The Effect of Interest Rates on Home Buying: Evidence from a Discontinuity in Mortgage Insurance Premiums

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Abstract: *Regression discontinuity estimates indicate that home buying is highly responsive to interest rates in a large segment of the population. A surprise 50 basis point cut in the effective interest rate for mortgages insured by the Federal Housing Administration (FHA) led to an immediate 14 percent increase in home buying among the FHA-reliant population. The effect of the rate cut holds across regions with varying economic conditions. Higher income households show far less sensitivity to rates, which has important implications for other stimulus policies.*

Keywords: Interest rates, home buying, FHA, stimulus, mortgages, mortgage insurance, regression discontinuity

JEL Codes: R21, R28, E5, G18, G21

Introduction

While the U.S. housing market is heavily subsidized by the federal government in normal times, it additionally serves as a major conduit of fiscal and monetary stimulus. For example, in response to the financial crisis, the Federal Reserve purchased $1.25 trillion in mortgage-backed securities in the first round of quantitative easing (QE). This unconventional action by the central bank was "taken to reduce the cost and increase the availability of credit for the purchase of houses," (Board of Governors, 2008). Also during the crisis, Congress expanded the reach of long-standing programs that support the housing market – the government-sponsored enterprises (GSEs), Fannie Mae and Freddie Mac, and the Federal Housing Administration (FHA) – by raising loan limits and thus extending government-subsidized mortgage rates to a larger share of the population. A more recent example is a 2015 cut in the effective mortgage rate for FHA loans, with the objective of boosting first-time home buying and residential investment (The White House, Office of the Press Secretary, 2015).[2]

Despite increasing home buying being a key motivation for major stimulus policies, evidence on the responsiveness of home buying to interest rates is scarce. In general, identifying the effects of interest rates on economic activity is challenging because of the lack of cross-sectional variation and the endogeneity of interest rates to aggregate demand. We address these identification challenges by exploiting the 2015 rate cut for FHA loans. This change in FHA pricing provides unique, exogenous time series and cross-sectional variation that allows us to study the response of home buying to interest rates.

In theory, drops in rates could increase demand for owner-occupied housing. In many housing market models, households prefer homeownership over renting for a variety of reasons, including preferential tax treatment of housing services and agency issues in home maintenance that generate a wedge between the cost to rent and the cost to own (see, for example, Sommer and Sullivan, forthcoming).[3] However, imperfect credit markets, sizeable transaction costs, and other frictions may prevent or delay homeownership for some households. Falling interest rates

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[2] In addition to stimulating housing consumption and investment via reduced mortgage costs, an increase in home sales is associated with increased demand for various real estate services (e.g. realtors, mortgage brokers, etc.) and for complementary housing-related durables (Benmelech, Guren and Melzer 2017; Best and Kleven 2016).
[3] Survey evidence suggests that the vast majority of renter households aspire to own their home (Shahdad, 2017).

might encourage home buying among households that had been waiting, and may also help ease credit constraints by lowering borrowers' monthly payments.

The FHA provides mortgage insurance that protects lenders and investors from losses when borrowers default. For borrowers with less than a 20 percent down payment and a below-average credit score, which includes many first-time homebuyers, FHA loans have been just about the only financing option since the financial crisis. In 2014, the FHA insured nearly 600,000 loans, or about one-fifth of all home purchase loans originated in the U.S., with about eight-in-ten FHA loans going to first-time homebuyers.

The FHA charges borrowers an annual mortgage insurance premium (MIP) – assessed as a percentage of the expected average loan balance in the coming year – and this premium is added to the borrower's monthly interest and principal payments. Thus, the MIP mimics an interest rate risk premium, and the FHA determines the size of this risk premium.[4] Following a surprise executive order from the Obama administration in January 2015, the FHA lowered the annual MIP by 50 basis points. For most households with below-average credit scores, the MIP reduction represented a direct drop in the cost of mortgage credit they faced.

Using the MIP cut, we implement a regression discontinuity (RD) design to test whether home buying is sensitive to changes in interest rates. The MIP cut generated a discontinuous drop in the cost of mortgages for a large subgroup of the population, while all other economic conditions that might affect home buying decisions evolved smoothly or remained constant. Using detailed loan-level data in which we observe the dates of application and rate lock, we find that the total number of home purchase loans to "FHA-likely" borrowers jumped discontinuously by nearly 14 percent when the new premiums went into effect. As explained in Section 2, this estimate nets out any shifts into FHA from alternative options such as private mortgage insurance (PMI). The discontinuity in home purchase borrowing can be clearly seen in Figure 1, which we will discuss in more detail later and replicate in other datasets.[5]

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[4] The base interest rate for FHA loans is market determined and, because FHA assumes the credit risk, is typically close to the prime mortgage rate.
[5] This paper builds on initial work in Bhutta and Ringo (2016b). Two other papers also study the FHA MIP cut. Park (2017) studies the effect of the 2015 FHA MIP cut on mortgage maturity choice. Davis et al. (2016) estimate that about half of the rise in FHA loans from 2014 to 2015 was a result of borrowers shifting into FHA from other programs like PMI. However, their data makes it difficult to disentangle how much of the remaining FHA growth

This jump in home buying implies a quick response by households, in contrast to previous time-series based evidence (Hamilton 2008). It seems unlikely that the MIP drop would cause people who were not already shopping for a home to immediately go out and apply for a mortgage. Instead, the drop in the MIP would probably be salient to those already shopping (almost surely their real estate agent or loan officer would know about it) and encourage more of them to bid on a house and get a mortgage. In other words, the MIP reduction may generate a higher "yield" of homebuyers from the pool of shoppers at the time of the MIP cut. We show that reduced premiums led to not only to an immediate increase in the number of mortgage originations, but also to an immediate increase in the number of new applications, suggesting a quick demand response.

Another reason for an immediate rise in home buying is that the MIP cut, by lowering mortgage applicants' monthly payments, could ease borrowing constraints due to limits on borrowers' debt-payment-to-income (DTI) ratios and increase the fraction of applications accepted. Indeed, we provide evidence that DTI limits bind, and that a 50 basis point reduction in premiums was enough to shift a substantial number of applicants across relevant underwriting thresholds.

Models of the housing market typically emphasize the importance of down payment constraints (e.g. Sommer and Sullivan forthcoming; Glaeser, Gottlieb, and Gyourko 2013), but our findings suggest that DTI constraints are important as well and can amplify the response of housing demand to interest rates.[6] New regulations under Dodd-Frank that discourage lending to borrowers with DTI ratios in excess of 43 percent add to the importance of understanding the extent to which DTI limits bind and how such limits influence the response of housing markets to interest rates (Bhutta and Ringo 2015; DeFusco, Johnson, and Mondragon 2016).

Our microdata allow us to examine whether the effect of interest rates varies in important ways. First, taking advantage of regional variation in local economic conditions, we find that the response to the FHA rate cut is similar across areas experiencing different economic trends.

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stems from the MIP cut as opposed to trend growth. In contrast, we employ an RD design using data with loan application dates and detailed borrower characteristics to directly estimate the MIP cut's causal effect on borrowing.
[6] Feldman (2001) simulates the effect of interest rates on homeownership through changes in DTI. Others have studied the likelihood of homeownership as a function of the likelihood of being credit constrained due to low income, low wealth or low credit score (e.g. Acolin et al. 2016). Other studies have shown the effect of credit constraints, including DTI constraints, on house prices, such as Anenberg et al. (2017) and Kuttner and Shim (2016). Johnson and Li (2010) show that a high DTI is predictive of the consumer having been denied credit.

Although aggregate house prices and employment were growing robustly by 2015, this result helps establish that rate cuts can stimulate home buying even in weaker economic environments.

Second, we find that the effect of the MIP reduction on home buying shrinks as household income rises, with the top-quartile of FHA-likely households (those with annual incomes of nearly $100k and higher) largely insensitive to the premium cut. These results imply that targeted interest rate subsidies to lower income households are more likely to produce substantial home buying responses, whereas the timing of home purchases for higher income households is less sensitive to interest rates.

In addition to affecting the decision of whether or not to buy a home, interest rates can also affect *intensive* margin housing and mortgage decisions. However, using the same RD design, we find no evidence that borrowers took out larger loans or paid more for their home (either by buying a larger home or by bidding up the price of a given home) in response to the reduced cost of credit. The lack of an intensive-margin response may stem from binding down payment constraints among FHA-likely borrowers, even those with relatively high incomes. That said, previous research has also found – among arguably less constrained borrowers – small intensive-margin responses to mortgage interest rates. In particular, DeFusco and Paciorek (2017) use a discontinuity in interest rates at the GSE conforming loan limit (the "jumbo-conforming spread") to estimate a semi-elasticity of loan size to interest rates of only about 2.[7]

Finally, we also employ a difference-in-difference design to test for longer-run effects on house prices, comparing FHA-reliant neighborhoods to less-reliant neighborhoods. We find little evidence that the MIP cut led to faster home price growth over the subsequent months and years.[8] Potentially, an increase in mortgage defaults following the influx of lower-income borrowers after the MIP cut could have put downward pressure on home values, but we do not find evidence of a deterioration in loan performance. The lack of house price effects in FHA-

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[7] Best et al. (2015) similarly exploit mortgage rate discontinuities in the U.K. and generate estimates slightly larger than DeFusco and Paciorek (2017). Jappelli and Pistaferri (2006) find that mortgage borrowing in Italy was largely unresponsive to changes in the tax treatment of mortgage interest in the early 1990's. Furthermore, survey estimates under hypothetical interest rate changes suggest small intensive-margin and willingness-to-pay elasticities (Fuster and Zafar 2015). See Zinman (2015) for a review of literature on the interest rate elasticity of non-mortgage of borrowing.

[8] Davis et al. (2016) estimate that quality-adjusted sales prices grew slightly more from 2014 to 2015 for FHA-financed homes compared to non-FHA-financed homes.

reliant neighborhoods differs somewhat from what has been found in higher-income markets (Adelino, Schoar, and Severino 2012). However, Anenberg and Kung (2017) argue that house prices may not always react strongly to interest rates because home sellers can respond to demand shocks along non-price dimensions such as the time to sell.[9] Altogether, our findings suggest that the reduction in FHA premiums increased home buying among lower income households, without much, if any, of the MIP cut being capitalized into house prices.

As noted previously, evidence on the responsiveness of home buying to interest rates is quite limited. For the U.S., perhaps the most comparable estimate comes from Adelino, Schoar, and Severino (2012), who find a small increase in home sales among houses that recently became easier to purchase with cheaper GSE financing due to changes in the conforming loan limit. Outside the U.S., Martins and Villanueva (2006, 2009) study a program in Portugal and find that interest rate subsidies for lower-income individuals encouraged household formation and mortgage borrowing. Relatively more attention has been paid to the relationship between interest rates and house prices. With the exception of Adelino, Schoar, and Severino (2012), these studies have been limited to aggregate time series analyses (e.g. Dokko et al. 2011; Glaeser, Gottlieb, and Gyourko 2013; Kuttner 2012).

A number of recent papers study the effects of recent declines in available mortgage interest rates due to QE and accommodative monetary policy, but focus on refinancing, equity extraction, mortgage default, and consumer spending decisions of *existing* homeowners.[10] In addition, Luck and Zimmerman (2017) examine the employment effects of QE.

The rest of the paper proceeds as follows. The next section provides more background about the FHA premium cut. Section 2 lays out the identification strategy. Section 3 describes our data. Section 4 provides the main results. Section 5 describes tests of key identifying assumptions.

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[9] Hilber and Turner's (2014) finding of a negative effect of the mortgage interest deduction on homeownership in highly regulated housing markets implies capitalization of the deduction in such markets, but the actual effect of interest rates on house prices is not estimated.

[10] Fuster and Willen (forthcoming) and DiMaggio et al. (forthcoming) focus on default, consumption and deleveraging responses to reductions in mortgage payments through ARM resets as rates fell after 2007. DiMaggio, Kermani and Palmer (2016), and Beraja et al. (2017) look at refinancing and equity extraction in response to QE. Agarwal et al. (2015) studies the effect of the Home Affordable Refinance Program, which relaxes collateral requirements for refinance loans, on refinancing and durables consumption. Bhutta and Keys (2016) examine the effect of early 2000s declines in interest rates on equity extraction.

Section 6 examines mechanisms by which the MIP cut increased home buying. Section 7 tests for effects of the MIP cut on house prices and loan performance. Finally, section 8 concludes.

1. Mortgage Insurance and the Surprise FHA Premium Cut in 2015

Loans with a high loan-size-to-home-value (LTV) ratio default at higher rates, and generate greater losses given default. Lenders often require applicants with low down payments to pay for mortgage insurance, which protects lenders against losses in the event of default. In addition to several large private mortgage insurance (PMI) companies, the FHA, a Federal agency within the Department of Housing and Urban Development (HUD), is a key provider of mortgage insurance. The FHA does not extend credit, but insures loans extended by private lenders if the loan meets the FHA's underwriting standards, and is within statutory loan size limits.[11]

Since 2012, 20-30 percent of all owner-occupied home purchase originations in the U.S. have carried FHA insurance. FHA-insured loans require a down payment as low as 3.5 percent of the property value, which can ease the transition into homeownership for households with few liquid assets. In 2014, more than 80 percent of FHA-insured home purchase loans went to first-time homebuyers, and over three-quarters of FHA-insured loans had down payments of less than 5 percent (HUD 2015). FHA mortgage insurance premiums can also be substantially lower than those from PMI companies for many borrowers, particularly those with lower credit scores.[12]

The FHA charges a one-time upfront premium, set as a percentage of the original loan amount (and which can be financed). The FHA also charges an annual premium, set each year during the life of the loan as a fixed percentage of the expected average outstanding balance during the year. The premium rates are generally the same for all borrowers, regardless of credit risk.[13]

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[11] The 2015 maximum loan size for a one-family house was $271,050 in most counties, and as high as $625,500 in high-cost areas such as counties in San Francisco.

[12] See the June 2016 *Housing Finance at a Glance* monthly chartbook published by the Urban Institute. Over half of FHA-insured mortgages in 2014 went to borrowers with credit scores under 680 (HUD, 2015). Fannie Mae and Freddie Mac, which purchased just under half of all new mortgage loans by dollar volume in 2015 according to Inside Mortgage Finance, by statute can only purchase loans with an LTV in excess of 80 percent if they have PMI.

[13] Currently, the annual premium is slightly higher if the loan amount exceeds $625,000 (add 5 basis points), or the LTV ratio at origination exceeds 95 percent (add 5 basis points). Premiums are significantly lower for loans with a maturity of 15 years or less, but 15-year FHA loans are rare.

On January 7, 2015, the Obama administration announced that the FHA would be reducing its annual mortgage insurance premiums by 50 basis points, from 135 basis points to 85 basis points for typical FHA loans (i.e. loan amount under $625,000 and LTV over 95 percent). This reduction would lead to a decline in premium payments of about $1,000 for a $200,000 loan in the first year of the loan, and about $4,700 in the first five years. The FHA provided additional details two days later. An important point, which we will come back to later, is that the new premiums would apply to loans that *close* on or after January 26, 2015, *regardless of loan application date*.

The 2015 premium cut came after several increases in FHA's premiums, beginning with a small rise in late 2008, and larger increases starting in 2010 (Figure 2). In 2008 and 2009, FHA insurance became heavily used, and FHA suffered sizeable losses on those vintages (Avery et al. 2010; HUD 2012). In response, FHA began raising premiums to help rebuild reserves more quickly. Prior to 2010, the annual MIP was essentially flat for at least a decade.

Notably, unlike the 2015 cut, the earlier rate hikes do not provide ideal experimental variation in interest rates. They were all announced at least a month prior to their implementation, and created an incentive for borrowers to shift their application dates to avoid the higher rates. As we explain in more detail in Section 5, such an incentive was explicitly eliminated for the 2015 rate cut.

Because FHA's reserves were still below target levels, the announcement on January 7th of the FHA premium cut appears to have been a real surprise. In its annual actuarial report released in November, 2014, the FHA noted that the economic value of its insurance fund had increased in 2014, but its capital ratio still stood at just 0.41 percent, well below the congressionally mandated 2 percent target (HUD 2014). Earlier in 2014, FHA Commissioner Carol Galante told the Washington Post, "[I]t's not the time to do a wholesale rollback of the premiums. FHA's financial condition is not where it should be yet."[14] Additionally, a Housing Wire article in December, 2014 remarked, "Industry analysts said that despite the increased health of the [FHA], changes in the FHA mortgage insurance premiums were unlikely in 2015,"[15] Finally, the Urban

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[14] ElBoghdady, Dina. "Why a government agency won't lower mortgage fees for borrowers." *Washington Post*, April 21, 2014.
[15] Lane, Ben. "18 Senators, mortgage bankers tell HUD: Time to lower FHA premiums." *Housing Wire,* December 18, 2014.

