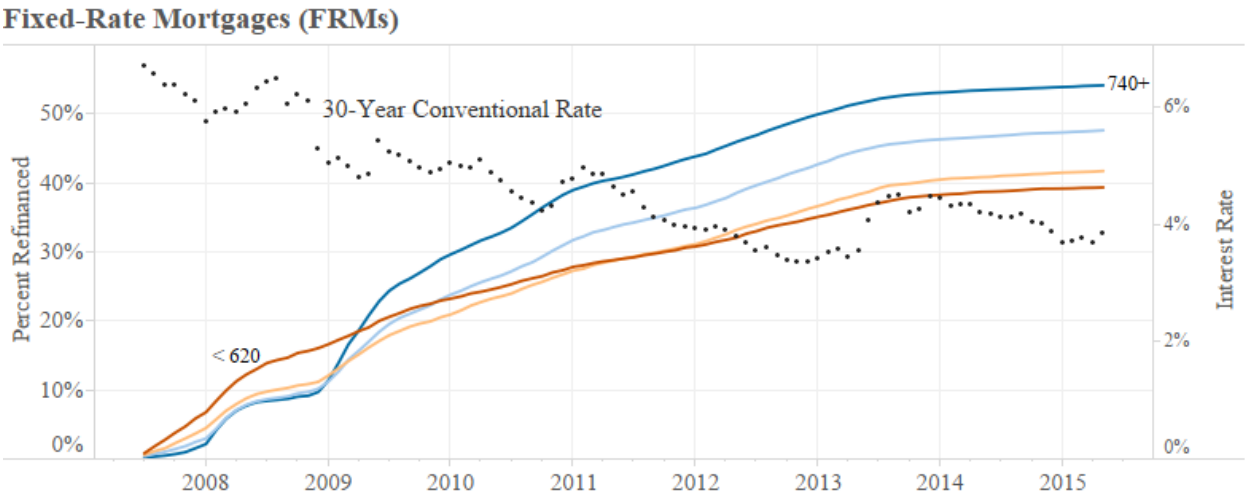
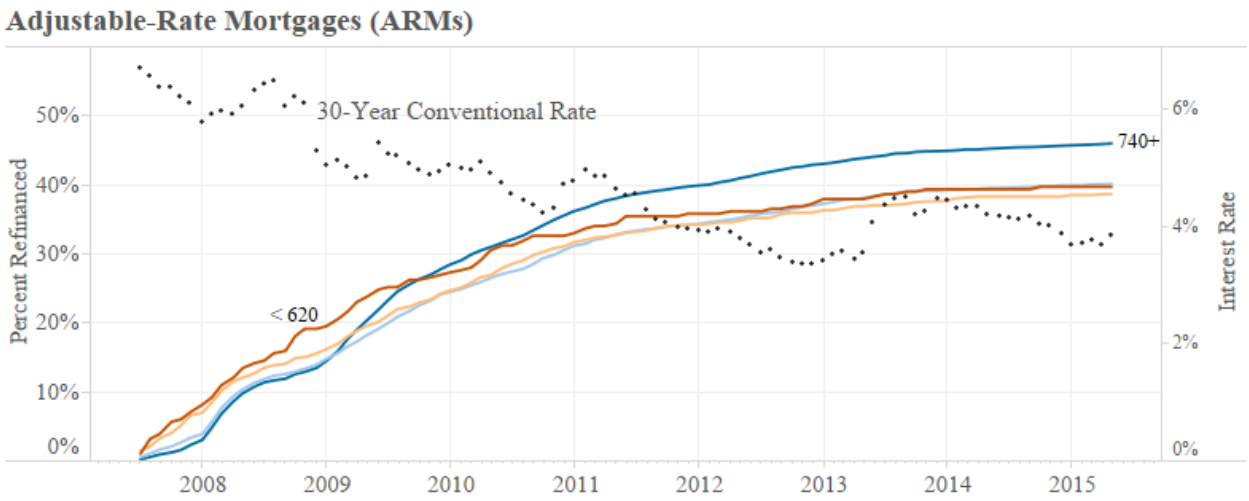
Figures and Tables

Figure 1. Cumulative Refinance Rates by Product Type and Borrower's FICO Score at the Origination of Purchase Mortgage





