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# **Monetary Policy and Home Buying Inequality**

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# Monetary Policy and Home Buying Inequality

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## Abstract

Does monetary policy influence who becomes a home owner? Home purchases by low- and moderate-income households may be particularly sensitive to mortgage interest rates, as these households' budgets are tighter and they more frequently come up against binding payment-to-income ratio constraints in credit decisions. Exploiting the timing of high-frequency observations of mortgage applicants locking in their interest rates around monetary policy shocks, I find that a 1 percentage point policy-induced increase in mortgage rates lowers the presence of low-income households in the population of home buyers by 1 percentage point, and of low- and moderate-income households by 2 percentage points, immediately following the shock. Effects are substantially stronger among first-time home buyers, and persist for approximately one year.

*Keywords:* Home ownership; inequality; monetary policy; interest rates; credit constraints

*JEL codes:* G21; E43; E44; R21.

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# 1 Introduction

Advancing home ownership—particularly among lower-income families and racial minorities—has been an explicit policy goal of the US government for decades.<sup>1</sup> As the largest asset on most households’ balance sheets, it is widely believed that homeownership is a crucial path to wealth building for the middle class.<sup>2</sup> Indeed, recent research suggests that the amortizing nature of mortgage payments actively helps households build wealth (see Bernstein and Koudijs, 2021 and Wainer and Zabel, 2020, for example). However, the homeownership gaps between higher- and lower-income families, and between white and minority families, are wide and have been growing in recent generations (Sabelhaus and Clemens, 2020).

Both academic researchers and policy makers have recently shown increased interest in the role monetary policy plays in reducing or exacerbating economic inequality. Research has investigated how monetary policy’s effects on employment and asset prices differentially affect households at different points on the income and wealth spectrums (see e.g. Coibion et al., 2017 and Bartscher et al., 2021). Central bankers have increasingly referenced inequality in their public remarks in recent years (Bank of International Settlements, 2021). However, little is known about how monetary policy can influence different households’ entry into homeownership, and thus begin the attendant steady accumulation of wealth.

In this paper I estimate how monetary policy affects the composition of home purchase borrowers. The home purchase market is sensitive to monetary policy, as central banks can influence the cost of mortgage credit. In particular, the (effective) demand of lower income households for home buying is potentially quite rate-elastic, as these households are more likely to find their borrowing constrained by binding debt service payment-to-income (DTI) ratio maximums.<sup>3</sup> Because of their lower incomes, underrepresented racial and ethnic

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<sup>1</sup>Policies include the Federal Housing Finance Agency’s affordable housing goals, the Fair Housing Act and the Department of Housing and Urban Development’s Housing Choice Voucher program, among many others.

<sup>2</sup>Home equity represents almost half of the total wealth of households below the 40th percentile of income and accounts for close to half of the median wealth gap between non-Hispanic white and minority households. Source: 2019 Survey of Consumer Finances, author’s calculations.

<sup>3</sup>A greater rate elasticity of demand among lower-income households is suggested by the experience of the first few months of 2022, when home purchase borrowing by below-average income households collapsed in the face of rapidly rising rates (Ringo, 2022).

minority groups may also be particularly sensitive to interest rates.

Prevailing interest rates are endogenous to current economic conditions that may also affect the home buying demand of lower-income households. I therefore identify the effects of monetary policy by exploiting the timing of high-frequency observations of mortgage rate locks around unanticipated monetary policy shocks conveyed in Federal Open Market Committee (FOMC) announcements. I find that a contractionary policy shock which increases mortgage rates by 1 percentage point would reduce the share of home purchase loans going to low- and moderate-income (LMI) borrowers by 2.1 percentage points (or 7.5 percent) in the weeks following the announcement. The share going to low-income borrowers alone would fall by 1.1 percentage points (16 percent).<sup>4</sup> The estimated effect on the share of home purchase loans by underrepresented minority households is statistically insignificant.<sup>5</sup> As discussed in Section 4.2, this may be due minority populations concentrating in lower-income, lower-priced metro areas.

The wealth-building consequences of being denied or discouraged from taking out a home purchase loan are particularly acute for households that do not already own their home. Notably, I find that the effects of monetary policy described above are even stronger for this population. Among first-time home buyers, a 1 percentage point tightening causes a 4 percentage point decline in the share of loans going to LMI households, and a 3 percentage point decline in the share going to low-income households alone. Monetary policy is an important factor determining who becomes a home owner, and therefore how income-segregated home ownership becomes.