Institute released an analysis on January 6, 2015 – the day before the announcement of the premium cut – arguing that, despite slower-than-expected improvements in their finances, the FHA *could* reduce its premiums (Bai, Goodman and Zhu 2015). The tone and timing of their discussion underscores the lingering questions around FHA's finances and suggests there was little expectation for the announcement that would come the next day. Indeed, data from Google Trends are consistent with the announced FHA premium cuts being a surprise, with searches for "FHA mortgage" and "FHA mip reduction" being steady for several months and then suddenly spiking on January 8, 2015 – the day after the announcement.[16] Overall, we have not found any news article or blog indicating any expectation among real estate and mortgage industry participants of an FHA premium cut in the weeks and months just before the announcement.[17]

2. Empirical Strategy

Our primary goal in this paper is to use the sharp 2015 FHA MIP cut to study the causal response of home buying to interest rates in a regression discontinuity (RD) design. The MIP cut mimics an interest rate decline, but helps avoid a central difficulty in estimating the effect of interest rates, which is the endogeneity of rates to a host of aggregate- and individual-level confounding factors. At the aggregate level, interest rates reflect expectations about growth and inflation, while cross-sectional differences in rates reflect individual level risk. In contrast to endogenous interest rate changes, the FHA MIP was cut abruptly in January 2015 without any shock to other determinants of housing demand (see Section 5).

Our main empirical approach tests for a discontinuity at the time of the MIP cut in the share of home purchase loans, by count, going to borrowers with below-average credit scores and less than a 20 percent down payment – characteristics that make them reliant on FHA insurance and hence exposed to the premiums. In our primary dataset from Optimal Blue, which we describe in the next section, about 85 percent of borrowers with a FICO score below 680 and an LTV over 80 percent used FHA insurance during the sample period. We refer to such borrowers

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[16] See Appendix Figure A1
[17] We searched for FHA-related articles available on the internet prior to January 7, 2015 using Google's date-specific search tool.

throughout the paper as "FHA-likely" borrowers, or "treatment group" borrowers. All other borrowers (implicitly the control group) used FHA insurance only 17 percent of the time.[18]

Our approach is motivated by two issues. First, a more straightforward test for a discontinuity in the total *number* of home purchase loans is confounded by the strong seasonal cyclicality of the mortgage market. In practice, a discontinuity can be difficult to distinguish from a sufficiently steep slope. To illustrate the difficulty, Figure 3 shows the count of home purchase loans from mid-2012 through 2015 by week of application, with vertical lines representing the week of January 26 for each year. The rate of change in loan count is typically rapid through the late January/early February period, so distinguishing any discontinuity in lending from the prevailing upward trend would be challenging. Instead, we test for a discontinuity in the *share* of all home purchase loans going to treatment group borrowers, which displays almost no seasonality as the control group absorbs seasonal trends.

A second issue is that some borrowers seeking a high-LTV loan may have a choice between PMI and FHA mortgage insurance, and the decrease in FHA premiums may have pulled some of these borrowers away from PMI and into FHA. Figure 4 shows a clear discontinuity in the FHA share of home purchase loans, from about 22 percent to 27 percent, but this discontinuity likely overstates the effect of the MIP cut on *new* borrowing. The discontinuity in the FHA share is confounded by borrowers shifting from PMI into FHA. In contrast, our treatment group share of home purchase loans is not affected by such shifting. If, for instance, a borrower with a FICO score of 670 got FHA insurance instead of PMI after the MIP cut, our treatment group share would not change – that borrower would contribute one loan to the numerator regardless.

Focusing on home purchase loans for owner-occupied properties, we estimate the equation:

$$y_i = \beta_0 + \beta_1 x_i + g(t_i|x_i) + \varepsilon_i \tag{1}$$

where *y* is an indicator for the borrower being a member of the treatment group. The variable *x* is a dummy for either the date of application or the date of interest rate lock, depending on our dataset, being within or after the week of January 26, 2015. Observing the application or rate

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[18] Most FHA borrowers have an LTV of 95 percent or more. In section 5 we discuss the potential for endogenous selection into the treatment group as borrowers could have some discretion over their LTV. We also test robustness to alternative definitions of the treatment and control groups in the appendix.

lock date in the data is key to our study because this date marks the point when a decision to borrow occurs, as opposed to the closing date of a loan which can occur weeks or months after application.[19] Finally, $g(t/x)$ is a flexible function in the week of application or rate lock. The function $g(\cdot)$ is specified relative to the week, rather than the exact date, to absorb day-of-the-week effects (mortgage applications exhibit strong periodicity within the week). Assuming y is a continuous function of t in the absence of the MIP cut, least-squares estimation of (1) yields a consistent estimate of β_1, the effect of the FHA MIP reduction on the treatment group share of home purchase loans. Following Imbens and Lemieux (2008), we model $g(\cdot)$ as a local linear function with different slopes on either side of the January 26 breakpoint. We try a variety of bandwidths, and cluster all standard errors by week.

3. Data

Data for this project come from several sources. One source is loan-level data reported under the Home Mortgage Disclosure Act (HMDA). These data cover nearly the entire residential mortgage market, and data collected include FHA status, the dates of application and origination, loan amount, loan purpose (home purchase, refinance or home improvement), property type, occupancy status, lien status and application outcome (originated, denied, withdrawn by applicant, etc.), borrower socioeconomic characteristics including income, race and ethnicity, and the census tract of the securing property.[20]

In addition, we draw on loan-level rate-lock data provided by Optimal Blue.[21] Optimal Blue is a lending services company that provides mortgage lenders with a software platform that can be used during the interest rate lock process. Optimal Blue retains the data entered by lenders, and these data can be purchased for research. In 2014 and 2015 they recorded approximately 1,600,000 rate locks for owner-occupied home purchase loans, about one quarter of the number of mortgage originations reported in HMDA over that period. Lenders using the Optimal Blue platform tend to be smaller and thus the data do not include loans originated by the largest banks

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[19] Rate locks usually occur shortly after application.

[20] The public version of the HMDA data does not include application and origination dates. See Bhutta and Ringo (2016a) for more details on the information available in the HMDA data.

[21] The data from Optimal Blue do not contain lender or customer identifiers, or complete rate sheets. We report only aggregate statistics.

such as Wells Fargo and JPMorgan Chase. The Optimal Blue data include borrower FICO score, DTI and LTV ratios as well as the contract rate, FHA status, date of rate lock, loan amount, occupancy status and the ZIP Code of the securing property. Unlike HMDA, the final disposition of the application is not available in this data – some applications may be withdrawn or denied after the borrower locks in a rate.

In order to assess how our estimated elasticity varies with borrowers' income, we perform a merge of home purchase loans in the HMDA and Optimal Blue data sets. Loans are merged based on loan amount (rounded to the nearest thousand), location (as determined by the overlap between ZIP Code Tabulation Areas and census tracts) and loan type (i.e. FHA, VA, RHS or no government insurance). We also require that the date of rate lock from Optimal Blue falls between the date of loan application and origination from HMDA. We then drop all non-unique matches. This leaves about 600,000 matches for 2014 and 2015, 540,000 of which were for owner-occupied properties.

Finally, to verify that our results are robust to the choice of data set, we replicate our estimation on a large sample of loans provided by McDash Analytics. The McDash data are composed of the servicing portfolios of the largest mortgage servicers in the U.S. These data cover over half of one- to four-family mortgage loans originated in 2014 and 2015, and, in contrast to the Optimal Blue data, coverage is skewed towards larger lenders.

The McDash data include information on the origination date, loan amount, contract rate and LTV ratio of the loan, as well as ZIP Code of the securing property and FICO score and back-end DTI ratio of the borrower. To get the associated application dates for these loans, we must merge these data with HMDA data. The merge is performed on loan amount, county, origination date, loan purpose and loan type.[22] McDash has records for over 3 million home purchase loans originated in the two-year window around the 2015 FHA MIP reduction, and we match over 1,600,000 to HMDA after dropping observations that were non-unique on the matching criteria in either data set.

Summary statistics for each loan-level data source are presented in Table 1, for all home purchase loans and for those with FHA insurance. FHA loans tend to be for smaller dollar

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[22] In accordance with our contract with Black Knight, the data provider, institutional identifying information was dropped before the merge and was not available to researchers in the final, merged data set.

amounts and carry higher LTV ratios, while FHA borrowers tend to have lower incomes and weaker credit scores than the overall borrower population. The HMDA data are the most representative, as the vast majority of residential mortgages are covered. Loans in the Optimal Blue data are slightly smaller on average and more likely to have FHA insurance. FHA loans or those with otherwise risky characteristics were less likely to have a unique match between the two data sets – the merged HMDA/Optimal Blue sample has a lower FHA share, lower DTI and LTV ratios, and a higher average FICO score. Relative to Optimal Blue, McDash covers a higher loan amount, higher income and a generally less risky borrower population.

4. The Effect of the MIP Cut on Home Buying

As mentioned earlier, Figure 1 illustrates our main finding. It plots the share of owner-occupied, home purchase loans going to the treatment group against the week of rate lock, using the Optimal Blue data. Rate lock typically occurs about one week after the loan application is recorded, and should therefore provide a good proxy for the FHA pricing regime the borrower faced. A local polynomial curve is fitted over the weekly data, and a vertical line represents the week of January 26, 2015. There is barely any seasonality in the treatment group share compared to the large fluctuations in total lending apparent in Figure 3. A jump in lending to the treatment group coincident with the FHA MIP reduction is quite apparent, with approximately 18 percent of loans going to treatment group borrowers before the change and 20 percent after.

Formal RD estimates are presented in the first row of Table 2. The function $g(\cdot)$ is estimated separately on either side of the breakpoint with a triangular weighting kernel. We show results for a variety of bandwidths, and find a statistically significant effect in all of them. At the narrowest bandwidths of 12 and 25 weeks, the point estimates match Figure 1, suggesting the new premiums increased the treatment group share of loans by about 2 percentage points, from 18 percent to 20 percent. The estimate at a bandwidth of 50 weeks is smaller at 1.2 percentage points. A rise in the treatment group share of 2 percentage points from 18 to 20 percent implies an increase in loans to the treatment group of about 14 percent.[23]

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[23] A change in treatment group loans of ΔT percentage points that causes the treatment group share to rise from 18 percent to 20 percent implies the following expression: $(18+\Delta T)/(100+\Delta T) = 0.2$. Solving for ΔT and then dividing by 18 yields 0.14.

This estimate assumes borrowing by the control group was unaffected by the MIP cut. If there was some response by the control group, this 14 percent effect would represent a *lower* bound on the true effect of the MIP cut on borrowing by the treatment group.[24] Note that in Appendix Table A1 we provide results under various treatment and control group definitions. The results are quite similar when we use more restrictive definitions for the control group, including specifications under which the control group has FHA utilization rates below 2 percent.

As a robustness check, we replicate the results in the merged HMDA/McDash dataset. A discontinuity in lending to the treatment group at the week of January 26 exists in these data as well, as can be seen in the second row of Table 2 (a graph of the discontinuity in these data is available in the appendix). The RD estimates are stable and statistically significant across the choice of bandwidth, and similar to the estimates from Optimal Blue – the share of lending to the treatment group increased by approximately 13 percent around January 26, 2015.

While it is tempting to try and draw conclusions about the persistence of the effects of the MIP cut (or lack thereof) from the figures, it is important to keep in mind that our RD estimates only identify the effects of the MIP cut near the dates when the cut was announced and went into effect. Thus, our analysis cannot definitively say whether the effect of the MIP cut was persistent or if it faded with time.

To help ensure that the estimated discontinuity is not an artifact of the time of year, we run placebo RD tests around the week of January 26 the year before the MIP reduction (2014) and the year after (2016; year after estimates are only available with the Optimal Blue data since 2016 HMDA data were not yet available at the time of writing). The estimates, also presented in Table 2 across three bandwidths, are all close to zero, inconsistent in sign, and statistically insignificant in all but one instance. Seasonality does not appear to be driving our main results.

Finally, note that the jump in the share of loans going to the treatment group is substantially less than the jump in the share of loans carrying FHA insurance (compare Figures 1 and 4). The FHA share of lending increased approximately 5 percentage points, in comparison to a 2 percentage point increase in the treatment group share. This difference indicates that in addition to inducing more new loans, the FHA MIP cut caused many borrowers to choose FHA insurance

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[24] If Δc is the percent point change in *control* group loans in response to the MIP cut, then the effect size for the treatment group would be $0.14 + 0.014*\Delta c$.

over PMI. The existence of these shifters – borrowers whose choice of mortgage insurance was responsive to the FHA premium – highlights the importance of constructing a treatment group whose membership is exogenous to the MIP cut in order to estimate the effect of the cut on *new* borrowing.

4.1 Effect of the MIP Cut under Different Local Economic Conditions

In January of 2015, the national economy was in the midst of a long and steady expansion. House prices had been growing for several years, and the national unemployment rate had recently fallen below 6 percent for the first time since the summer of 2008. Our findings so far therefore suggest that subsidizing the cost of mortgage credit can effectively stimulate housing demand under relatively mild economic circumstances. We would like to know, however, whether cutting mortgage rates can be an effective form of counter-cyclical stimulus. Would home buying respond as strongly to the premium cut in recessionary conditions?

To answer this question, we exploit geographic variation in the strength of local economies. We compare the estimated jump in treatment group borrowing in different counties ranked by their unemployment rate in 2014 (as measured in the 1-year 2014 ACS); the rate of recent home price appreciation (as measured by the growth rate in Zillow's home value index from December 2011 through December 2014); and the rate of recent income growth (as measured by the growth rate in median household income from the 1-year 2011 ACS through the 1-year 2014 ACS). For each of these three measures, we group counties into ten equally sized bins and re-estimate the discontinuity in treatment-group borrowing within each bin. Results are presented in Figure 5. Estimated discontinuities are plotted with the weaker economies (high unemployment, low house price growth, low income growth) on the left and the stronger economies (low unemployment, high house price growth, high income growth) on the right.

Figure 5 does not reveal any tendency toward a smaller effect of the MIP cut in relatively weak economies. If anything, the effect is smaller in counties that experienced the highest rate of growth in home prices over the preceding three years. This indicates that low unemployment, rising prices or rising incomes are not prerequisites for interest rate cuts to effectively stimulate home buying.

4.2 Heterogeneous Responses by Borrower Income

Applicants with lower incomes may be relatively more sensitive to reduced premiums for two reasons. First, lower-income borrowers may have higher DTI ratios, and are therefore more likely to be on the margin of denial. Reduced premiums could then have a greater effect on their probability of being approved for a loan. Second, lower income households could conceivably have more price-elastic demand for owner-occupied housing, in which case reducing premiums would bring relatively more lower-income applicants into the market.

We test for a heterogeneous response to the MIP cut by dividing treatment group borrowers in the merged Optimal Blue/HMDA data into four quartiles based on HMDA reported applicant income. The cutoffs are annual incomes of $46,000, $66,000 and $96,000. We estimate a discontinuity in the share of all lending going to each treatment group subsample as in (1). Results are reported in Table 3.[25] The discontinuity is strongest in the lowest income sample, and weakens as income increases. We repeat the analysis on the merged HMDA/McDash data, and find very similar results, also shown in Table 3. In both data sets, the estimated effect decreases with borrower income. It appears that among households with annual incomes above $96,000, the demand for home purchase loans is essentially rate inelastic.

5. Validity of the RD Design

In this section we discuss four potential concerns about the validity of the RD design. To conserve space, we keep this section brief and provide additional details in the Appendix.

One potential concern is that other economic shocks coincided with the MIP cut. The consistency of our estimates requires that the only relevant difference in housing market conditions just before and just after January 26 is the level of the FHA premiums. Indeed, treasury rates, the stock market, and unemployment all evolved smoothly around the time of the

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[25] Summing over the four income categories, the estimated discontinuities, in percentage point terms, are smaller in the merged Optimal Blue/HMDA data than those in the Optimal Blue data alone (Table 2). This is because the merged data contains a lower proportion of FHA and treatment group borrowers (see Table 1). The estimated discontinuity as a percent of the 2014 treatment group share is similar in both the merged and non-merged data.

cut. Further, our RD estimates are robust to including controls for these macro variables (see Table 2).

A second concern might be that the MIP cut was not fully passed through to borrowers. If interest rates on FHA loans increased and offset the premium cut, it would potentially suggest that our findings are spurious. We confirm that the MIP cut was passed through by testing for a discontinuity in the average interest rate for treatment group loans, finding no change in interest rates that would offset it (RD results available in the appendix).

A third concern is that the discontinuity observed in Figure 1 simply reflects strategic delays in mortgage applications in anticipation of, or in response to, the announced premium cut. As already emphasized, the MIP cut was a surprise and was quickly implemented. Furthermore, the lower premium applied to loans *closing* on or after January 26, regardless of the application date. Thus, applicants in the pipeline at the time of the announcement did not need to withdraw and reapply to take advantage of the premium cut. Indeed, as shown in the appendix, we find that many borrowers who applied for loans before the announcement but who had not closed by the 26th took advantage of this option. We also find no increase in application withdrawals (withdrawals are recorded in HMDA) among treatment group borrowers.