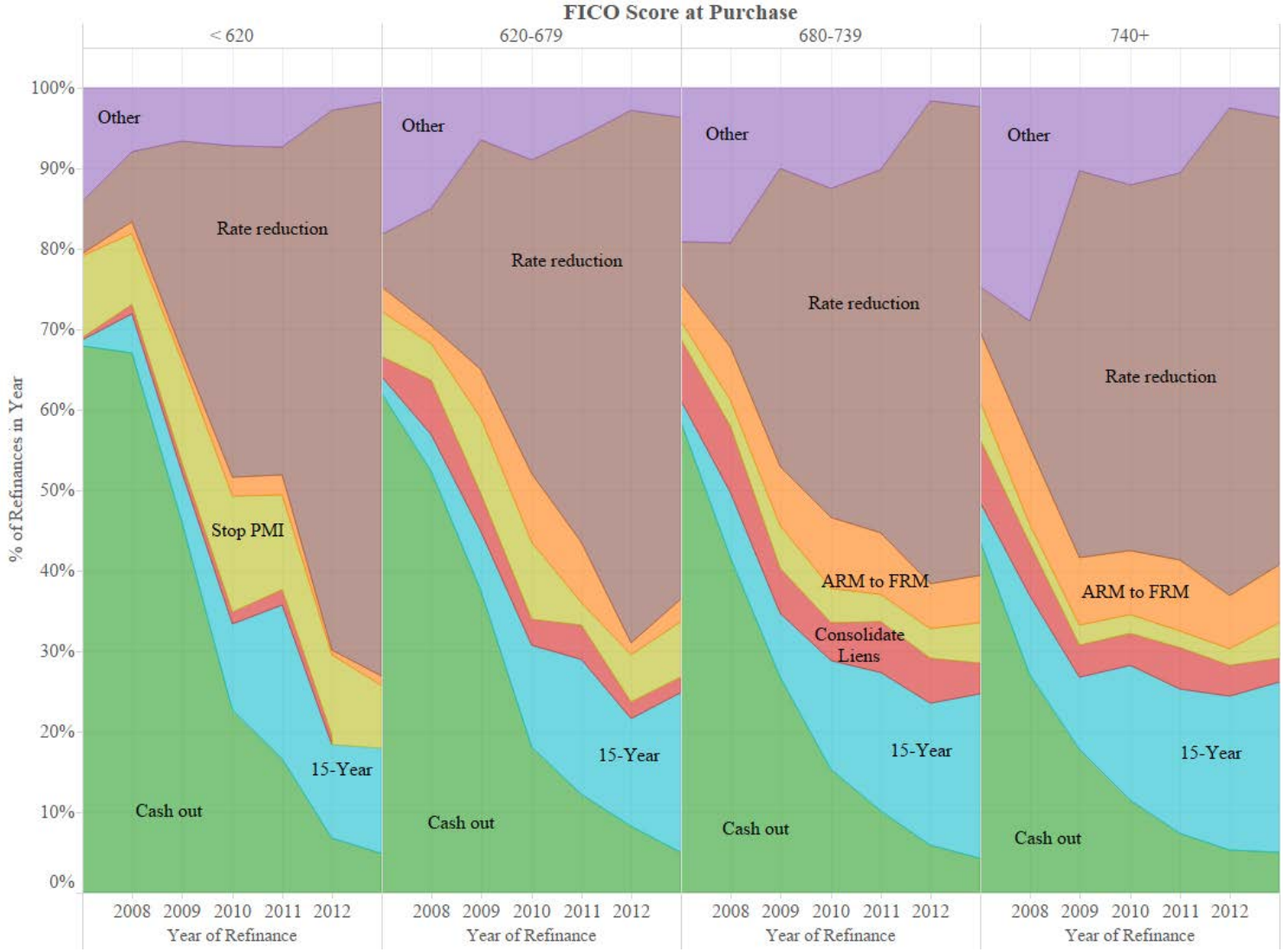
Cumulative Refinance Rates as of May 2015

	FICO at Purchase			
	< 620	**620-679**	**680-739**	**740+**
FRMs	39.3%	41.7%	47.6%	54.1%
ARMs	39.7%	38.6%	40.1%	46.0%