Monetary policy shocks can have a near-instantaneous effect on the composition of home buyers because of the nature of mortgage underwriting. Applicants who locked their mort-

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<sup>4</sup>Throughout the paper, I use the definition of low-income and moderate-income households provided by the regulations implementing the Community Reinvestment Act. A household is considered low-income if its annual income is less than 50 percent of the local area median family income, and moderate-income if its income is between 50 percent and 80 percent of area median family income. Those with incomes above 80 percent of area median family income are designated middle- or upper-income households. The Federal Housing Financial Authority uses these same cutoffs to set affordable housing goals for Fannie Mae and Freddie Mac, although the terminology is different (very low income and low income, rather than low income and moderate income, respectively).

<sup>5</sup>Underrepresented minorities are defined as those who self-identify, or who are identified by their loan officer, as Black, Hispanic, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, or those of mixed race.

gage rate (a standard step in the origination process) prior to the shock are unaffected by the new rates. Anyone who had not yet locked (or applied) until after the shock faces the new rate environment—if rates rose, their resulting DTI ratio may be too high to qualify for credit, whereas the same application under previous, lower rates could have been approved. Indeed, I find monetary contractions cause a particularly sharp reduction in the presence of borrowers who are likely to be highly leveraged. Applicants do not need to adjust their behavior, or even be aware of the change, for interest rate movements to affect borrowing. Applicants can make some adjustments to lower their DTI ratio (paying points to lower the rate, or putting more money down, for example), but these options may be particularly difficult for liquidity-constrained, low-income households. In a closely related paper, Bhutta and Ringo (2021) found that cutting mortgage insurance premiums of new FHA borrowers led to an immediate increase in originations, particularly among lower-income households and those close to the margin of denial based on their DTI ratio.<sup>6</sup>

The effect of a rate shock on home buyer composition might be expected to fade over time, as house prices respond and borrowers adjust by e.g. finding homes that fit their new budget. However, I find these adjustments are apparently a slow process. Using the local projection method of Jordà (2005), I find that the lower-income share of home buyers remains persistently lower for approximately one year following a contractionary monetary policy shock (although the estimates do become imprecise, particularly at longer time horizons). This finding of considerable persistence suggests that a one-time monetary policy decision has the potential to meaningfully affect the income composition of the stock of home owners by altering the composition of the inflow for a protracted period.

I can also use the framework described above to estimate the semi-elasticity of home buying to interest rates among the various socioeconomic and demographic groups. I find

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<sup>6</sup>In the appendix, I show evidence that monetary policy also shifts the composition of home buying by location. A contractionary shock causes the share of loans going to lower-income neighborhoods to fall. However, across metro areas, contractionary shocks are associated with a reduction in lending to *higher*-income metropolitan statistical areas (MSAs). This finding also suggests the importance of borrower leverage as a mechanism: within a given metro area, loans in relatively lower income neighborhoods tend to have higher DTI ratios while across metro areas higher-income MSAs tend to have higher DTI ratios. This suggests the combination of rising interest rates and binding DTI constraints shifts the locus of home buying away from higher income (but higher priced) metros, while within metros lower income neighborhoods and households both lose out.

that low-income and low- and moderate-income households have semi-elasticities of 21 and 18, respectively, over the year following the shock.<sup>7</sup> Middle- and upper-income households are estimated to have a semi-elasticity of 6. Underrepresented minority households have a semi-elasticity of 10. With approximately 1.5 million home purchase loans made to LMI borrowers in 2021, these estimates imply that a one percentage point mortgage rate increase would prevent approximately 260,000 LMI households from buying a home in the subsequent year.

Mortgage payments (and hence DTI ratios) move with interest rates because house prices do not adjust enough in the short term to offset them. The relative insensitivity of house prices to rates is discussed by Glaeser, Gottlieb and Gyourko (2012). While some recent research indicates asking prices do adjust quickly to monetary policy shocks (Gorea, Kryvtsov and Kudlyak, 2022), the evidence suggests that these adjustments are not enough to keep quantity demanded constant. For example, Anenberg and Kung (2017) find that the time a for-sale home takes to find a buyer is highly sensitive to interest rates.

This paper is related to a large literature that investigates the distributional effects of monetary policy more generally.<sup>8</sup> In particular, some research suggests that monetary tightening reduces wealth inequality, including across racial groups (see e.g. Mumtaz and Theophilopoulou, 2017, Luetticke, 2021, and Bartscher et al., 2021). While the literature has considered the effect of monetary policy on wealth inequality via the channel of asset prices conditional on the current distribution of those assets, this paper shows that equality of access to the most important asset class for most households is also dependent on monetary policy. I find that tighter policy leads to *greater* inequality in ownership, in contrast to the literature that finds *reduced* wealth inequality based on asset prices. The effects of homeownership on wealth take time to accumulate, so the influence of this access channel on wealth inequality would accrue only with a considerable lag. Short-run estimates of the effect of monetary policy on wealth levels would miss it. Moreover, the marginal wealth holding studied in this

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<sup>7</sup>Using a shock to mortgage insurance premiums, Bhutta and Ringo (2021) estimated a very similar semi-elasticity of 19 among households with low credit scores and low levels of liquid wealth.