A fourth concern might be that selection into our treatment group is not exogenous. In particular, perhaps some low-FICO borrowers with the liquid assets to make a down payment of 20 percent or more decided to put less down and take an FHA loan when the MIP dropped. However, sub-680 FICO score borrowers with a down payment of 20 percent or more were uncommon even before the MIP cut, limiting the scope for treatment group endogeneity. Furthermore, the decision to put less than 20 percent down would be very costly, as the borrower would have to pay mortgage insurance on the entire loan, as well as interest and insurance on the additional borrowed funds. Nonetheless, in the appendix we explicitly test this exogeneity assumption, and find little or no switching into the treatment group due to the MIP cut.

6. Mechanisms

Understanding the mechanisms by which the MIP cut caused more home buying is helpful for the extrapolation of these results to other contexts and the broader population. We posit that two

distinct channels are responsible. First, reduced premiums mechanically improve applicants' DTI ratios and could thereby have led to many borrowers being approved for loans that they would otherwise have been denied. Second, more applicants may have decided to buy homes in response to lower premiums (the typical quantity-demanded response to a price decrease). In this section we provide evidence that both mechanisms were at work.

6.1 Denial Rates and the DTI Ratio

This section provides evidence of binding DTI ratios and for the notion that the MIP cut could have led to an appreciable increase in lending via a reduction in DTI-based denials. To begin, we note that HMDA data reveal that many FHA mortgage applications are denied, with high DTI ratios being one of the most commonly cited reasons for denial. In 2014, over 17 percent of FHA home purchase applications were denied, and a high DTI was a factor in at least 20 percent of denials.

In addition, the MIP cut was big enough to have changed applicants' DTI ratios meaningfully. All else equal, we estimate that the MIP cut would lower FHA borrowers' DTI ratios by 1.5 percentage points on average. So, for applicants within a percentage point or two of the margin for denial, their access to credit could conceivably have hinged on the reduction in premiums.

Figure 6 uses administrative data from HUD and shows the distribution of DTI ratios for all FHA home purchase loans in 2014 and 2015, in bins of a single percentage point. For borrowers with a FICO score below 620, a 43 percent DTI appears as a clear cutoff. For borrowers with a higher FICO score, we can see substantial drop-offs in the density at 45, 50, 55 and 57 percent. [26] These figures are suggestive of binding DTI caps. A 1.5 percentage point shift in DTI due to the MIP cut would move an appreciable mass of mortgage applicants across these thresholds, affecting their denial probabilities.

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[26] The FHA imposes underwriting standards that tighten in a stepwise manner as the applicant's DTI ratio increases. A basic cap of 43 percent is imposed on manually underwritten loans with no compensating factors. For borrowers with additional compensating factors, this limit may be raised to 47 percent or 50 percent. Acceptable compensating factors include cash reserves, residual income not included in the DTI calculation and proof that the new mortgage payment represents a minimal increase over previous housing payments. Using the FHA's automated underwriting tool, borrowers may be approved with a DTI ratio up to 57 percent. However, lenders may impose overlays and use somewhat lower thresholds.

If the new premiums increased lending to the treatment group by reducing DTI-based denials, we should see a discontinuous drop in the overall denial rate around January 26, 2015. Unfortunately, seasonality again makes it difficult to directly test this prediction, as denial rates fall rapidly through the early months of every year. Furthermore, the HMDA data–our only source of information on denied applications–do not have FICO scores or LTV ratios, and so we cannot use our previously defined treatment and control groups to deal with the seasonality issue. In Appendix Table A2, we show that the denial rate for FHA loan applications dropped discontinuously on January 26, 2015, relative to all other applications. However, the reduction in premiums may have led to changes in the composition of the FHA applicant pool (particularly due to switchers from PMI), so the fall in FHA denial rates may reflect stronger underwriting factors among new FHA applicants in addition to any easing of DTI constraints.

6.2 Volume of Applications

In this section, we provide evidence that the reduction in FHA premiums caused more households to submit home purchase mortgage applications. Although home buying can be a lengthy process, our RD results indicate that there was a quick (within the first couple weeks) response to reduced premiums. If marginal applicants were responding this quickly, it suggests there is a pool of potential home buyers active in the housing market but uncommitted to applying for a mortgage. Such households may be monitoring mortgage markets closely, or could learn about changes in FHA premiums from real estate agents and mortgage brokers. To test for their presence, we look for a jump in the number of *applications* for home purchase.

Again, seasonality is a confounder and difficult to deal with in the HMDA data because of the lack of FICO scores and LTV ratios which would allow us to form treatment and control groups as in Section 4. However, as we demonstrated in section 4.2, the response to the premium cut was concentrated among lower-income households, and applicant income is reported in HMDA. Although income is not as strong a predictor of FHA usage as FICO score and LTV ratio, given the earlier results we should expect to see a discontinuous jump in *originations* to lower-income borrowers, relative to higher-income borrowers, around the time of the premium cut. If, additionally, lower-income *applications* (originated or not) simultaneously jump, it would be suggestive (with one caveat discussed later) that household demand responded to the news of the lower premiums.

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In Figure 7 we plot the ratio of lower-income (under $75k) to higher-income applications and originations over time. To further isolate the most elastic borrowers, we also stratify on the ratio of loan amount to income (LTI). High LTI households may have tighter budgets, and also be more in danger of denial due to a high DTI ratio. Panel A shows the ratio of lower-income and above-median LTI applicants to all higher-income applicants, while panel B shows the ratio of lower-income, below-median LTI applicants to all higher-income applicants.

Figure 7 indicates that both applications and originations for lower-income, higher-LTI households jumped discontinuously around January 26, 2015. The jump in applications implies that the additional originations were not simply a result of reduced denial rates for those who would have applied even under the earlier pricing regime.

In contrast, there is no apparent jump in either applications or originations from lower-LTI, lower-income households. Further, while loan amounts are potentially endogenous to the rate cut, the lack of a discontinuous drop in applications or originations in the lower-LTI, lower-income segment suggests that the jumps in panel A reflect a true rise in the number of new applications, rather than applicants switching from low to high LTI. (Moreover, in the next section we will show directly that loan amounts did not respond appreciably to the MIP cut.)

As an alternative to the treatment-control framework, a second potential method for dealing with seasonal variation is to difference out the seasonality by taking year-over-year weekly growth rates. In Figure 8, the annual growth in the number of applications is plotted by week around the premium cut on January 26, 2015 and around a placebo date on January 26, 2014. Again, we can see a jump in both (seasonally adjusted) home purchase applications and originations at the time of the MIP cut. In contrast, no such jump occurred in 2014 (panel B), suggesting annual differencing successfully controlled for seasonality and the jump in applications in 2015 is evidence of a demand response to a reduction in the cost of credit.

While the number of applications is our best measure of quantity demanded, we note that it is not without flaws. Prospective borrowers may be discouraged from submitting an application if they believe they are likely to be denied credit. For example, households may seek a pre-approval before applying for a loan. If the pre-approved amount is insufficient to purchase their reservation value house, the household will not submit an official application. Following the MIP cut, pre-approved loan amounts may have increased as DTI restrictions effectively eased,

causing more households to formally apply. In this way, the number of applications received may be affected by the denial channel as well as the underlying demand for homes.

7. The Effect of the MIP Cut on Loan Amounts, Home Prices and Loan Performance

In addition to the extensive margin of home buying, borrowers may respond to a reduction in their cost of credit along the intensive margin by bidding more for a given home, purchasing more expensive properties, and/or taking out larger loan amounts. Increasing demand along both the extensive and intensive margins could lead to higher house prices. In this section we estimate borrowers' responses along the intensive margin, as well as whether the shock to housing demand caused an increase in the overall level of house prices.

7.1 Loan Amounts and Purchase Prices

To begin, we test for a discontinuity in (log) amount borrowed and in (log) purchase price around January 26, 2015. Note that an unconditional discontinuity test is likely to pick up the effect of a change in the composition of treatment group borrowers. As shown earlier, new borrowers induced into home buying by the MIP reduction tended to have relatively low incomes. These lower income households may buy less expensive homes, which would tend to pull the average loan amount of treatment group borrowers down after the premium cut. Indeed, Table 4 indicates that treatment group mortgage amounts and purchase prices dropped 7 to 9 percent, on average, after January 26. However, when we control for borrower income and FICO scores, the RD estimates for loan amount and purchase price are close to zero and statistically insignificant. With the caveat that residual compositional effects may still be biasing our estimates downward, we find no evidence that lower FHA premiums caused households to borrow and spend more, conditional on getting a mortgage.

These results reflect RD estimates for the treatment group (FHA-likely borrowers) relative to the control group (all other borrowers). However, if FHA-likely borrowers bid up house prices, that might affect the prices and loan amounts in the control group, biasing the RD estimates toward zero. To check for this issue, we restrict the sample to only treatment group borrowers and estimate the discontinuity in loan size and purchase price without the control group. Results are presented in Table 4. We again find no evidence of house price or loan size effects.

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One possible explanation for the lack of an intensive margin response is binding underwriting constraints. While the MIP cut reduced DTI ratios for any given FHA loan, LTV ratio limits may still have bound. FHA loans have a maximum LTV ratio of 96.5 percent, and the median LTV ratio among treatment group FHA borrowers in 2014 was 95.7 percent. Even if home buyers would have liked to borrow more in response to the lower premiums, many had little scope to do so without producing a larger down payment.

7.2 Aggregate Prices

The FHA premium reduction could have led to a more gradual rise in home prices, which the RD approach may not pick up. Therefore, in addition to these RD estimates, we also test if home prices accelerated after the premium cut more rapidly in areas that are more reliant on the FHA. In some neighborhoods, the FHA share of loans tends to be much higher than the national average. If lowering interest rates drives up home prices by spurring housing demand, then the reduction in FHA premiums may similarly drive up prices in areas where a greater portion of the population relies on FHA financing.

To test for an effect on home prices in FHA reliant areas, we estimate equations of the form:

$$\Delta P = \beta_0 FHAshare + \beta_1 Post + \beta_3 FHAshare \times Post + \theta + \varepsilon \tag{2}$$

where ΔP is local house price growth (in log points), *FHAshare* is the fraction of all home purchase loans in 2014 that carried FHA insurance, and *Post* is an indicator for the period after the premium cut. The vector θ contains a set of fixed effects described below. We compare price growth in windows of 6, 12 and 24 months prior to the premium cut to matching post-cut windows. FHA shares are observed in the HMDA data at the census tract level. For house price data, we use the ZIP code level single-family home house price index from Zillow. Estimates of house prices at the census tract level are produced by averaging across the price levels of ZIP codes that intersect with the target tract, weighted by the fraction of housing units in that tract that appear in each ZIP code.

Equation (2) describes a difference-in-differences estimator with a continuous measure of treatment status (the FHA share). A key identification concern is that neighborhoods with high

FHA shares may experience different economic conditions and be on different price trends than neighborhoods with low shares.

To deal with this issue, we try a number of specifications controlling for various fixed effects. First, we include county-by-time period fixed effects. This specification absorbs any regional differences in economic conditions that might affect high and low FHA share areas differently. Second, we use a matching estimator to compare tracts to their peers with nearly identical pre-trends in home price growth. We place each tract into buckets based on the growth rate in house prices across 2014, with bin widths of a single percentage point, and then control for fixed effects of these buckets interacted with the pre/post dummy. The final specification uses fixed effects for the combination of time, county and price growth bins.

The coefficient of interest, β_3, indicates how acceleration in house prices after the MIP reduction correlates with the tract's 2014 FHA share. Estimates of β_3 are presented in Table 5 for various time windows. The FHA share is measured between 0 and 1, so the coefficients represent the estimated difference in post-MIP cut log price growth between a hypothetical tract whose population was completely reliant on FHA insurance to one whose population did not use FHA insurance at all. Overall, the estimates do not provide strong evidence that FHA reliant areas experienced more rapid price growth as a result of the FHA premium reduction. The estimates in the second column suggest a modest positive effect after 12 and 24 months, but these are not robust to matching on pre-trend growth, as seen in columns 3 and 4.

Our finding of an elastic demand response with little change in prices may be reconciled to some extent by the mechanism outlined in Anenberg and Kung (2017). They argue that the average time-on-market of homes for sale could absorb demand shocks from interest rates, with house prices showing little change. In addition, our finding of no intensive margin response to the MIP reduction may have mitigated any upward pressure on prices.[27]

7.3 Loan Performance

Earlier, we found that the reduced premiums affected the composition of the borrower pool by pulling in lower-income borrowers. If marginal borrowers have a higher than average propensity

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[27] Rappoport (2016) models the process by which interest rate subsidies get capitalized into house prices, offsetting much of the benefit of the subsidy to borrowers.

to miss payments, the overall delinquency rate could rise and act as a drag on neighborhood home prices. However, at the same time, the reduced MIP lowers payments for all new borrowers, which could help borrowers stay current (see Ehrlich and Perry, 2015 and Fuster and Willen, forthcoming). Thus, ex-ante, the overall effect of the MIP cut on delinquency is ambiguous.

We test for an effect of the 50 basis point reduction in MIPs on delinquencies using the McDash data, which tracks loan performance over time. We estimate (1) on the probability a payment for a treatment-group loan is ever 30 days or more past due within the first 12 months after origination. Results are presented in Table 4. We cannot reject the null hypothesis that there was no change in the delinquency rate among the treatment group, despite the influx of new borrowers and the lower insurance premiums. It is possible that these two opposing forces cancel each other out, or that the net effect is simply too small to be detected.

8. Conclusion

This paper uses a sudden drop in the pricing of government-provided mortgage insurance to identify how the volume of home buying responds to the cost of credit. Using a regression discontinuity design and loan-level data, we find that a 50 basis point reduction in the FHA's annual mortgage insurance premium increased home purchase borrowing by FHA-likely borrowers (those with below-average credit scores and less than a 20 percent down payment) by about 14 percent. Further evidence suggests that the reduced premiums both improved applicants' debt payments-to-income ratios, thus easing underwriting constraints, and encouraged a greater number of applicants to enter the market.

We also find heterogeneity in the borrowing response by income, with low- and moderate-income borrowers exhibiting a strong response to the premium cut, and high-income borrowers demonstrating little or no response. Although we study the FHA market, many homebuyers outside the FHA market (those getting VA-guaranteed loans and conventional, or non-government, loans) may have similar liquidity positions and be responsive to interest rates. In 2014-2015, about 30 percent of non-FHA home buyers had incomes below the median of $60,000 for FHA borrowers; roughly 45 percent made a down payment of less than 20 percent;

and the distribution of DTIs suggests many borrowers bump up against DTI constraints in the non-FHA market.[28] Thus, we believe the evidence in this paper demonstrates that policies, including monetary policy, that influence the cost of mortgage credit can have a significant and immediate effect on housing demand. That said, the overall demand response to an interest rate shock that applies to all households will be more muted than the response to the MIP cut we estimate, as our target population contains a higher proportion of relatively low-income, low-wealth borrowers. In this sense, our findings suggest that subsidizing FHA premiums may be more effective at increasing home buying than subsidizing interest rates in general, as the FHA implicitly targets a borrower population with more elastic demand. General equilibrium effects could also attenuate the benefits or costs of interest rate shocks to borrowers, as rate changes may be capitalized into home values, although evidence provided in this paper and others in the literature suggests that interest rates exert only weak influence over house prices. Furthermore, capacity constraints could mitigate the effect of lower interest rates on home purchase lending, as discussed in Sharpe and Sherlund (2016).

References

Acolin, Arthur, Jesse Bricker, Paul Calem, and Susan Wachter (2016). "Borrowing Constraints and Homeownership," *American Economic Review*, vol. 106 (5),pp. 625-629.

Adelino, Manuel, Antoinette Schoar, and Felipe Severino (2012). "Credit Supply and House Prices: Evidence from Mortgage Market Segmentation," *NBER Working Paper Series* 17832. Cambridge, Mass.: National Bureau of Economic Research, February, http://www.nber.org/papers/w17832.pdf

Agarwal, Sumit, Gene Amromin, Souphala Chomsisengphet, Tomasz Piskorski, Amit Seru and Vincent Yao (2015). "Mortgage Refinancing, Consumer Spending, and Competition: Evidence from the Home Affordable Refinancing Program," *NBER Working Paper Series* 10485.

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[28] We estimate the fraction of non-FHA home buyers with incomes below $60,000 from HMDA data. The fraction of non-FHA buyers with a down payment of less than 20 percent assumes that all VA borrowers put down less than 20 percent, and we estimate that about 1.3 million out of 3.6 million conventional borrowers took out PMI, implying that they put down less than 20 percent. Goodman et al. (2016) report that PMI accounted for about 38 percent of all insured or guaranteed loans in 2014-2015, which translates into about 1.3 million conventional mortgages with PMI. Finally, regarding DTI constraints, the GSEs impose a 45 percent cap on DTI ratios, which is allowed to rise to 50 percent for loans with strong compensating factors. As can be seen in Appendix Figure A10, these thresholds are very important for borrowers in the non-FHA space as well. Nearly 10 percent of non-FHA borrowers in Optimal Blue are just under one of these DTI thresholds (in the sense that adding a 50 basis point MIP would push them over) while only 3 percent are just above these thresholds.