FICO at Purchase
- < 620, ARMs
- 620-679, ARMs
- 680-739, ARMs
- 740+, ARMs

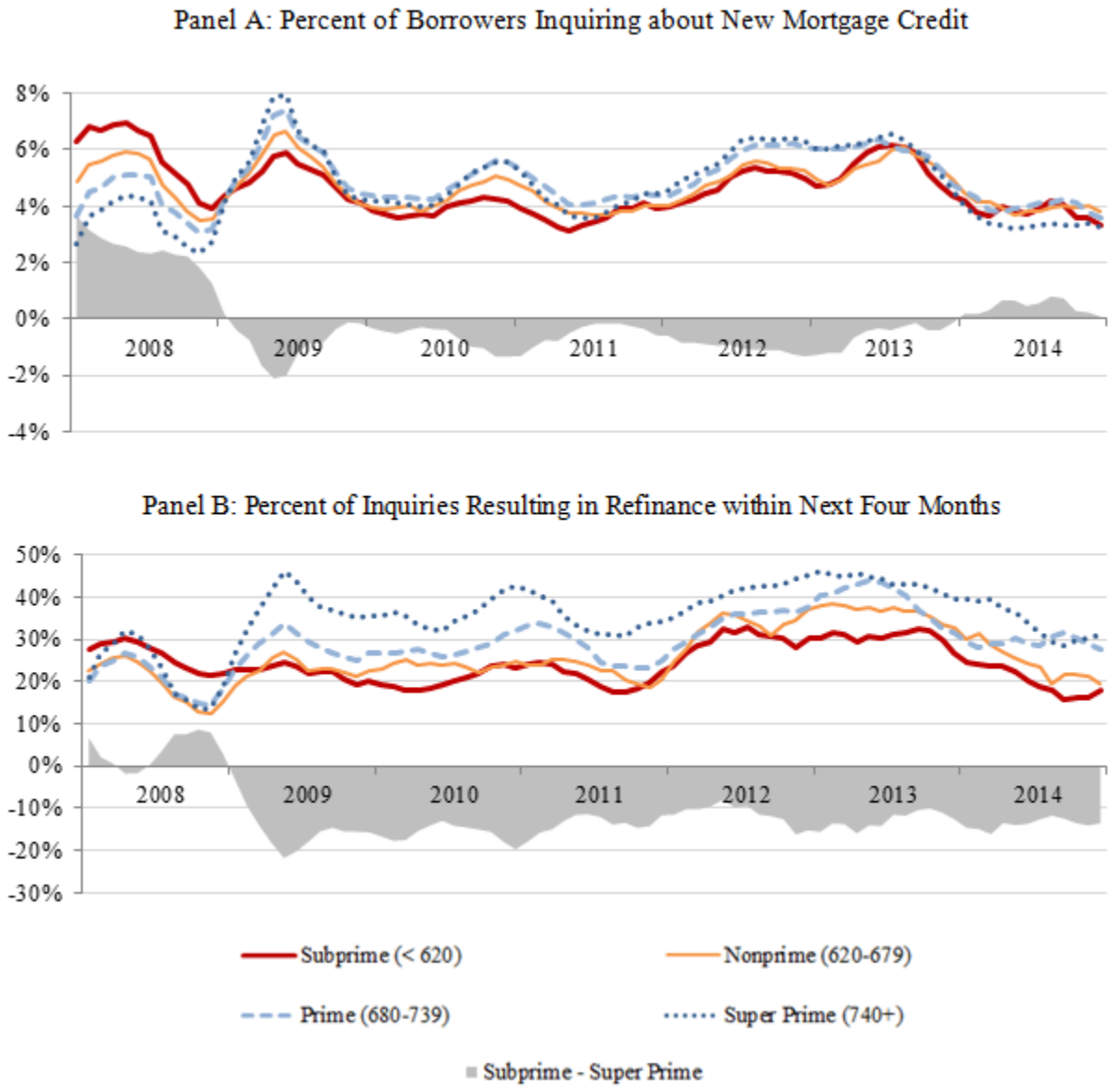
Source: Authors' calculations of McDash Analytics and Equifax Credit Risk Insight™ Servicing data, 2006 originations

Figure 2. Changes in Motives for Refinancing



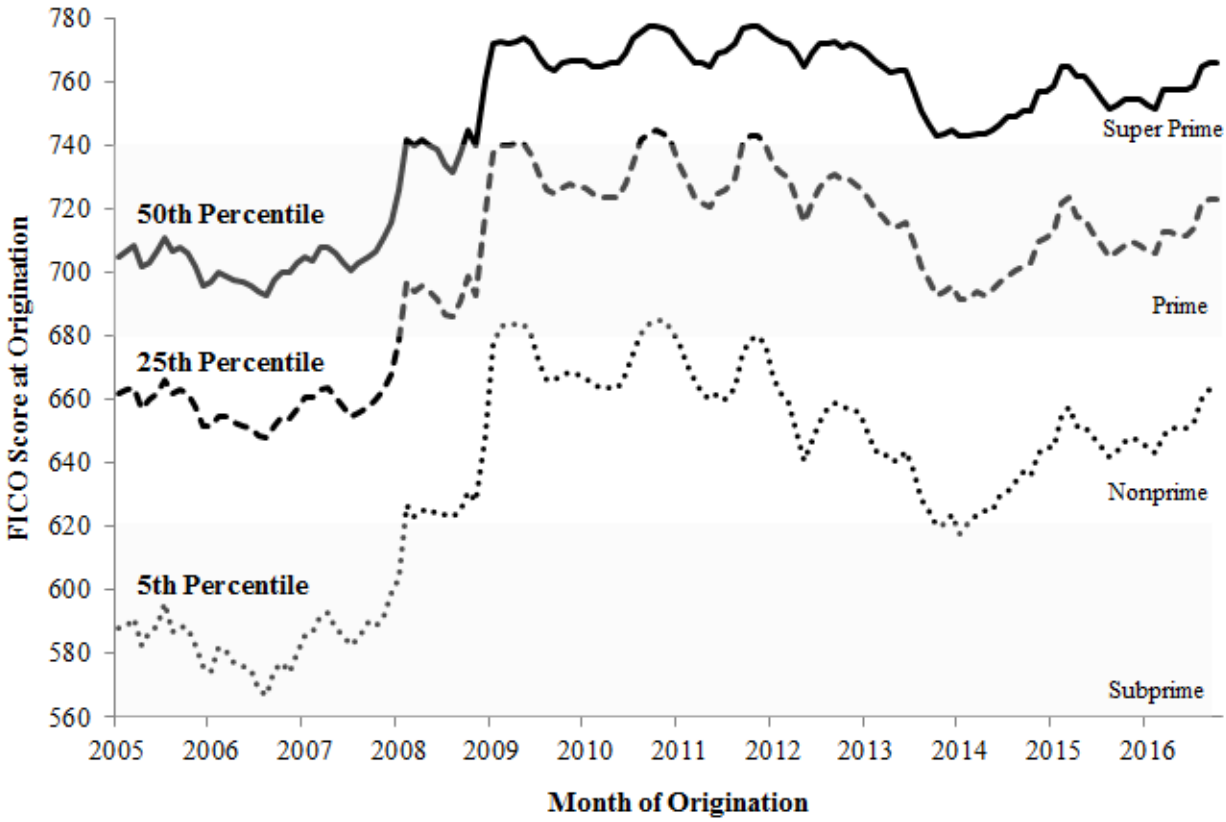
Source: Authors' calculations of McDash Analytics and Equifax Credit Risk Insight™ Servicing data. Sample includes borrowers who purchased using 30-year, fixed-rate or adjustable-rate mortgages in 2006 and refinanced a loan that was also included in the McDash dataset and matched by Equifax to the borrower.