Cambridge, Mass.: National Bureau of Economic Research, August,
http://www.nber.org/papers/w21512.pdf

Anenberg, Elliot, Aurel Hizmo, Edward Kung and Raven Molloy (2017). "Measuring Mortgage Credit Availability: A Frontier Estimation Approach," unpublished paper, Board of Governors of the Federal Reserve System, Division of Research and Statistics.

Anenberg, Elliot and Edward Kung (2017). "Interest Rates and Housing Market Dynamics in a Housing Search Model." unpublished paper.

Avery, Robert B., Neil Bhutta, K.P. Brevoort, and Glenn B. Canner (2010). "The 2009 HMDA Data: The Mortgage Market in a Time of Low Interest Rates and Economic Distress," *Federal Reserve Bulletin*, vol. 96 (December), pp. A39-A77.

Bai, Bing, Jun Zhu and Laurie Goodman (2015). "FHA: Time to Stop Overcharging Today's Borrowers for Yesterday's Mistakes." *Urban Wire: Housing and Housing Finance*. Urban Institute.

Benmelech, Efraim, Adam Guren, and Brian T. Melzer (2017). "Making the House a Home: The Stimulative Effect of Home Purchases on Consumption and Investment." National Bureau of Economic Research, No. w23570.

Beraja, Martin, Andreas Fuster, Erik Hurst and Joseph Vavra (2017). "Regional Heterogeneity and Monetary Policy," *NBER Working Paper Series* 23270. Cambridge, Mass.: National Bureau of Economic Research, March, http://www.nber.org/papers/w23270.

Best, Michael Carlos, and Henrik Jacobsen Kleven (2016). "Housing Market Responses to Transaction Taxes: Evidence From Notches and Stimulus in the UK."

Best, Michael Carlos, James Cloyne, Ethan Ilzetzki, and Henrik Jacobsen Kleven (2015). "Interest Rates, Debt and Intertemporal Allocation: Evidence from Notched Mortgage Contracts in the United Kingdom." Bank of England Staff Working Paper No 543.

Board of Governors of the Federal Reserve System (2008). "Federal Reserve announces it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises and mortgage-backed securities backed by Fannie Mae, Freddie Mac and Ginnie Mae" press release, November 25.
https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm

Bhutta, Neil and Benjamin J. Keys (2016). "Interest Rates and Equity Extraction during the Housing Boom," *American Economic Review*, vol. 106 (7), pp.1742-74.

Bhutta, Neil, and Daniel Ringo (2015). "Effects of the Ability to Repay and Qualified Mortgage Rules on the Mortgage Market." Board of Governors of the Federal Reserve System, December 29, 2015, https://www.federalreserve.gov/econresdata/notes/feds-notes/2015/effects-of-the-ability-to-repay-and-qualified-mortgage-rules-on-the-mortgage-market-20151229.html.

Bhutta, Neil, and Daniel Ringo (2016a). "Residential Mortgage Lending from 2004 to 2015: Evidence for the Home Mortgage Disclosure Act Data," *Federal Reserve Bulletin,* vol. 102 (6), pp. 1-26.

Bhutta, Neil, and Daniel Ringo (2016b). "Changing FHA Mortgage Insurance Premiums and the Effects on Lending," Finance and Economics Discussion Series. Washington: Board of Governors of the Federal Reserve System, September 29, 2016, http://dx.doi.org/10.17016/2380-7172.1843.

Davis, Morris A., Stephen D. Oliner, Tobias J. Peter, and Edward J. Pinto (2016). "Credit Liberalization in a Seller's Market – FHA's 2015 Mortgage Insurance Premium Cut," a speech presented at the Fifth International Conference on Housing Risk held at the American Enterprise Institute, Washington, DC, October 5.

DeFusco, Anthony A., Stephanie Johnson, and John Mondragon (2017). "Regulating Household Leverage," Kellogg School of Management, March.

DeFusco, Anthony A., and Andrew Paciorek (2017). "The Interest Rate Elasticity of Mortgage Demand: Evidence from Bunching at the Conforming Loan Limit," *American Economic Journal: Economic Policy*, vol. 9 (February), pp. 210-240.

DiMaggio, Marco, Amir Kermani, Benjamin J. Keys, Tomasz Piskorski, Rodney Ramcharan, Amit Seru and Vincent Yao (Forthcoming). "Interest Rate Pass-Through: Mortgage Rates, Household Consumption, and Voluntary Deleveraging," *American Economic Review*.

Dokko, Jane, Brian M. Doyle, Michael T. Kiley, Jinill Kim, Shane Sherlund, Jae Sim, Skander Van Den Heuvel (2011). "Monetary Policy and the Global Housing Bubble," *Econ Policy* , vol. 26 (66), pp. 237-287.

Ehrlich, Gabriel and Jeffrey Perry (2015). "Do Large-Scale Refinancing Programs Reduce Mortgage Defaults? Evidence From a Regression Discontinuity Design," Congressional Budget Office , Working Paper Series, 2015-06. https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/50871-FHA.pdf

Feldman, Ron J (2002). "Mortgage Rates, Homeownership Rates, and Government-Sponsored Enterprises," Federal Reserve Bank of Minneapolis, *The Region*, vol. 16 (1), pp. 4-24.

Fuster, Andreas, and Basit Zafar (2015). "The Sensitivity of Housing Demand to Financing Conditions: Evidence from a Survey," Staff Report 702. New York: Federal Reserve Bank of New York (August).

Fuster, Andreas and Paul Willen (Forthcoming). "Payment Size, Negative Equity, and Mortgage Default," *American Economic Journal: Economic Policy*

Glaeser, Edward L., Joshua D. Gottlieb, and Joseph Gyourko (2013). "Can Cheap Credit Explain the Housing Boom?" in Edward L. Glaeser and Todd Sinai, *Housing and the Financial Crisis* Chicago: University of Chicago Press, pp. 301-359.

Goodman, Laurie, Alanna McCargo, Ellen Seidman, Jim Parrott, Sheryl Pardo, Jun Zhu, Wei Li, Bing Bai, Karan Kaul, Maia Woluchem and Alison Rincon (2016). "Housing Finance at a Glance: A Monthly Chartbook, June 2016," webpage, *Urban Institute*, http://www.urban.org/research/publication/housing-finance-glance-monthly-chartbook-june-2016/view/full_report.

Hamilton, James D. (2008). "Daily monetary policy shocks and new home sales." *Journal of Monetary Economics*, vol 55 (7), pp. 1171-1190.

Hilber, Christian AL, and Tracy M. Turner (2014). "The Mortgage Interest Deduction and its Impact on Homeownership Decisions," *Review of Economics and Statistics,* vol. 96 (4), pp.. 618-637.

Imbens, Guido W., and Thomas Lemieux (2008). "Regression Discontinuity Designs: A Guide to Practice," *Journal of Econometrics,* vol. 142 (2), pp. 615-635.

Jappelli, Tullio and Luigi Pistaferri (2007). "Do People Respond to Tax Incentives? An Analysis of the Italian Reform of the Deductibility of Home Mortgage Interests," *European Economic Review*, vol. 51, pp. 247-271.

Johnson, Kathleen W., and Geng Li (2010). "The Debt-Payment-to-Income Ratio as an Indicator of Borrowing Constraints: Evidence from Two Household Surveys," *Journal of Money, Credit and Banking*, vol. 42 (7), pp. 1373-1390.

Kuttner, Kenneth N. (2012). "Low Interest Rates and Housing Bubbles: Still no Smoking Gun," In Douglas Evanoff, Cornelia Holthausen, George Kaufman, and Manfred Kremer, eds., *The Role of Central Banks in Financial Stability: How Has It Changed*. World Scientific Publishing Co. Pte. Ltd., pp. 159-186.

Kuttner, Kenneth N., and Ilhyock Shim (2016). "Can Non-Interest Rate Policies Stabilize Housing Markets? Evidence from a Panel of 57 Economies," *Journal of Financial Stability*, vol. 26, pp. 31-44.

Luck, Stephan and Tom Zimmerman (2017). "Employment Effects of Unconventional Monetary Policy: Evidence from QE," Available at SSRN: https://ssrn.com/abstract=3002047

Martins, Nuno C., and Ernesto Villanueva (2006). "The impact of mortgage interest-rate subsidies on household borrowing." *Journal of Public Economics,* vol. 90 (8), pp. 1601-1623.

Martins, Nuno C., and Ernesto Villanueva (2009). "Does the High Cost of Mortgage Debt Explain Why Young Adults Live with Their Parents?" *Journal of the European Economic Association*, vol. 7 (5), pp. 974-1010.

Park, Kevin (2017). "An Event Study in Mortgage Insurance Premiums and Choice of Loan Term," unpublished paper.

Rappoport, David (2016). "Do Mortgage Subsidies Help or Hurt Borrowers?" Finance and Economics Discussion Series 2016-81. Washington: Board of Governors of the Federal Reserve System, October, https://doi.org/10.17016/FEDS.2016.081.

Shahdad, Sarah (2017). "Renters Report Future Home Buying Optimism, While Family Financial Assistance is Most Available to Populations with Higher Homeownership Rates,"

Sharpe, Steve A. and Shane M. Sherlund (2016). "Crowding Out Effects of Refinancing on New Purchase Mortgages," *Review of Industrial Organization*, vol. 48 (2), pp. 209-239.

Sommer, Kamila and Paul Sullivan (2017). "Implications of U.S. Tax Policy for House Prices, Rents and Homeownership," unpublished paper, Board of Governors of the Federal Reserve System, Division of Research and Statistics.

U.S. Department of Housing and Urban Development (2012). *Annual Report to Congress Regarding the Financial Status of the FHA Mutual Mortgage Insurance: Fund Fiscal Year 2012*. Washington: Department of Housing and Urban Development, https://portal.hud.gov/hudportal/documents/huddoc?id=F12MMIFundRepCong111612.pdf

U.S. Department of Housing and Urban Development (2014). *Annual Report to Congress Regarding the Financial Status of the FHA Mutual Mortgage Insurance: Fund Fiscal Year 2014*. Washington: Department of Housing and Urban Development, https://portal.hud.gov/hudportal/documents/huddoc?id=FY2014FHAAnnRep11_17_14.pdf

U.S. Department of Housing and Urban Development (2015). *Annual Report to Congress Regarding the Financial Status of the FHA Mutual Mortgage Insurance: Fund Fiscal Year 2015*. Washington: Department of Housing and Urban Development, https://portal.hud.gov/hudportal/documents/huddoc?id=2015fhaannualreport.pdf

The White House, Office of the Press Secretary (2015). "FACT SHEET: Making Homeownership More Accessible and Sustainable," Washington: The White House, https://obamawhitehouse.archives.gov/the-press-office/2015/01/07/fact-sheet-making-homeownership-more-accessible-and-sustainable

Zinman, Jonathan (2015). "Household debt: Facts, puzzles, theories, and policies." *Annual Review of Economics*, vol 7, (1), pp. 251-276.

Figure 1. Treatment Group Share of Home Purchase Loans by Week of Rate Lock
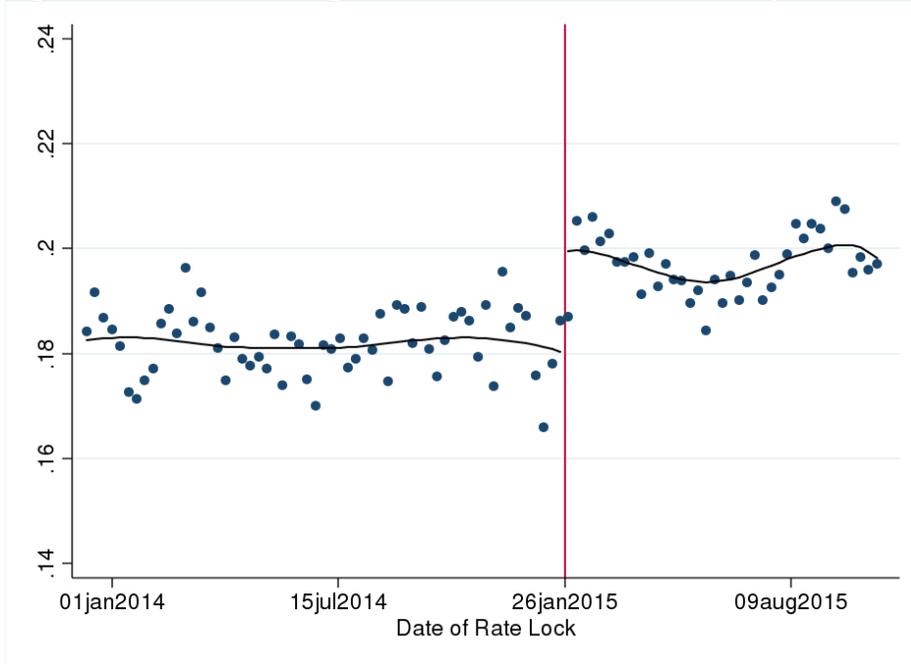

Note: Treatment group defined as borrowers with a FICO score less than 680 and an LTV above 80 percent. The vertical line marks the week of January 26, 2015, the date of the FHA annual MIP reduction. Curve of best fit overlaid on weekly data.
Source: Optimal Blue

Figure 2. Mortgage Rate and FHA Premium, 2001-2015
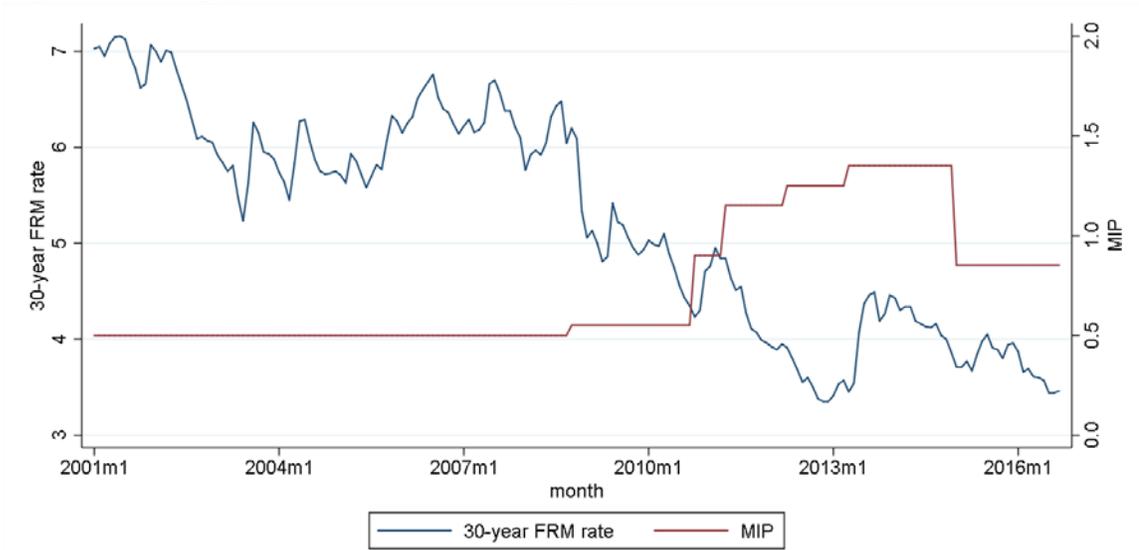
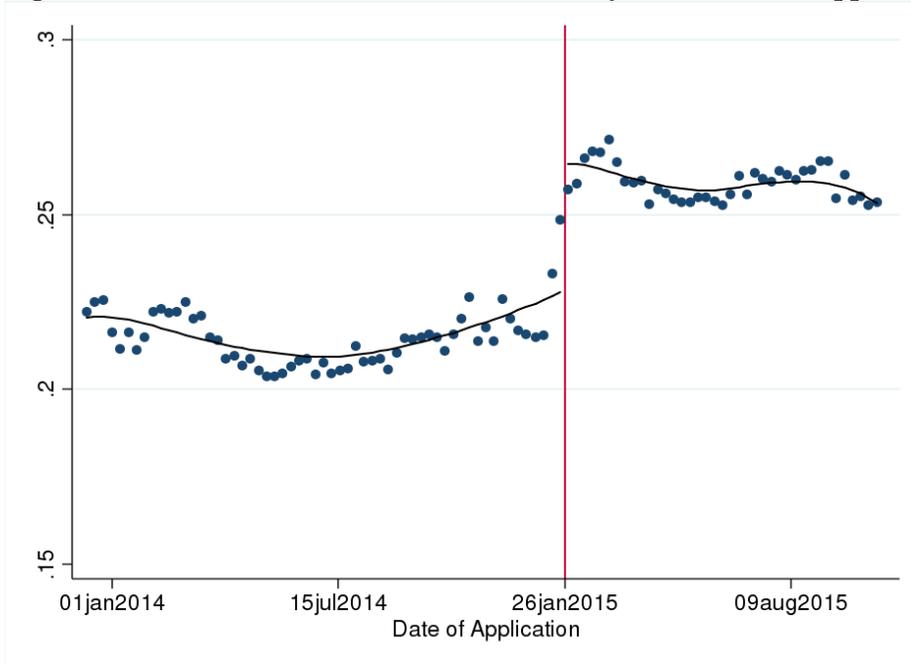Source: Freddie Mac and HUD.

Figure 3. Count of Home Purchase Loan Originations for 1- to 4-Family, Owner-Occupied Properties, by Week of Loan Application
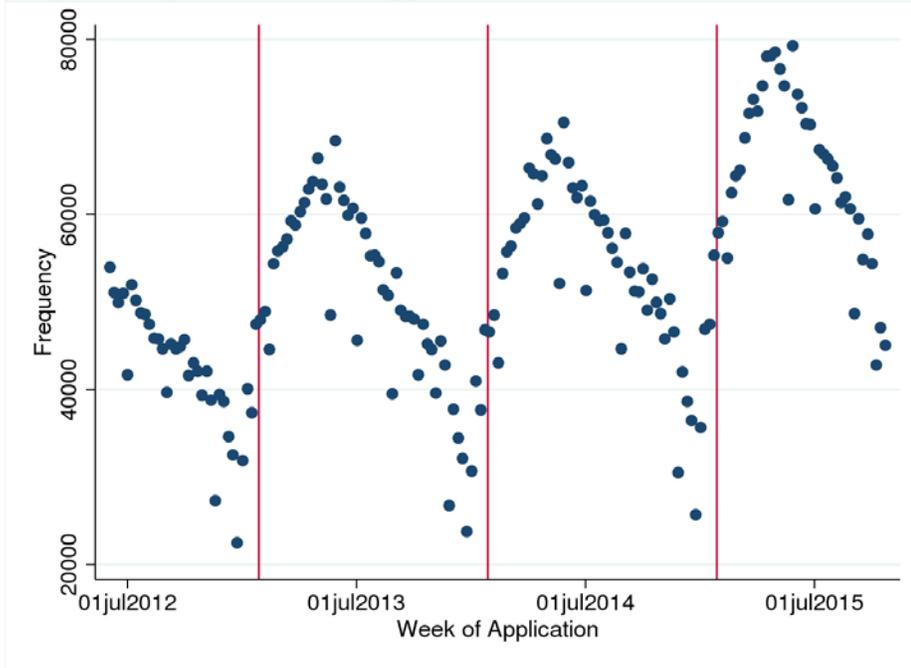
Note: Vertical lines mark the weeks of January 26, 2013, 2014 and 2015.
Source: Data reported under HMDA.

Figure 4. FHA Share of Home Purchase Loans by Week of Loan Application

Note: The vertical line marks the week of January 26, 2015, the week of the FHA annual MIP reduction. Curve of best fit overlaid on weekly data.
Source: Data reported under HMDA.

Figure 5. Regression Discontinuity Estimates of the Effect of MIP Cut on Treatment Group Share, by Local Economic Conditions


Note: Figure shows regression discontinuity estimates of the change in the share of home purchase loans going to treatment group borrowers around the week of January 26, 2015, for each decile of county unemployment rate in 2014, house price growth from 2011 through 2014, and household income growth from 2011 through 2014. Estimates using a 25-week bandwidth shown. Circles represent point estimates, bars represent the 95 percent confidence interval. Standard errors clustered by the week of rate lock. Source: Optimal Blue, Census Bureau and Zillow.

Figure 6. Distribution of DTI Ratios for FHA Home Purchase Loans

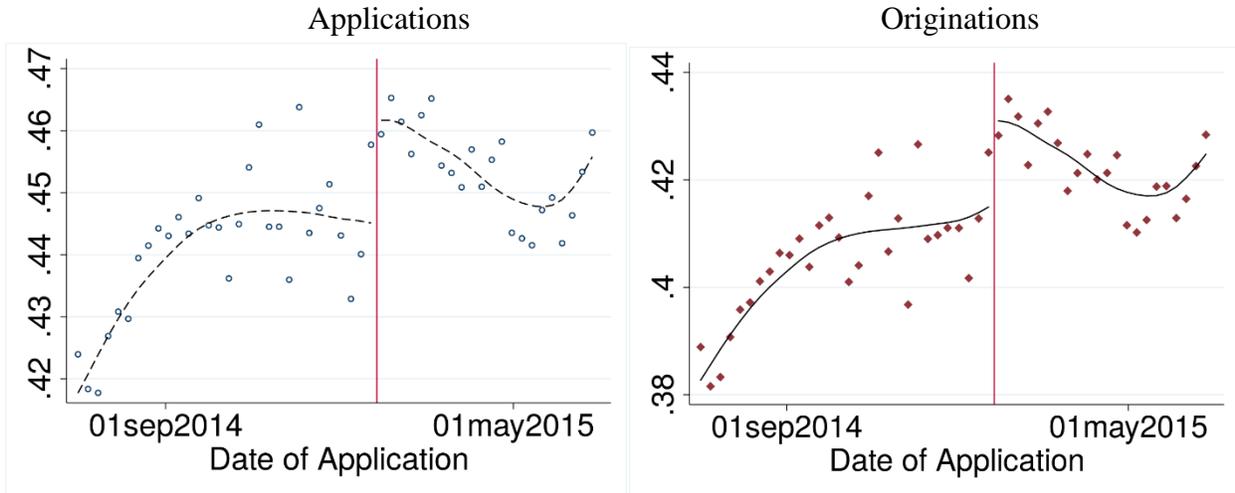**A. FICO Score < 620**
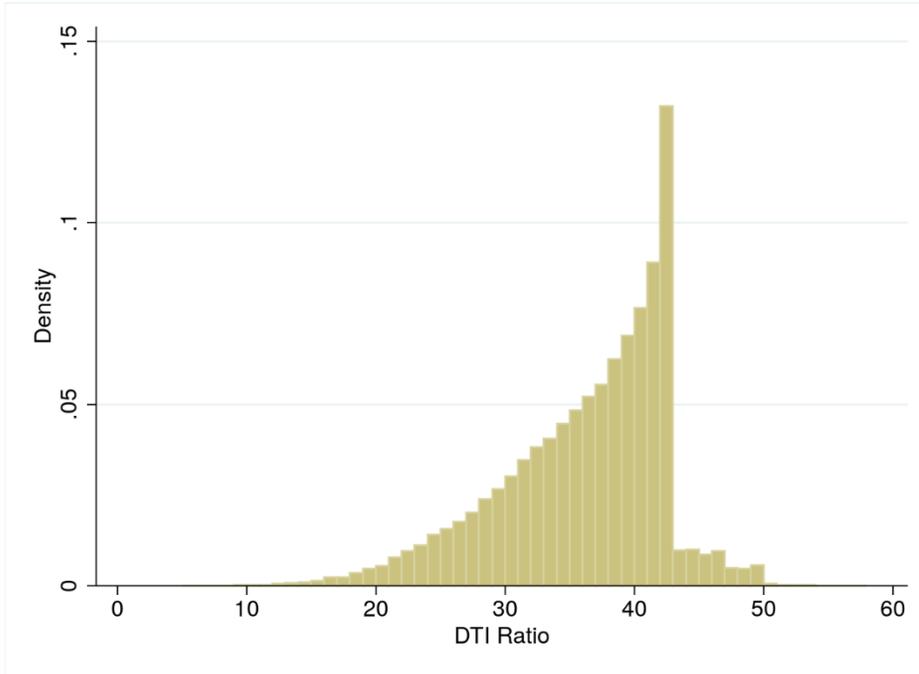
B. FICO Score ≥ 620
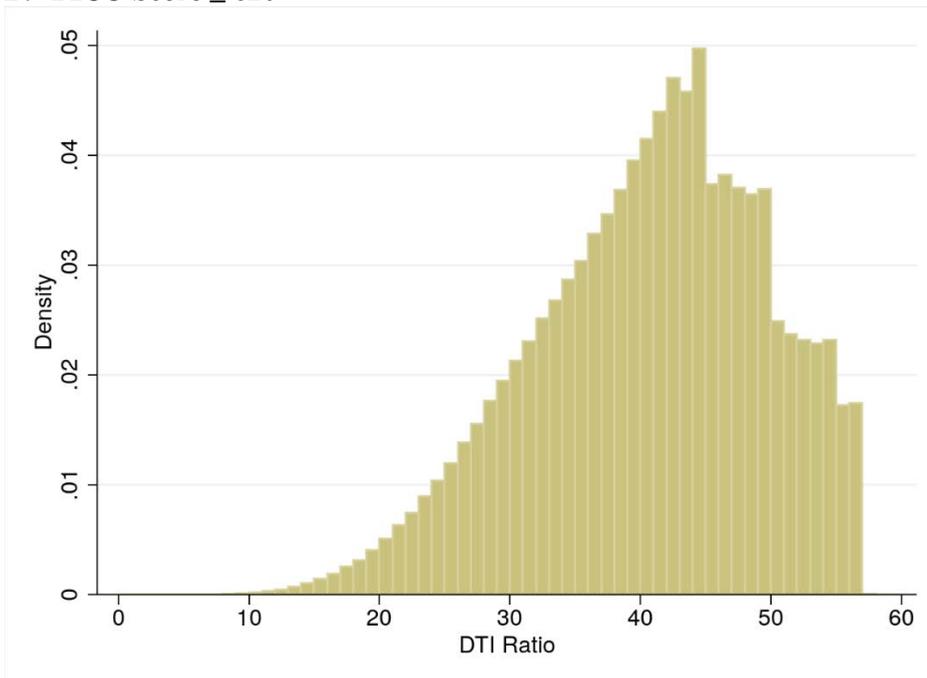
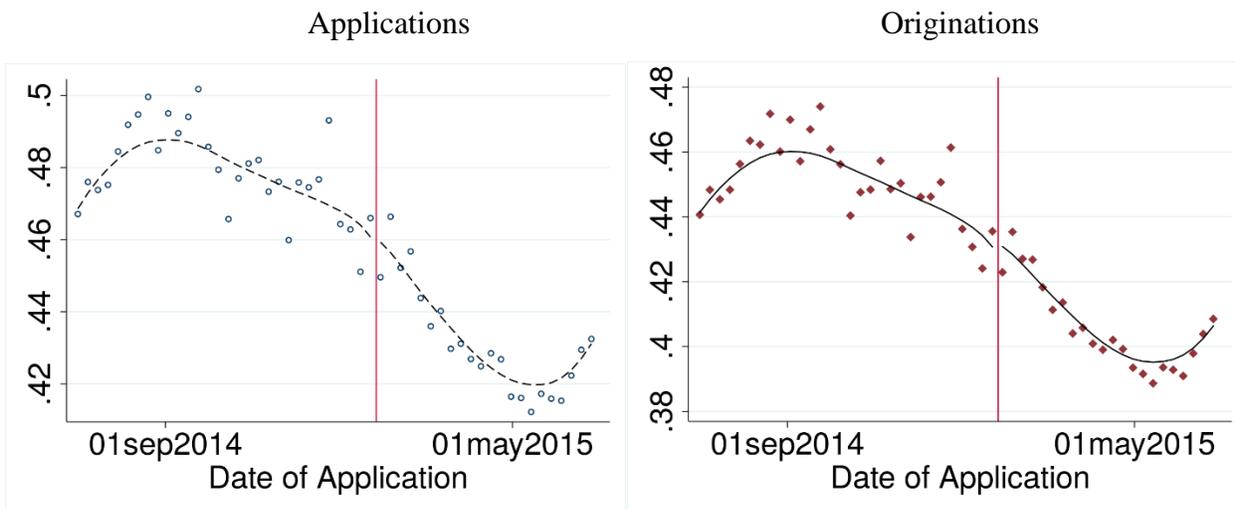Note: Sample densities in one-percentage point bins.
Source: HUD loan-level data.

Figure 7: Ratio of Lower-Income to Higher-Income Applicants among Applications and Originations, by Week of Loan Application and LTI Ratio

A. Above-Median LTI Ratio

B. Below-Median LTI Ratio

Note: Higher- and lower-income cutoff set at $75,000 annual income. The two charts in panel A plot the ratio of lower-income, high LTI applicants and borrowers to all higher income applicants and borrowers. The two charts in panel B plot the ratio of lower-income, low LTI applicants and borrowers to all higher income applicants and borrowers. The red vertical lines indicate the week of January 26, 2015. Curve of best fit overlaid on weekly data. Source: Data collected under HMDA

Figure 8: Year-over-Year Log Growth in the Number of Home Purchase Applications and Originations, by Week of Loan Application

A. 2015
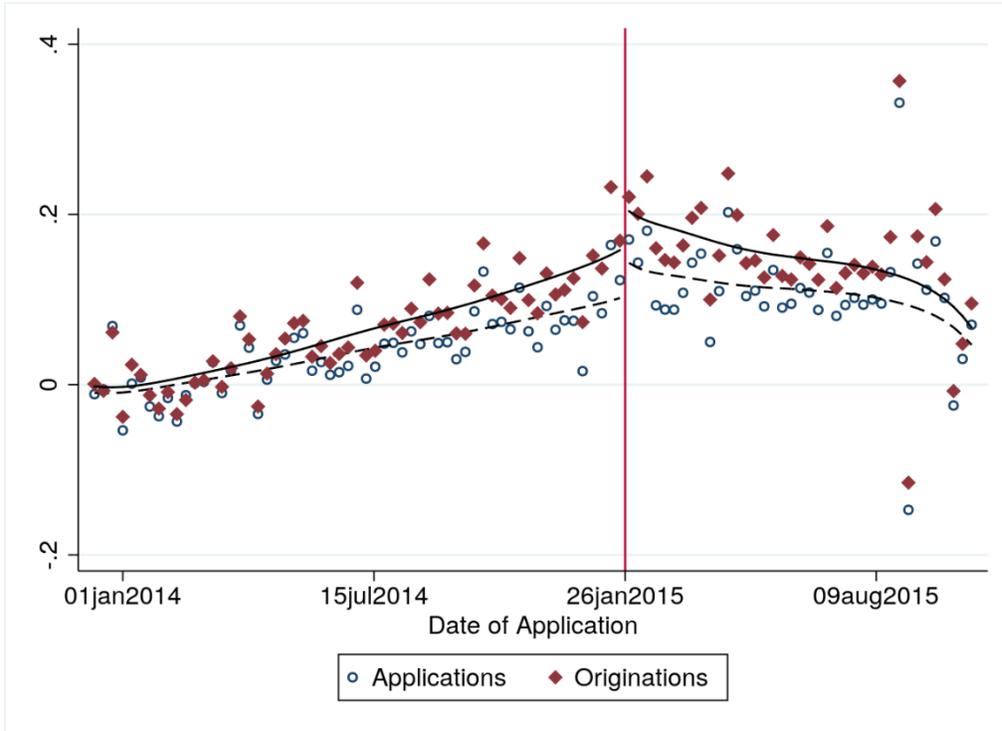
B. 2014
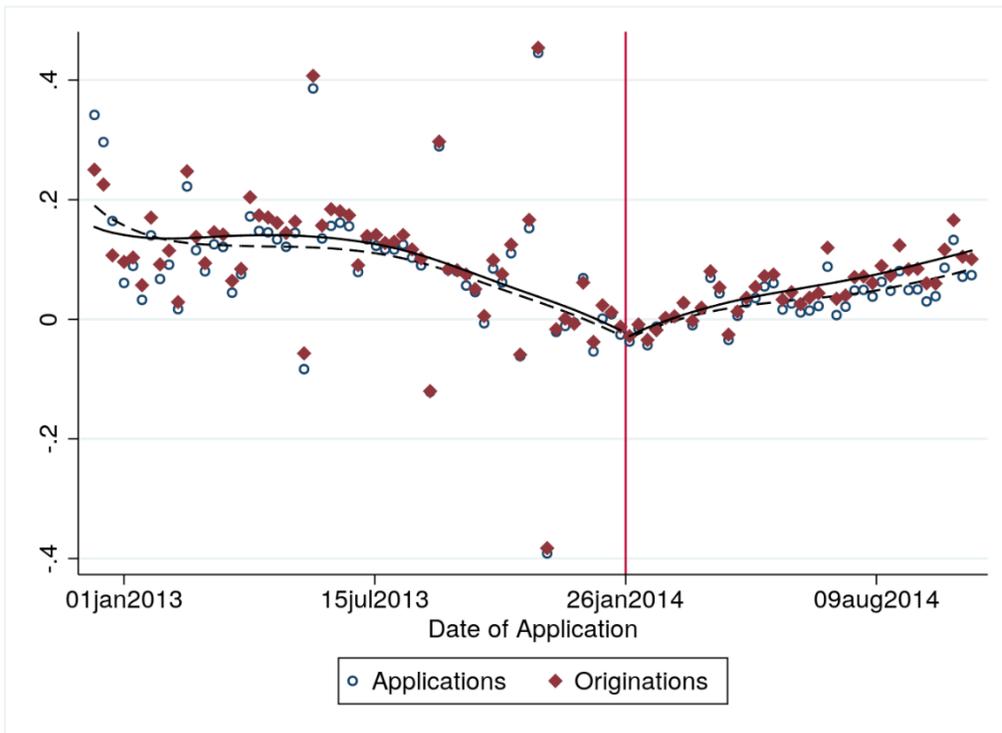
Source: Data collected under HMDA

Table 1. Summary of Loan Level Data for 2014-15

	HMDA	Optimal Blue	HMDA/Optimal Blue Merge	HMDA/McDash Merge
			Data Source	

A. All Loans

	HMDA	Optimal Blue	HMDA/Optimal Blue Merge	HMDA/McDash Merge
Loan Amount ($, 000's)	244	236	241	241
	(210)	(155)	(158)	(220)
FHA	0.24	0.3	0.09	0.21
	(0.42)	(0.45)	(0.3)	(0.41)
Income ($, 000's)	101		97	117
	(125)		(89)	(162)
LTV Ratio		89	87.7	84
		(13.3)	(14.1)	(17.1)
FICO Score		719	730	740
		(57)	(54)	(52)
N	5,865,166	1,574,184	542,794	1,679,119

B. FHA Loans

	HMDA	Optimal Blue	HMDA/Optimal Blue Merge	HMDA/McDash Merge
Loan Amount ($, 000's)	185	190	181	169
	(97)	(97)	(84)	(87)
Income ($, 000's)	67		65	64
	(40)		(39)	(38)
LTV Ratio		95.2	95.4	94.9
		(5.5)	(4.8)	(16.5)
FICO Score		679	678	689
		(45)	(44.8)	(44)
N	1,371,074	469,577	49,350	458,485

Note: Sample means shown. Sample standard deviations in parentheses.