Figure 3. Fixed-Rate Mortgage Borrowers' Inquiries and Refinances, by Month and FICO Score at Purchase Mortgage Origination



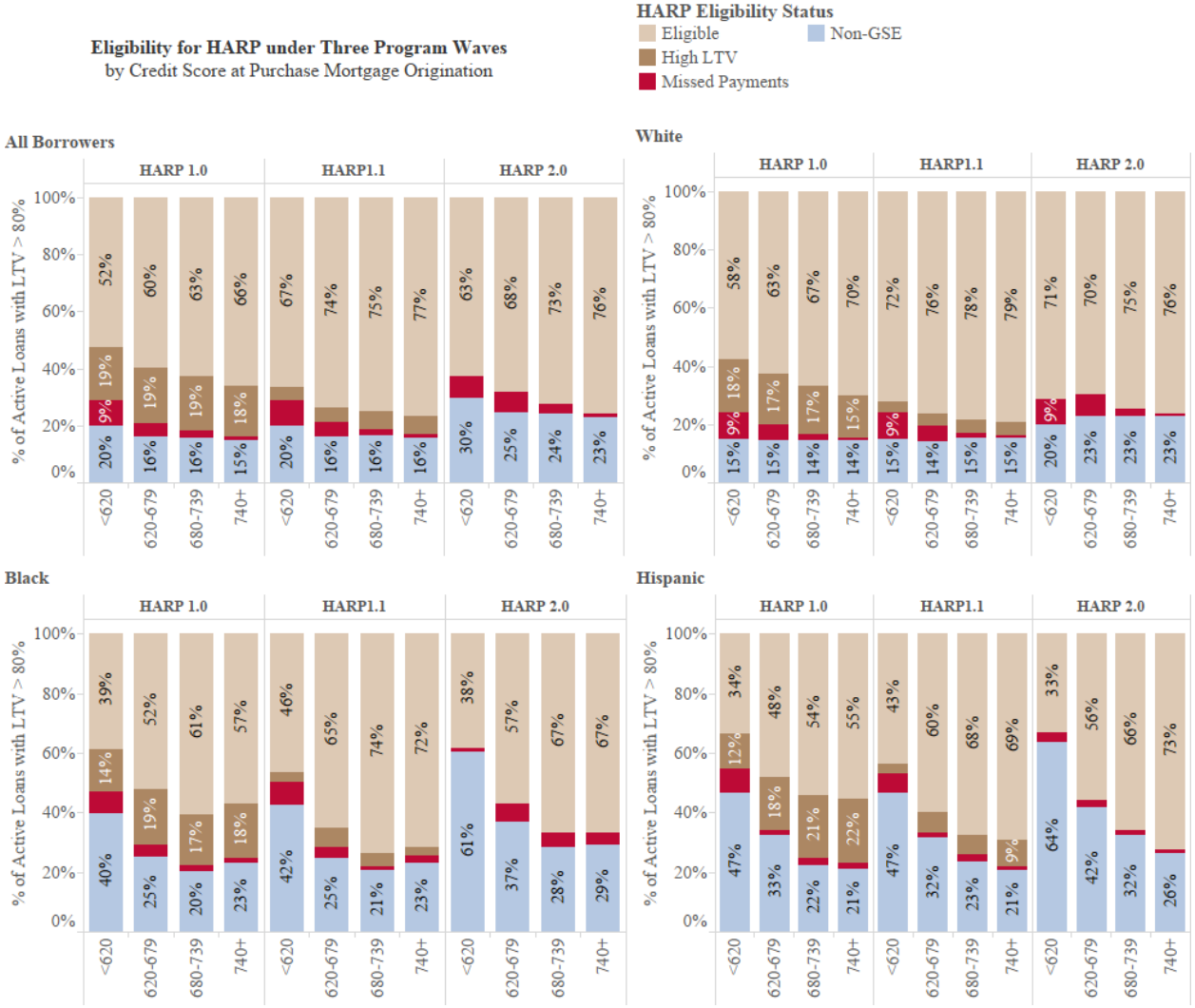
Source: Authors' calculations of McDash Analytics and Equifax Credit Risk Insight™ Servicing data. Sample includes borrowers who purchased using 30-year, fixed-rate mortgages in 2006.