Table 2: Regression Discontinuity Estimates of the Effect of the FHA MIP Reduction on Treatment Group Share of Lending

			Bandwidth (Weeks)		
Year	Data Source	Macro controls	12	25	50
2015	Optimal Blue	No	0.021	0.019	0.012
			(0.006)	(0.005)	(0.003)
	HMDA/McDash	No	0.015	0.016	0.013
			(0.004)	(0.003)	(0.002)
	Optimal Blue	Yes	0.015	0.018	0.014
			(0.005)	(0.003)	(0.003)
	HMDA/McDash	Yes	0.011	0.014	0.013
			(0.005)	(0.003)	(0.002)
2014	Optimal Blue	No	-0.004	-0.002	-0.005
			(0.004)	(0.004)	(0.003)
	HMDA/McDash	No	0.004	0.006	0.002
			(0.003)	(0.003)	(0.003)
2016	Optimal Blue	No	-0.006	0.006	0.004
			(0.005)	(0.005)	(0.003)

Note: Table shows the estimated discontinuity at January 26, 2015 in the share of home purchase loans going to the treatment group. Estimated placebo tests for discontinuities on January 26 in 2014 and 2016 are also shown. Effects estimated using a local linear regression and a triangular weighting kernel. Treatment group share refers to the fraction of total home purchase loans for which the borrower had a FICO score below 680 and an LTV ratio between 80 and 100 percent. Macro controls are the national unemployment rate, the yield on 1 year and 10 year treasury securities, and the value of the S&P 500 stock market index. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table 3: Effect of FHA MIP Reduction on Treatment Group Share, by Borrower Income

Data Source	Borrower Income	Bandwidth (Weeks)		
		12	25	50
Optimal Blue	Less than $46,001	0.005	0.005	0.006
		(0.002)	(0.002)	(0.001)
	$46,001-$66,000	0.003	0.004	0.004
		(0.002)	(0.001)	(0.001)
	$66,001-$96,000	0.002	0.002	0.002
		(0.001)	(0.001)	(0.001)
	Greater than $96,000	-0.004	-0.002	-0.002
		(0.002)	(0.002)	(0.001)
HMDA/McDash	Less than $46,001	0.008	0.008	0.005
		(0.002)	(0.001)	(0.001)
	$46,001-$66,000	0.004	0.004	0.003
		(0.002)	(0.001)	(0.001)
	$66,001-$96,000	0.003	0.003	0.003
		(0.002)	(0.001)	(0.001)
	Greater than $96,000	0.0002	0.001	0.003
		(0.001)	(0.001)	(0.001)

Note: Table shows the estimated discontinuity at January 26, 2015 in the fraction of total home purchase loans going to borrowers with FICO scores below 680 and LTV ratios between 80 and 100 percent in each of the income categories. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table 4: Effect of the FHA MIP Reduction on Loan Amounts, Purchase Prices and Delinquencies

Outcome Variable	Include Control Group?	Underwriting Controls	Bandwidth (Weeks)		
			12	25	50
Log Loan Amount	Yes	No	-0.089	-0.070	-0.074
			(0.016)	(0.014)	(0.012)
	Yes	Yes	-0.027	-0.019	-0.018
			(0.020)	(0.013)	(0.009)
Log Purchase Price	Yes	No	-0.094	-0.069	-0.073
			(0.017)	(0.017)	(0.014)
	Yes	Yes	-0.015	-0.004	0.001
			(0.019)	(0.013)	(0.009)
Log Loan Amount	No	No	-0.089	-0.064	-0.045
			(0.019)	(0.014)	(0.012)
	No	Yes	-0.016	-0.002	0.011
			(0.018)	(0.012)	(0.008)
Log Purchase Price	No	No	-0.094	-0.070	-0.052
			(0.019)	(0.014)	(0.012)
	No	Yes	-0.019	-0.006	0.006
			(0.019)	(0.012)	(0.008)
Delinquency Rate for Treatment Group	Yes	No	0.006	-0.002	-0.004
			(0.005)	(0.006)	(0.004)
	Yes	Yes	0.006	-0.003	-0.004
			(0.007)	(0.005)	(0.004)

Note: Table shows the estimated discontinuity at January 26, 2015 in the outcome variable for the treatment group. Data is from Optimal Blue and McDash merged with data collected under the Home Mortgage Disclosure Act. Effects estimated using a local linear regression and a triangular weighting kernel. Treatment group refers to borrowers with a FICO score below 680 and an LTV ratio between 80 and 100 percent, while the control group is all others. Delinquency rate is the fraction of loans with a payment that was 30 days or more past due within 12 months after origination. Control variables consist of flexible functions of borrower income and FICO score. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table 5: Effect of Local FHA Share on Census Tract House Price Growth after MIP Reduction

Time Window	(1)	(2)	(3)	(4)
6 Months	-0.002	-0.00001	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.001)
12 Months	0.002	0.011	0.0001	0.0002
	(0.005)	(0.004)	(0.0001)	(0.0002)
24 Months	0.014	0.030	-0.016	0.004
	(0.014)	(0.009)	(0.013)	(0.005)
County-by-Time Fixed Effects		X		
Pre-Period Growth Rate-by-Time Fixed Effects			X	
County-by-Pre-Period Growth Rate-by-Time Fixed Effects				X
				N=55,743

Note: Table shows the estimated influence of the share of loans in 2014 that used FHA insurance on the subsequent growth in house prices at the census tract level. Prices are measured in logs. The FHA share takes values between 0 and 1. The time window refers to the number of months before and after January 2015 house price growth is measured over. Standard errors, shown in parentheses, are adjusted for clustering at the county level.

Appendix (FOR ONLINE PUBLICATION)

A1. Robustness of the Main Result to Treatment Group Definition

Table A1 shows the estimated discontinuity at January 26, 2015 in the treatment group share of loans is robust to alternative definitions of treatment and control groups. In the first row, we repeat the headline result from Table 2 for comparison – this is the estimated effect in the Optimal Blue data comparing lending to borrowers with FICO scores below 680 and LTV scores above 80 percent to all others.

In the next three rows we try different control groups. In the second row, we restrict the control group to borrowers with FICO scores above 680 and LTV ratios below 80 percent. Borrowers in this group rarely use FHA insurance (1.5 percent in our sample) and so lending in the control group should be minimally responsive to the FHA MIP reduction. In the third row the control group has FICO scores below 680 and LTV ratios below 80 percent. These borrowers use FHA insurance somewhat more frequently (5.5 percent) but may share more similarities with the treatment group, and thus better control for seasonal factors or aggregate shocks that affect the treatment group. Similarly, in the fourth row we define the control group as borrowers with FICO scores above 680 and LTV ratios above 80 percent. Borrowers in this group are substantially more likely to use FHA insurance (29%). In all cases we find a strongly significant effect of the MIP reduction on treatment group share. The point estimates vary, in part because the treatment group represents a different fraction of the estimation sample across rows, from 58 percent in row 2 to 8 percent in row 4.

In rows 5 through 8, we repeat the analysis with a different definition of the treatment group. FICO scores are now capped at 650 for this group, increasing the share of treatment group borrowers that use FHA insurance to 92. The size of the discontinuity in treatment group share is re-estimated for the same four variations on the control group. Again, the reduced MIP is found to have a strongly significant effect regardless of the precise definition of treatment and control groups.

A2. Validity of the Identification Strategy

In this section we address four potential issues related to the validity of the RD design. They include: exogeneity in the timing of the MIP reduction with respect to other macroeconomic

trends; the extent to which lenders pass-through the MIP cut to borrowers, exogeneity of the assignment variable; and selection into the treatment group.

A2.1 Was the Timing of the MIP Reduction Exogenous?

To be certain that we can attribute the increase in treatment group share of borrowing to the reduced FHA premiums, we need to make sure that the other economic drivers of housing demand did not vary discontinuously around January 26. In Figure A2 we plot a variety of economic indicators across time around the date of the premium cut. These are the yields on 1-, and 10-year Treasury securities, the S&P 500 stock market index, and the seasonally adjusted unemployment rate. None of these measures show evidence of a discontinuity around January 26. In addition, we rerun our main RD specifications including these macro series as control variables. The results, shown in Table 2, are robust to adding these controls.

A2.2 Pass-Through of the MIP Reduction to Borrowers

Was the MIP cut fully passed through to borrowers? Previous research has found, for instance, that price reductions in the mortgage backed securities market are not fully passed through to consumer-facing interest rates, particularly in times of high mortgage borrowing volume (Fuster, Lo, and Willen 2017). This research attributes this incomplete pass through to capacity constraints, as mortgage retailers become overwhelmed with demand.

To be sure that the MIP cut was passed through, we test for a discontinuity in the contract interest rate among treatment group borrowers relative to control group borrowers. Full pass through of the MIP reduction to borrowers would imply no change in this rate. Because the premium cut changed the composition of treatment group borrowers by inducing more marginal households into the pool of borrowers, we try specifications with and without controls for various underwriting factors that could influence the rate. Results are presented in Table A4. There appears to be little or no effect on the interest rates treatment group borrowers paid, regardless of specification, implying full pass through of the MIP reduction to borrowers. Notably, the FHA MIP cut we study occurred in January, near the trough of the highly cyclical mortgage market, when there may have been slack capacity for lenders to originate more loans and allow for full pass through.

A2.3 Did Borrowers Shift their Loan Application Date?

As noted earlier, the validity of our RD design depends on whether borrowers delayed their loan applications upon hearing the news to take advantage of the lower premiums. A related concern is that, at the time of the announcement, those who had already submitted an application but not yet reached settlement could withdraw their application and reapply to get the lower premiums. The jump we see in treatment group lending might represent these delayers and withdrawers, rather than a true increase in lending.

However, the implementation of the MIP reduction removed most of the incentive for borrowers to withdraw and re-apply for and FHA loan. Eligibility for the lower FHA premium depends on the FHA "case assignment date" rather than the loan application date. When the new MIP was announced, FHA also announced that existing FHA mortgage applicants who had not yet closed could simply cancel their existing case number and get a new one in order to receive the lower MIP, without withdrawing the loan application (as long as they close on or after January 26th).[29]

Indeed, many borrowers appear to have moved their case number assignment dates. In Figure A3, using loan-level data obtained from HUD on all FHA loans originated from 2011 through 2015 merged to HMDA, we plot the average number of days between loan application and case number assignment for all FHA home purchase loans by week of loan application. While the typical gap is approximately one week, the gap rose substantially for loans with application dates in December 2014 and early January 2015. This pattern is consistent with many borrowers getting new case numbers assigned post-January 26, despite their much earlier loan application dates.

While there was no incentive for FHA applicants to withdraw in response to the MIP news, and most treatment group borrowers were FHA applicants, it is still possible some treatment group applicants withdrew and then reapplied. Using the merge between HMDA applications and Optimal Blue rate locks, we can test for an increase in the withdrawal rate of treatment group applications (among those that made it to rate lock before withdrawing).

In Figure A5 we plot the share of all withdrawn loans for which the applicant was a treatment group household, by the week of application. A rise in treatment group withdrawals in late 2014 and early 2015, or a sharp fall in withdrawals after January 26, 2015, might suggest that

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[29] FHA made clear the ability for borrowers to get a new case number assignment date in an FAQ released at the time they announced the new premium structure. See Figure A4.

borrowers were manipulating their application date in response to the lower premiums. No such pattern is apparent, however, as the share of withdrawn loans by treatment group applicants holds steady for the months around the MIP reduction.

In addition to withdrawals, we may be concerned about the possibility that some borrowers delayed applying in response to the news of the lower premiums. Again, there was no actual incentive to do so, as borrowers could always get a case number assignment after the 26th even with an earlier application date. There was also very limited scope for delay – the White House announced the premium reduction less than 3 weeks before it was implemented. Inspection of Figures 1 and A6 also reveals no indication of a sudden dip in applications or rate locks in the few weeks just before the premium reductions, suggesting that borrowers were not delaying their applications.

A2.4 Is Selection into the Treatment Group Exogenous?

We demonstrate above that the fraction of home purchase loans going to borrowers with a FICO score below 680 and an LTV ratio in excess of 80% jumped discontinuously when the FHA reduced its premiums. A concern with our interpretation of this finding is that the amount of down payment is a choice made by the borrower, so there is potential for endogenous selection. If borrowers who counterfactually would have put 20% of the purchase price or more down under the old FHA premiums put down less than 20% given the new MIP, our estimates would be biased upward.

We believe endogenous selection into the treatment group is at most a minor source of bias, for several reasons. First, borrowers with a FICO score below 680 were very likely to be part of the treatment group regardless of the FHA's policy—in 2014, only 10 percent of these low-score borrowers had an LTV ratio less than or equal to 80 percent in the Optimal Blue data. Essentially all of these households would have had to "switch" into the treatment group in response to the MIP reduction to explain the magnitude of the discontinuity seen in Figure 1.

Second, the cost of borrowing jumps discontinuously at an 80% LTV ratio, as borrowers have to pay annual and upfront insurance premiums on the entire loan balance once they cross that threshold, in addition to interest and insurance on the additional amount borrowed. Borrowers

with the liquid assets available for a 20% down payment who chose to put less down and get an FHA loan would be costing themselves a substantial amount of money.

Third, while we cannot theoretically rule out the existence of borrowers who responded to the MIP reduction by getting an FHA loan despite being able to afford a 20 percent down payment, we can test for their presence. For a given house value, borrowers face a budget constraint, trading off between the amount of down payment (conversely, the LTV ratio) and the amount of their monthly mortgage payments. With mortgage insurance required above an 80 percent LTV ratio, both the total and marginal "cost" of a higher LTV ratio jump at this threshold. This notch in the budget constraint at 80 percent LTV explains the commonly observed bunching of borrowers right at this threshold. In the Optimal Blue data, over half of borrowers with a FICO score below 680 and an LTV less than or equal to 80 percent in 2014 had an LTV exactly equal to 80 percent. If we assume that borrowers have convex preferences over combinations of LTV ratio and monthly payments (i.e. if the disutility from the marginal dollar of down payment and debt service payments is increasing in their respective levels) then we can show:

1) Any borrower whose optimal LTV under the old (higher) MIP was less than 80 percent will have the same optimal LTV under the new (lower) MIP.
2) For any borrower whose optimal LTV under the new MIP is above 80 percent, and whose optimal LTV under the old MIP was less than or equal to 80 percent, the optimal LTV under the old MIP was exactly 80 percent.

We can therefore test for endogenous selection into the treatment group, as any such "switching" borrowers should be of the second type described above – coming from the group who would choose exactly 80 percent LTV under the old MIP.

We redefine the treatment group as households with a FICO score below 680 and an LTV ratio in excess of 79 percent and re-estimate equation 1. Results are quite similar to those presented in Table 2, indicating that there was not a significant shift of borrowers from an 80 percent LTV ratio to the treatment group in response to the lower MIP. We therefore conclude that the assumption of exogeneity of treatment group status is sound. A graphical demonstration of points 1) and 2) above is presented in Figures A7-A9, and a results using the redefined treatment group are presented in Table A4.

References

Fuster, Andreas, Stephanie H. Lo, and Paul Willen (2017). "The Time-Varying Price of Financial Intermediation in the Mortgage Market," Staff Report 805. New York: Federal Reserve Bank of New York (January).

Appendix **Figure A1** shows the time series pattern of Google search volume for the phrases "fha mortgage" and "fha mip reduction" from mid-2014 through February 2015. We downloaded the data from Google Trends on April 17, 2017.

Figure A1: FHA-Related Internet Search Volume Over Time
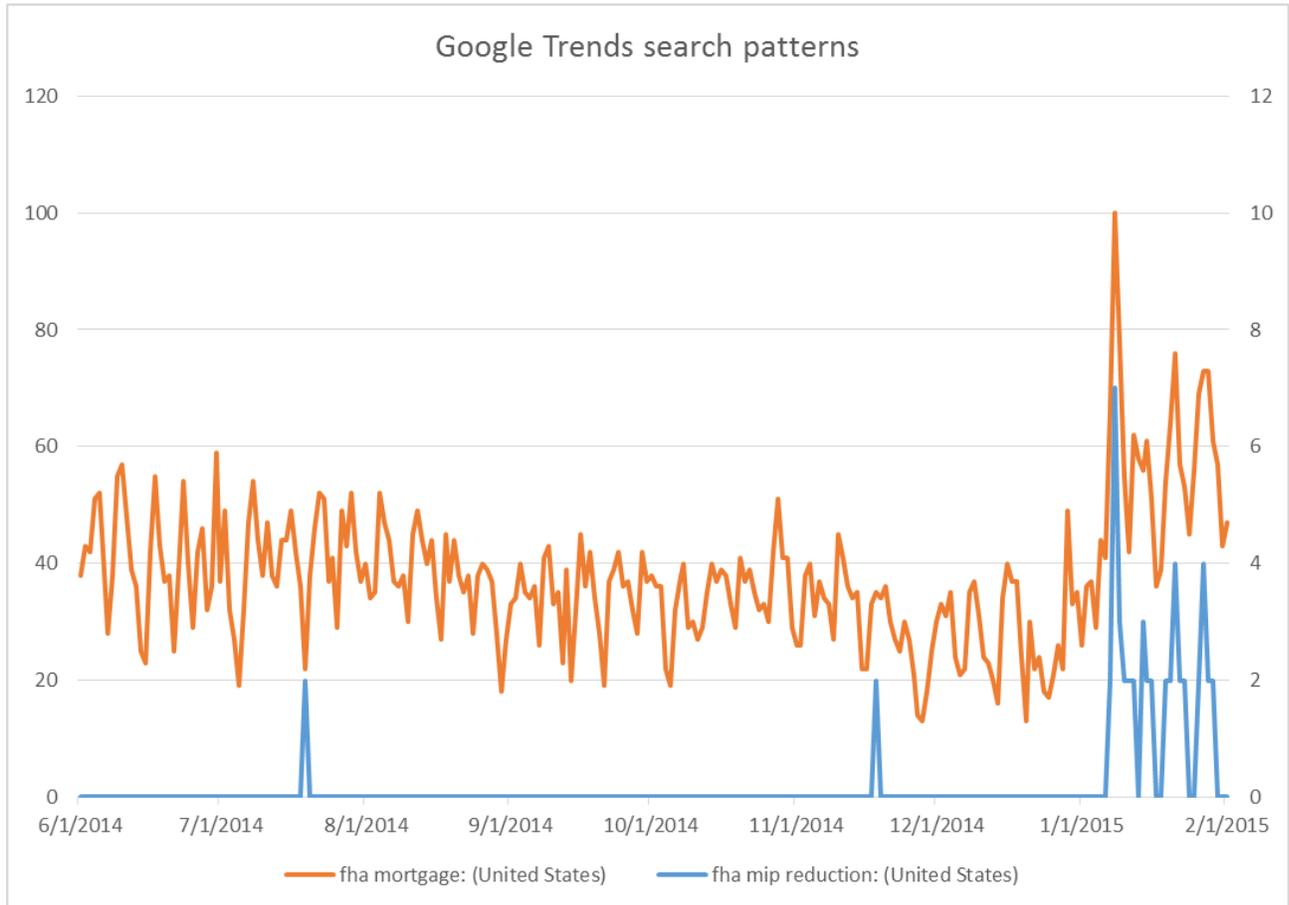
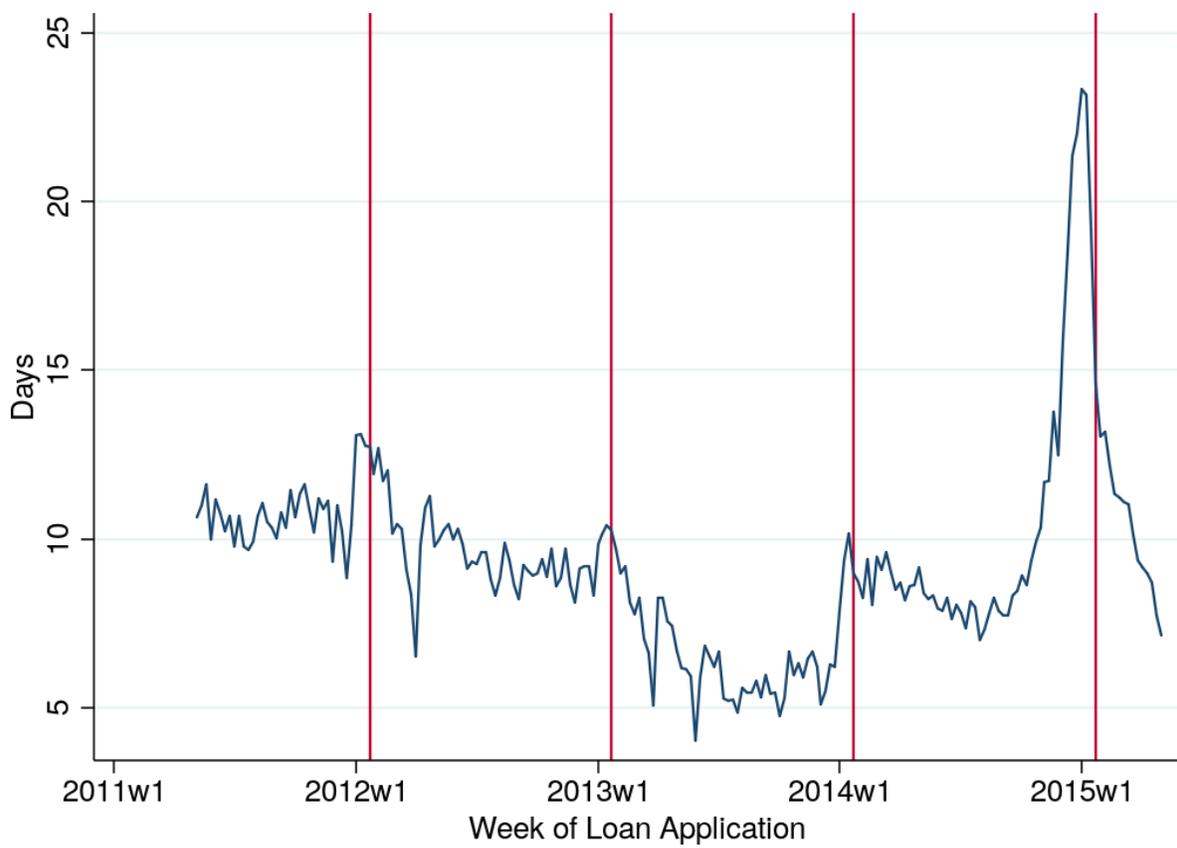**Figure A2. Continuity of Other Economic Indicators**
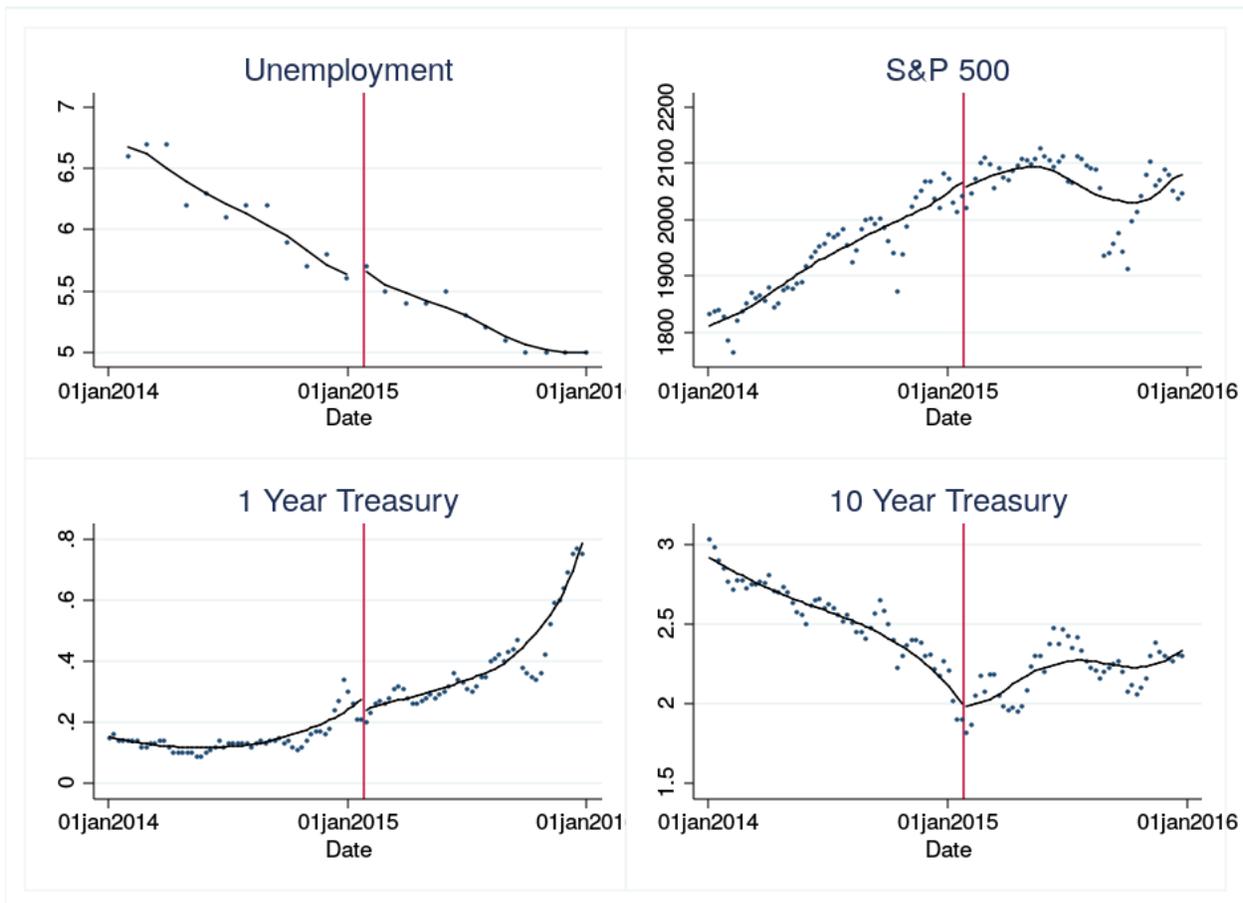
Figure A3. Average Time between Loan Application and Case Number Assignment, by Week of Loan Application

Note: Vertical lines indicate the week January 26 for the years 2012-2015.

Source: HUD loan-level data and data reported under HMDA.

Figure A4: FHA MIP Reduction FAQ

FHA TO REDUCE ANNUAL INSURANCE PREMIUMS
Frequently Asked Questions

1. When will the FHA's new annual premium rates take effect?

The reduction is effective as of January 26, 2015. Borrowers with case numbers assigned on and after January 26, 2015 will be eligible for reduced annual mortgage insurance premiums.

2. What steps do I need to take to take advantage of these new lower premiums?

Contact an FHA-approved lender for information regarding FHA's new annual mortgage insurance premiums.

3. What will the impact of FHA's new premiums be on my monthly mortgage costs?

Future borrowers who qualify for FHA's new reduced annual premiums will enjoy the benefits of a more affordable FHA loan with lower costs. HUD estimates these lower premiums will save more than two million FHA homeowners an average of $900 annually and spur 250,000 new homebuyers to purchase their first home over the next three years.

4. I've already been approved for an FHA-insured mortgage and have been assigned an FHA case number. How can I take advantage of the new rate?

FHA will permit lenders to cancel existing case numbers and assign new case numbers so borrowers who have yet to close on their loans may take advantage of the new premium reduction. The new case number must be assigned on or after January 26, 2015. Contact your lender for information regarding your case assignment and case cancellation and read FHA's Mortgagee Letter.

5. I already have an FHA case number and will work with my lender to cancel it and have a new one assigned. But how might this impact my closing date or the 'lock-in period' for my interest rate?

Contact your lender for information regarding your case assignment and case cancellation and any impact this may have on your closing date or your rate lock.

Figure A5. Treatment Group Share of Home Purchase Loans by Week of Loan Application (HMDA/McDash Merge)
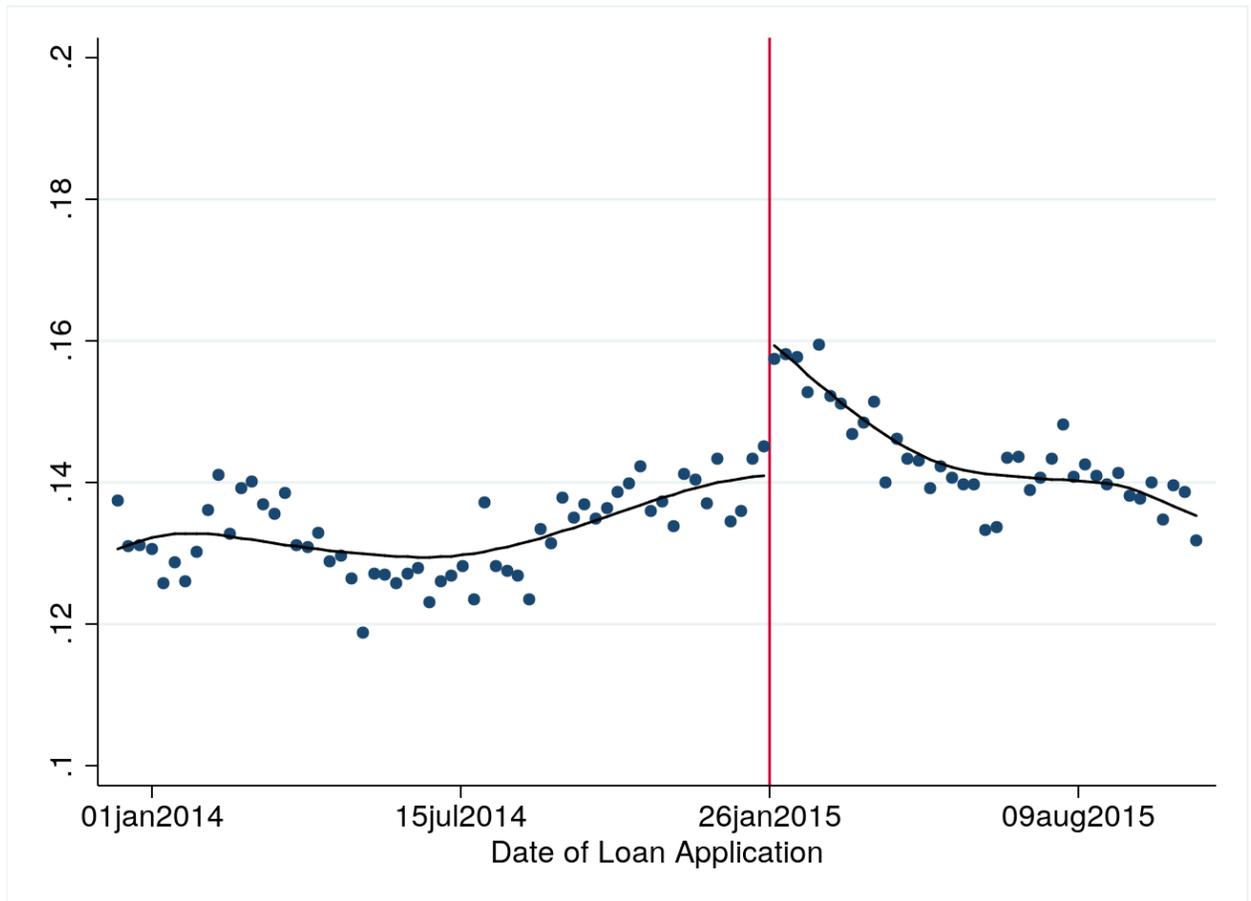
Note: The vertical line marks January 26, 2015, the date of the decrease in annual FHA MIP. Estimated curve of best fit overlaid on weekly data.

Source: McDash Analytics and data reported under HMDA.