Figure 4. Distribution of FICO Scores for Conventional Refinance Mortgages by Origination Month



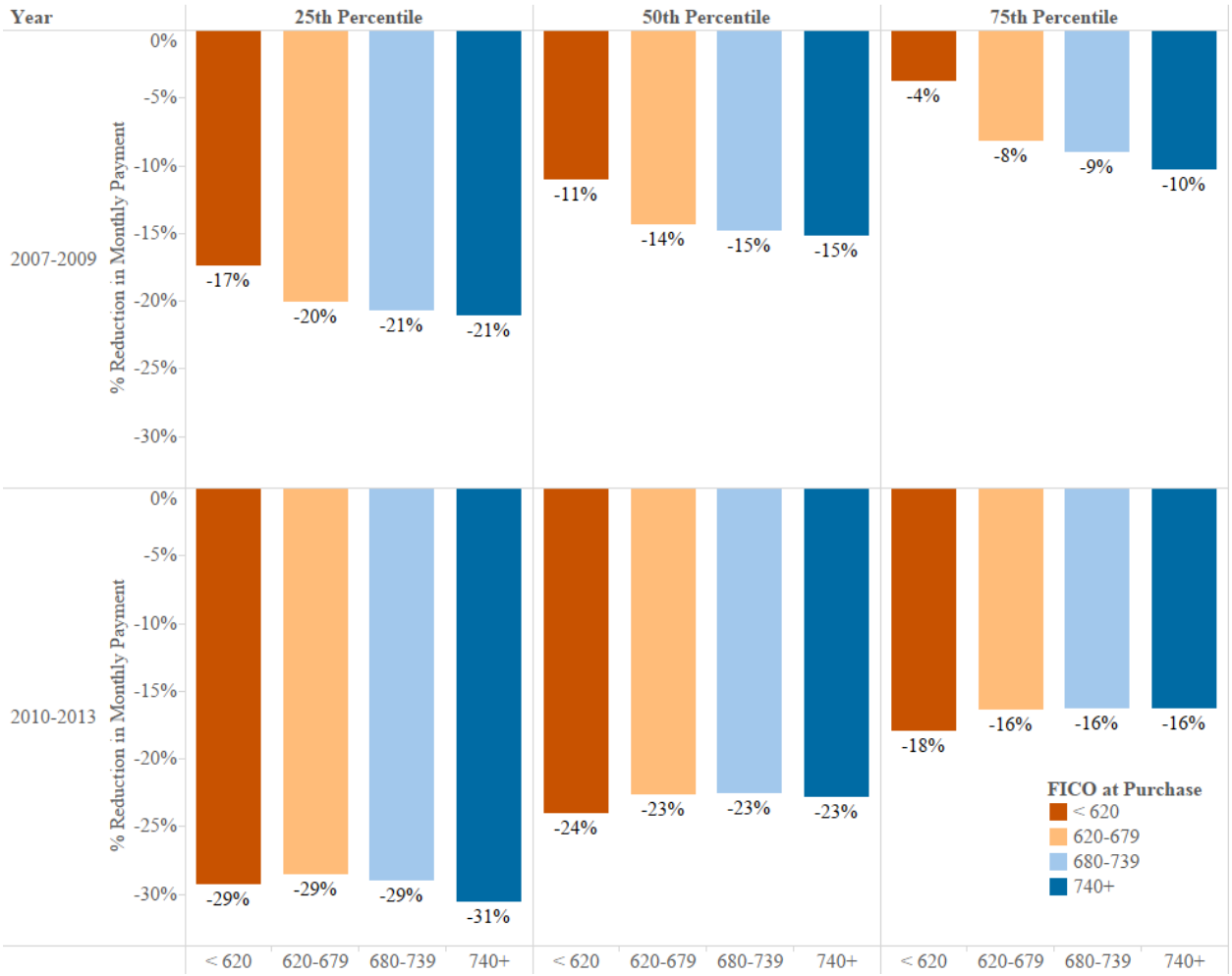
Note: Tick mark indicates January of each calendar year.
Source: Authors' calculations of McDash Analytics data.

Figure 5. HARP Eligibility by Borrower's FICO Score at Purchase Mortgage Origination and Race/Ethnicity



Source: Authors' calculations of McDash Analytics, Equifax Credit Risk Insight™ Servicing, and CoreLogic data, 2006 originations, matched to Home Mortgage Disclosure Act Data. Sample is restricted to conforming, conventional loan borrowers with combined loan-to-value ratios of over 80 percent, the minimum LTV threshold for HARP. For these loans, ineligibility is coded in a waterfall fashion, starting with "non-GSE," then "missed payments," and finally "LTV too high." In other words, some non-GSE loans were also ineligible because the borrowers had missed payments or their combined LTVs were too high, although they are coded here as ineligible because their loans were not owned by Fannie Mae or Freddie Mac.

Figure 6. Typical Monthly Payment Changes for Fixed-Rate Mortgage Borrowers Who Refinance, by Time Period of Refinance and Borrower's FICO Score at Purchase Mortgage Origination



Source: Authors' calculations of McDash Analytics and Equifax Credit Risk Insight™ Servicing data. Sample includes borrowers who purchased using 30-year, fixed-rate mortgages in 2006 and refinanced into another 30-year mortgage in 2007–2009 or 2010–2013, without withdrawing any cash or by otherwise increasing the size of the mortgage by more than $5,000. To be included in this sample, the new loan was also included in the McDash dataset and matched by Equifax to the borrower.

Table 1. Borrower and Loan Characteristics by FICO Score at Origination

	Subprime < 620	Nonprime 620-679	Prime 680-739	Super-Prime 740+	Total
Origination amount (in thousands)					
Median	$135	$157	$179	$197	$178
Mean	$156	$190	$222	$243	$221
Standard deviation	$88	$122	$149	$164	$151
Adjustable-rate mortgages (ARMs)	4%	11%	16%	17%	15%
Initial reset:					
5 years after origination	3%	8%	10%	9%	9%
7 years after origination	1%	2%	3%	4%	3%
10 years after origination	0%	2%	3%	4%	3%
Median interest rate at origination	6.8%	6.6%	6.5%	6.4%	6.5%
Fixed-rate mortgages	96%	89%	84%	83%	85%
Median interest rate at origination	6.5%	6.5%	6.3%	6.2%	6.3%
Mortgage characteristics					
Interest-only	1%	7%	10%	8%	8%
Option ARM	1%	1%	2%	2%	2%
Prepayment penalty	6%	5%	3%	2%	3%
Private mortgage insurance	45%	32%	17%	9%	18%
Piggyback mortgage at origination	8%	28%	42%	35%	33%
Second-lien mortgage at any time	17%	38%	52%	45%	43%
Combined loan-to-value ratio at origination					
< 65%	11%	10%	11%	20%	15%
65%–80%	28%	30%	35%	41%	37%
80.1%–95%	32%	32%	31%	26%	29%
95.1%–98%	11%	9%	6%	3%	6%
98.1%–100%	18%	18%	15%	8%	12%
> 100%	2%	1%	2%	2%	2%
Share with > 5% down	30%	28%	23%	13%	19%
Share with > 20% down	38%	39%	46%	62%	52%
Mark-to-market CLTV (at termination or last observation)					
CLTV < 90%	60%	66%	75%	81%	75%
CLTV 90%–105%	28%	22%	16%	13%	16%
CLTV > 105%	12%	12%	9%	7%	8%
Zip code minority share (median)	18%	17%	17%	16%	17%
Zip median home value (in thousands)	$170	$204	$234	$257	$234

Continued on next page

	Subprime < 620	Nonprime 620-679	Prime 680-739	Super-Prime 740+	Total
Nonnmortgage debt					
Auto debt					
< $5,000	51%	49%	54%	62%	57%
$5,000–$20,000	29%	30%	28%	24%	27%
> $20,000	20%	20%	18%	13%	16%
Credit card balance					
< $500	31%	23%	21%	25%	24%
$500–$1,999	18%	15%	16%	22%	19%
$2,000–$10,000	35%	36%	33%	35%	35%
> $10,000	16%	26%	30%	19%	23%
Student loan debt					
< $10,000	85%	83%	84%	89%	87%
$10,001–$40,000	10%	11%	10%	7%	9%
> $40,000	5%	6%	5%	4%	5%
Other debt					
< $500	65%	67%	76%	84%	77%
$500–$2,000	10%	10%	7%	5%	7%
> $2,000	25%	23%	17%	11%	16%
Past due on nonmortgage debt	23%	13%	7%	3%	8%
Percent of sample	10%	12%	29%	49%	100%
Number of loans/borrowers in sample	6,483	7,457	17,902	30,148	61,990
Percent of sample matched to HMDA	65%	62%	65%	68%	66%
Number of loans matched to HMDA	4,229	4,615	11,574	20,517	40,935
Number of loans matched and in sample	3,735	4,098	10,253	18,166	36,252
Race of borrower					
White	74%	79%	82%	87%	83%
Black	13%	7%	4%	2%	4%
Hispanic	11%	10%	7%	5%	7%
Asian	2%	4%	6%	6%	6%
Number of borrowers					
Two borrowers	43%	46%	49%	50%	48%
Single male	31%	30%	30%	27%	29%
Single female	27%	24%	22%	23%	23%

Note: Origination amount and monthly payment are winsorized at the 1st and 99th percentiles. Monthly payment includes principal and interest only; mortgage insurance and escrow components are not included. Zip code median home value is captured at origination, and the source is Zillow. The zip code minority share is from the 2000 Census. **Source:** Authors' calculations of McDash Analytics, Equifax Credit Risk Insight™ Servicing, CoreLogic, and Home Mortgage Disclosure Act data.