Figure A6. Treatment Group Share of Withdrawn Home Purchase Applications, by Week of Loan Application
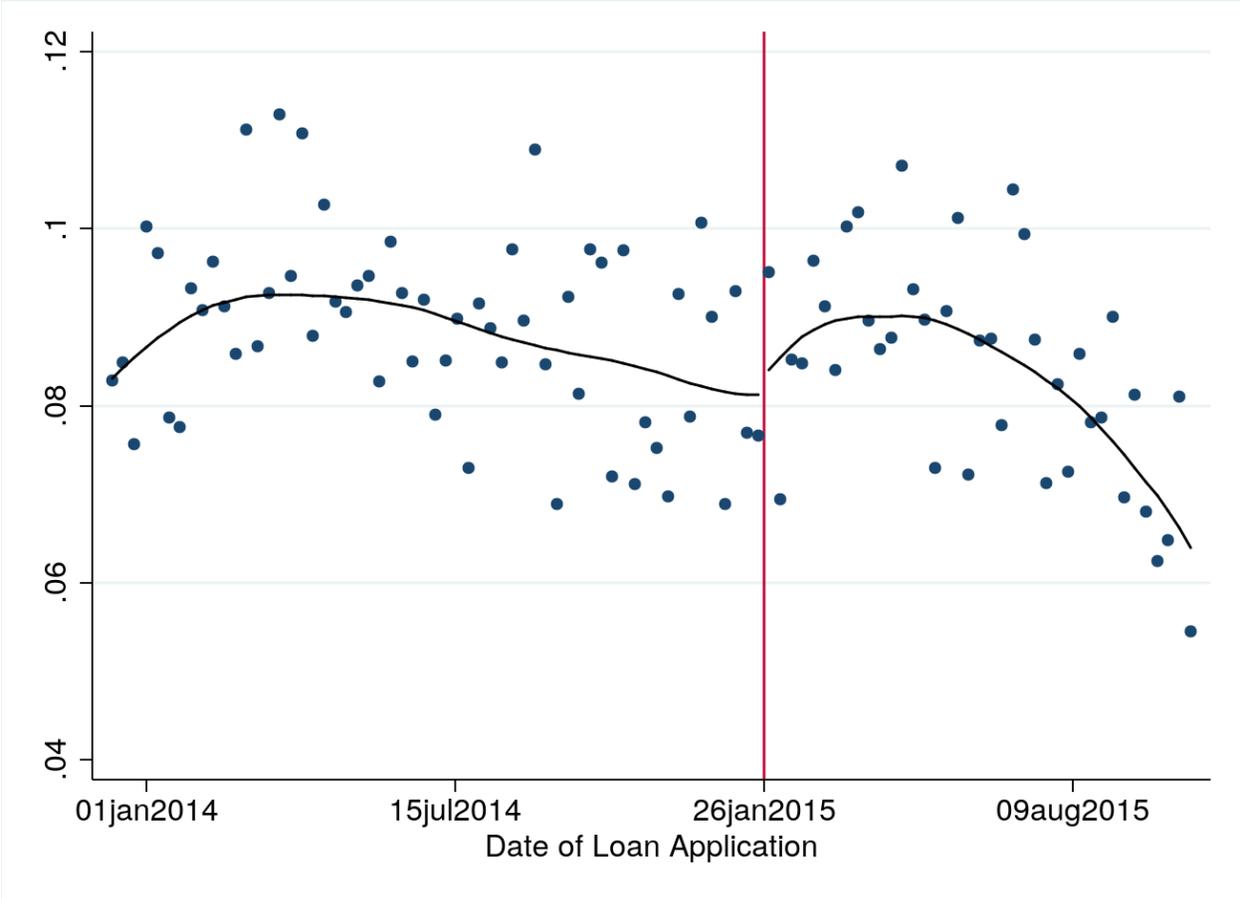
Source: Data collected under HMDA and Optimal Blue

Appendix **Figure A7** plots the budget constraint a home buyer faces when considering a mortgage. For a given house value, the scheduled monthly payments increase proportionately with the initial LTV ratio. At 80% LTV, mortgage insurance (priced as a fraction of the entire outstanding loan balance) is required, causing the budget constraint to drop and the slope to steepen. The black line indicates the budget constraint under the old (higher) MIP, while the red line indicates the budget constraint under the new (lower) MIP.

Figure A7: Budget Constraint of Home Buyer
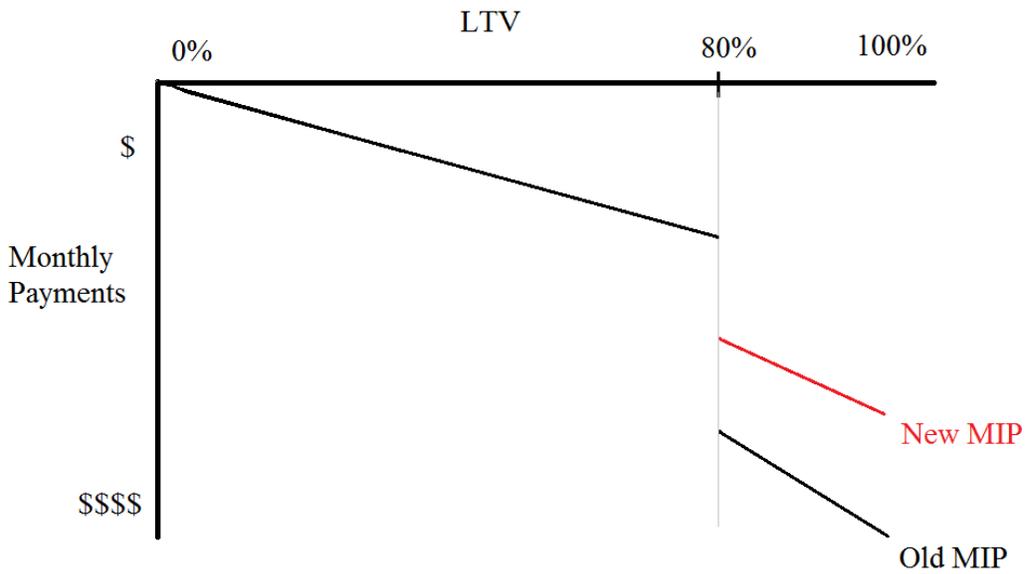
In **Figure A8** we plot indifference curves of a borrower whose optimal LTV under the old MIP was below 80%. Because of the increase in both total and marginal costs for LTV ratios above 80%, a convex indifference curve that is tangential to the budget constraint at a point below 80% LTV will be preferred to every point on the budget constraint above 80% LTV even under the new, lower MIP.

Figure A8: Indifference Curves of Type 1
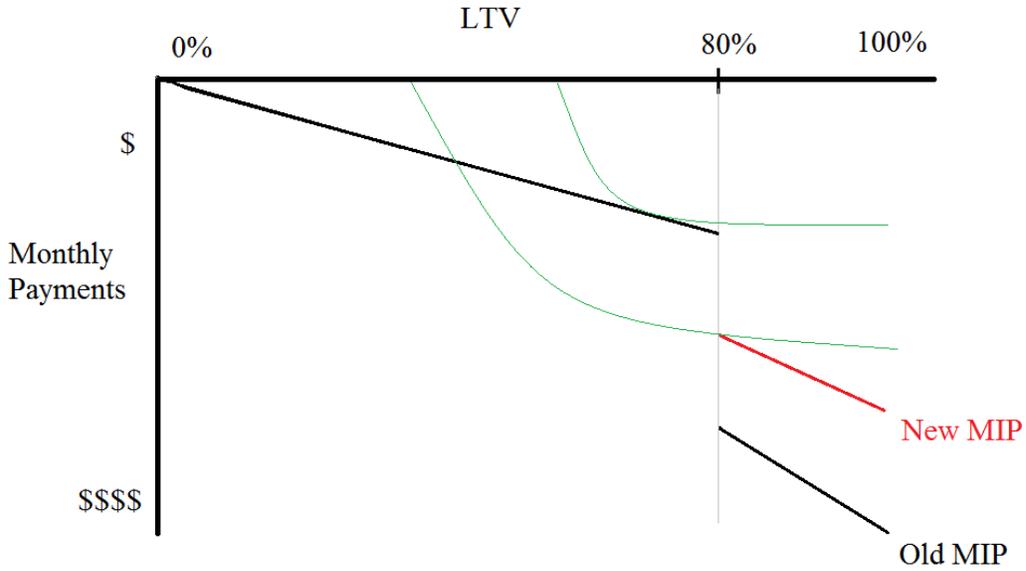
In **Figure A9** we plot indifference curves of a borrower whose optimal LTV under the new MIP is greater than 80%, and whose optimal LTV under the old MIP was less than or equal to 80%. Because of the notch in the budget constraint, a convex indifference curve that fits the above description must be tangent to the budget constraint exactly at 80% LTV under the old MIP.
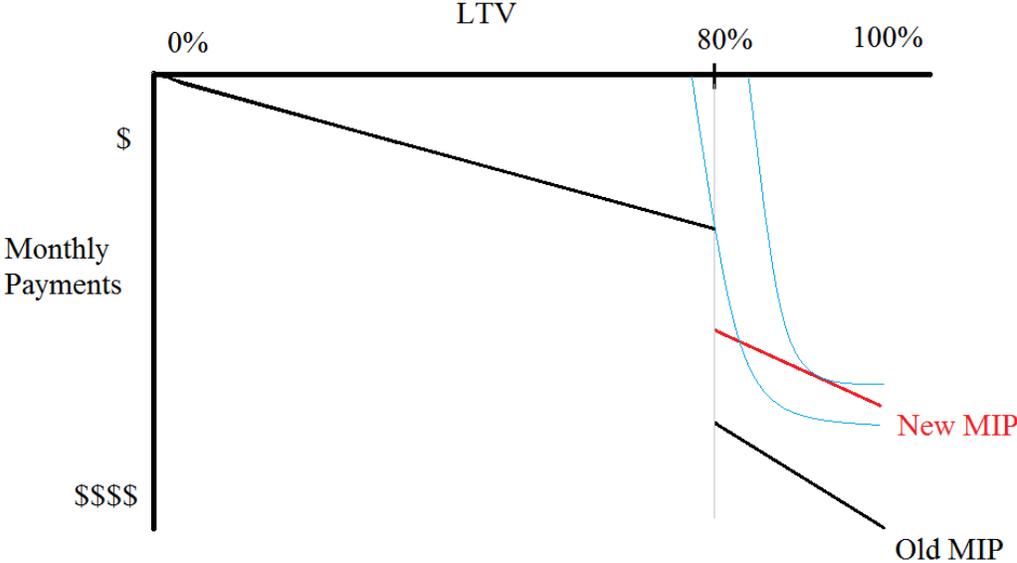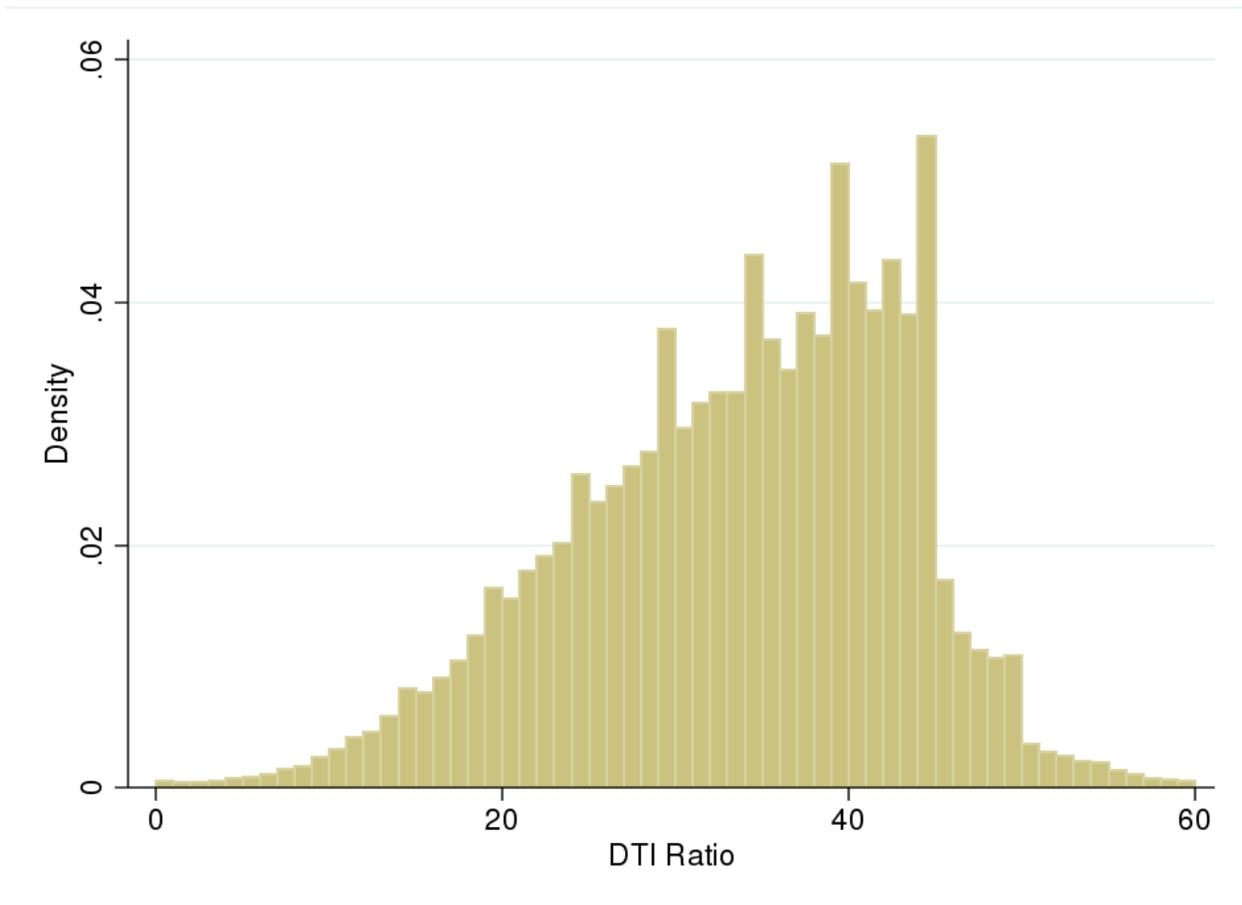
Figure A9: Indifference Curves of Type 2

Figure A10. Distribution of DTI Ratios for Non-FHA Home Purchase Loans

Note: Sample densities in one-percentage point bins.

Source: Optimal Blue

Table A1: Estimated Effect of the FHA MIP Reduction under Different Treatment and Control Group Definitions

Treatment		Control		Treatment Group Share	Bandwidth (Weeks)		
Definition	FHA Share	Definition	FHA Share		12	25	50
FICO < 680, LTV > 80%	85%	All Others	17%	18%	0.021	0.019	0.012
					(0.006)	(0.005)	(0.003)
FICO < 680, LTV > 80%	85%	FICO > 680, LTV < 80%	1.5%	58%	0.036	0.044	0.033
					(0.013)	(0.010)	(0.006)
FICO < 680, LTV > 80%	85%	FICO > 680, LTV > 80%	29%	30%	0.027	0.021	0.006
					(0.008)	(0.007)	(0.005)
FICO < 650, LTV > 80%	92%	All Others	27%	8%	0.016	0.011	0.005
					(0.004)	(0.004)	(0.003)
FICO < 650, LTV > 80%	92%	FICO > 680, LTV < 80%	1.5%	39%	0.052	0.050	0.032
					(0.015)	(0.013)	(0.008)
FICO < 650, LTV > 80%	92%	FICO > 680, LTV > 80%	29%	16%	0.027	0.017	0.003
					(0.007)	(0.007)	(0.005)

Note: Table shows the estimated discontinuity at January 26, 2015 in the share of loans in the estimation sample going to the treatment group. The treatment and control groups are defined by the borrower's FICO score and LTV ratio as shown in the first and third columns. The second and fourth columns, labeled "FHA Share," display the fraction of treatment and control group loans that carry FHA insurance in the estimation sample for each definition of treatment and control group. The fifth column "Treatment Group Share" displays the fraction of all loans in each restricted subsample that belonged to the treatment group in 2014. Data are from Optimal Blue. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table A2: Effect of the FHA MIP Reduction on FHA Denial Rates

	Bandwidth (Weeks)		
	12	25	50
Denial Rate Difference between FHA and non-FHA Applicants	-0.015	-0.023	-0.019
	(0.005)	(0.006)	(0.004)

Note: Table shows the estimated discontinuity at January 26, 2015 in the denial rate of FHA loan applications relative to non-FHA loan applications. Effects estimated using a local linear regression and a triangular weighting kernel. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table A3: Effect of the FHA MIP Reduction on Contract Rates

		Bandwidth (Weeks)		
Outcome Variable	Underwriting Controls	12	25	50
Contract Rate (Percentage Points)	No	0.009	0.015	-0.002
		(0.068)	(0.071)	(0.058)
	Yes	0.002	0.011	-0.01
		(0.025)	(0.017)	(0.012)

Note: Table shows the estimated discontinuity at January 26, 2015 in the contract rate on treatment group loans, relative to the control group. Data is from Optimal Blue merged with data collected under the Home Mortgage Disclosure Act. Effects estimated using a local linear regression and a triangular weighting kernel. Treatment group refers to borrowers with a FICO score below 680 and an LTV ratio between 80 and 100 percent. Control variables consist of flexible functions of borrower income and FICO score. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.

Table A4: Test of Treatment Group Exogeneity

			Bandwidth (Weeks)		
Outcome Variable	Data Source	LTV Cutoff	12	25	50
Treatment Group Share	Optimal Blue	80%	0.021	0.019	0.012
			(0.006)	(0.005)	(0.003)
		79%	0.019	0.017	0.009
			(0.006)	(0.005)	(0.003)
	HMDA/McDash	80%	0.015	0.016	0.013
			(0.004)	(0.003)	(0.002)
		79%	0.015	0.015	0.012
			(0.005)	(0.003)	(0.002)

Note: Table shows the estimated discontinuity at January 26, 2015 in the share of loans in the estimation sample going to the treatment group. The treatment group is defined as borrowers with FICO scores below 680 and LTV ratios in excess of the percentage in the "LTV Cutoff" column. Standard errors, shown in parentheses, are adjusted for clustering at the weekly level.