Table 2. Likelihood of Refinancing by Interest Rate Type and Period

	(1) All Loans		(2) Fixed Rate		(3) 5/1 Adjustable Rate		(4) All Loans, Jan. 2009+	
	ME	Z	ME	Z	ME	Z	ME	Z
Credit bucket at purchase								
Subprime	0.0023***	4.57	0.0027***	4.89	0.0019	0.89	-0.0086***	-15.63
Subprime * months elapsed	-0.0001***	-10.51	-0.0001***	-10.44	-0.0001*	-2.13	0.0001***	6.45
Nonprime	-0.0016***	-4.26	-0.0019***	-4.72	0.0023~	1.74	-0.0076***	-14.35
Nonprime * months elapsed	-0.0000**	-3.19	-0.0000*	-2.25	-0.0001**	-2.87	0.0001***	6.31
Prime	-0.0018***	-6.48	-0.0021***	-7.09	-0.0007	-0.99	-0.0056***	-11.97
Prime * months elapsed	0	-0.28	< 0.0001	0.54	< 0.0001	0.46	0.0001***	6.51
Equity and prepayment penalties								
CLTV 90%–105% †	-0.0036***	-23.94	-0.0035***	-21.64	-0.0027***	-6.24	-0.0044***	-20.71
CLTV > 105% †	-0.0067***	-41.61	-0.0066***	-36.11	-0.0064***	-15.42	-0.0080***	-34.8
Second lien †	0.0007***	4.53	0.0005**	3.25	0.0009*	2.11	0.0004~	1.93
Prepayment penalty	-0.0036***	-6.9	-0.0023**	-3.25	-0.0041***	-5.37	-0.0065***	-7.73
Interest spread (loan rate minus prevailing rate)								
0.1%–1%	0.0065***	43.85	0.0067***	40.61	0.0055***	10.36	0.0087***	28.47
1%–2%	0.0130***	60.35	0.0130***	56.2	0.0080***	9.89	0.0131***	52.69
2%–3%	0.0142***	44.21	0.0135***	39.87	0.0073***	5.01	0.0144***	47.92
>3%	0.0137***	25.74	0.0125***	23.95	0.0107**	3.06	0.0134***	26.15
Origination amount								
$100,000–$199,999	0.0047***	32.47	0.0049***	31.39	0.0029***	4.42	0.0065***	32.88
$200,000–$299,999	0.0099***	44.11	0.0104***	41.63	0.0052***	7.16	0.0136***	42.12
$300,000+	0.0122***	43.63	0.0127***	39.23	0.0057***	7.76	0.0172***	41.78
Contemporaneous credit characteristics†								
Past due on any accounts	-0.0065***	-33.56	-0.0066***	-31.27	-0.0053***	-9.43	-0.0102***	-41.62
Auto debt								
$5,000 – $19,999	0.0001	0.9	0.0002	1.36	-0.0005	-1.09	0.0002	0.7
$20,000+	-0.0001	-0.34	-0.0001	-0.24	0.0010~	1.74	-0.0004	-1.41
Credit card debt								
$500–$1,999	0.0013***	6.37	0.0012***	5.35	0.0020**	3.08	0.0021***	7.07
$2,000–$9,999	0.0015***	8.13	0.0014***	7.03	0.0014**	2.74	0.0020***	7.81
$10,000+	-0.0009***	-4.9	-0.0010***	-4.78	-0.0007	-1.33	-0.0016***	-5.87
Student loan debt								
$10,000–$39,999	-0.0006*	-2.57	-0.0006*	-2.28	-0.0004	-0.65	-0.0002	-0.58
$40,000+	-0.0020***	-6.93	-0.0014***	-3.96	-0.0026***	-3.96	-0.0019***	-4.34
Other mortgage debt								
$500–$1,999	-0.0002	-0.62	-0.0002	-0.56	0.0002	0.18	-0.0008*	-1.99
$2,000+	-0.0003~	-1.77	-0.0002	-1.13	-0.0012*	-2.12	-0.0012***	-4.09
Interest type (omitted = FRM)								
ARM 5/1, 7/1, 10/1	0.0073***	19.09					0.0073***	13.59
Interest-only	-0.0084***	-50.68	-0.0045***	-14.07	-0.0090***	-17.62	-0.0118***	-53.14
Observations (loan—month)	2,567,729		2,181,367		231,299		1,570,048	
Pseudo R^2	0.047		0.045		0.062		0.045	

Notes: Average marginal effects are reported, with z-statistics in parentheses. ~ p<.10, * p<.05, ** p<.01,*** p<.001. Each model includes state fixed effects and calendar-quarter dummies. **Source:** Authors' calculations of McDash Analytics, Equifax Credit Risk Insight™ Servicing, and CoreLogic data. † indicates variables with a two-month lag, to help capture the state of the borrower's credit report at the time he/she applied for the refinance mortgage. Models 1–3 use observations from July 2007 to May 2015. Model 4 uses observations from January 2009 to May 2015.

Table 3. Likelihood of Refinancing by FICO Score at Purchase Mortgage Origination

	Subprime (< 620)		Nonprime (620–679)		Prime (680–739)		Super-Prime (740+)	
	ME	Z	ME	Z	ME	Z	ME	Z
Equity and prepayment penalties								
CLTV 90%–105% †	-0.0019**	-2.64	-0.0030***	-4.09	-0.0034***	-6.06	-0.0066***	-12.68
CLTV > 105% †	-0.0046***	-5.84	-0.0065***	-8.11	-0.0063***	-9.82	-0.0114***	-19.93
Second lien †	0.0003	0.32	0.0027***	3.39	0.0021***	4.06	0.0011*	2.28
Prepayment penalty	-0.0011	-0.52	-0.0041~	-1.68	-0.0078***	-3.6	-0.0106***	-4.27
Interest spread (loan rate minus prevailing rate)								
0.1%–1%	0.0036***	3.73	0.0069***	6.34	0.0096***	11.66	0.0127***	19.77
1%–2%	0.0071***	9.63	0.0107***	13.41	0.0137***	21.67	0.0203***	36.91
2%–3%	0.0121***	13.34	0.0140***	14.66	0.0155***	20.94	0.0210***	27.53
> 3%	0.0145***	9.96	0.0131***	8.58	0.0157***	11.54	0.0212***	13.3
Origination amount								
$100,000–$199,999	0.0060***	9.17	0.0066***	9.36	0.0070***	13.04	0.0078***	15.54
$200,000–$299,999	0.0126***	8.7	0.0108***	9.19	0.0130***	15.69	0.0173***	22.83
$300,000+	0.0111***	5.55	0.0133***	8.14	0.0137***	14.27	0.0203***	22.78
Contemporaneous credit characteristics †								
Past due on any accounts	-0.0060***	-9.23	-0.0075***	-10.03	-0.0096***	-13.78	-0.0155***	-20.55
Auto debt								
$5,000–$19,999	0.0017*	2.21	-0.0005	-0.69	-0.0001	-0.15	-0.0002	-0.32
$20,000+	0.0014	1.61	0.001	1.09	-0.0008	-1.18	-0.0016*	-2.41
Credit card debt								
$500–$1,999	0.001	0.94	0.0008	0.73	0.0015~	1.82	0.0035***	5.26
$2,000–$9,999	< 0.0001	0.04	0.0003	0.34	0.0021**	2.96	0.0035***	5.77
$10,000+	-0.0002	-0.21	-0.0001	-0.06	-0.0027***	-3.98	-0.0018**	-2.72
Student loan debt								
$10,000–$39,999	0.0022~	1.89	0.0006	0.52	0	-0.01	-0.0027**	-3.12
$40,000+	0.0009	0.6	-0.0031*	-2.37	-0.0018~	-1.78	-0.0037***	-3.36
Other mortgage debt								
$500–$1,999	0.0017	1.37	0.0001	0.04	0.0001	0.05	-0.0009	-0.8
$2,000+	-0.0012	-1.6	-0.0004	-0.41	-0.0004	-0.54	-0.0026***	-3.51
Interest type (omitted = FRM)								
ARM 5/1, 7/1, 10/1	0.0001	0.05	0.0062**	3.05	0.0096***	6.38	0.0132***	10.02
Interest-only	-0.002	-0.88	-0.0080***	-8.42	-0.0124***	-21.54	-0.0181***	-35.8
Race of borrower								
Black	-0.0037***	-4.33	-0.0029**	-2.58	-0.0034**	-3.25	-0.0062***	-5.27
Hispanic	-0.0040***	-4.47	-0.0036***	-3.57	-0.0054***	-7.00	-0.0050***	-5.38
Asian	-0.0001	-0.04	< 0.0001	0.01	-0.0014	-1.52	-0.0024**	-2.73
Number of borrowers (omitted = 2 borrowers)								
Single male	-0.0018*	-2.45	-0.0031***	-4.06	-0.0035***	-6.47	-0.0039***	-7.66
Single female	-0.0014~	-1.79	-0.0019*	-2.32	-0.0041***	-7.07	-0.0039***	-6.93
Observations (loan—month)	97,428		109,990		260,918		401,240	
Pseudo R^2	0.053		0.043		0.042		0.044	

Notes: Average marginal effects are reported, with z-statistics in parentheses. ~ p<.10, * p<.05, ** p<.01,*** p<.001. Each model includes state fixed effects and calendar-quarter dummies. **Source:** Authors' calculations of McDash Analytics, Equifax Credit Risk Insight™ Servicing, CoreLogic, and Home Mortgage Disclosure Act data. † indicates variables with a two-month lag, to help capture the state of the borrower's credit report at the time he/she applied for the refinance mortgage. Models use track loans' outcomes from January 2009 to May 2015.