<sup>8</sup>For example, studies have found that monetary tightening increases inequality of income and consumption (e.g. Coibion et al., 2017, Ampudia et al., 2018 and Amberg et al., 2022)—although the evidence is not totally one sided (see e.g. Andersen et al., 2022).

paper—whether or not a lower-income household becomes a homeowner—may have larger welfare consequences than e.g. variation in the prices of financial assets held by already wealthy households.<sup>9</sup>

A further related strain of the literature investigates how well government programs with an explicit mandate to promote home ownership among lower-income households via mortgage lending achieve their goals. This literature includes estimates of the effects of the Community Reinvestment Act and of Fannie Mae and Freddie Mac’s affordable housing goals.<sup>10</sup> Estimates from this literature are mixed, with some well-identified studies finding negligible effects and others finding strong effects. The results of the present paper suggest that programs focused on subsidizing interest rates for lower-income borrowers could reliably increase their home purchase borrowing.

To be sure, home ownership carries risks and costs and may not be the best choice for every household. Market timing matters: as Wainer and Zabel (2020) point out, homeowners who bought at the peak of the mid-2000s housing boom lost considerable wealth in the ensuing bust. Sakong (2022) finds that lower-income households experience lower returns to housing due to the timing of their buying and selling decisions. Furthermore, low- and moderate-income home buyers are more likely to default on their loans (Ringo, 2017). Any policy effort to encourage lower-income home buying should be made with these potential downsides in mind.

## 2 Estimation

The current stance of monetary policy, the markets’ expectations of its future path, and mortgage interest rates (which heavily depend on these expectations) all reflect the current economic environment. Simple regressions of the composition of home buyer demographics

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<sup>9</sup>This paper is also related to the literature that investigates the role housing markets—including real estate assets and debts on the household balance sheet—play in the transmission of monetary policy (see Cloyne, Ferreira and Surico, 2020 and Di Maggio et al., 2017, for example).

<sup>10</sup>Studies that estimate the effect of the Community Reinvestment Act on mortgage lending to lower-income communities include Ringo (2017), Bhutta (2011), Ding and Nakamura (2021), Lee and Bostic (2020), and Saadi (2020). Studies that estimate the effect of the affordable housing goals include Bhutta (2012), Bostic and Gabriel (2006), and Avery and Brevoort (2015).

on some measure of interest rates will tend to be biased, therefore, if the relative demand for home buying varies across groups in response to aggregate conditions. To deal with this issue, I exploit high frequency variation in the composition of borrowers around unanticipated monetary policy shocks.

## ***2.1 Short-Run Effects***

When an FOMC announcement surprises the market, interest rates (for debts of various maturities, depending on the nature of the information) move rapidly. By isolating interest rate movements in a narrow time window around the release, the size of the shock to monetary policy can be estimated. I use the short-term reaction in home purchase borrower characteristics to these shocks to estimate the effect of monetary policy on the inequality of home buying.

Estimating the response to shocks measured in this way is a common technique in the literature on the effect of monetary policy on asset prices and other macroeconomic aggregates (see Cochrane and Piazzesi, 2002 and Nakamura and Steinsson, 2018, for example). An obstacle to estimating effects on real economic activity is that many of the outcomes of interest may be slow to respond to interest rate changes (the infamous “long and variable” lags of Friedman, 1961). This can create a problem for causal inference, as measured monetary policy shocks may be predictive of future economic conditions (i.e the Fed information effect), or be correlated with slower moving trends that may not be adequately corrected for by e.g. vector autoregression techniques. Mortgage borrowing, however, has a feature more in common with financial asset pricing than many other forms of real activity: a nearly instantaneous response to interest shocks can be expected. This is because, as described in the introduction, mortgage credit is rationed on the basis of hard limits on the borrower’s DTI ratio, which ratio is a function of mortgage interest rates. As soon as a monetary policy shock is passed through to retail mortgage rates, borrowers attempting to lock their mortgage rate that day may be denied or approved for credit based on the direction and magnitude of the shock. Using a narrow time window around the monetary policy shock



helps ensure the measured change in borrower composition is truly a response to the shock.

An important factor to consider when measuring monetary policy shocks is which portion of the yield curve is affected. A typical mortgage has a 30-year term. While many mortgages prepay, the overnight federal funds rate is much less relevant than e.g. the yield on 10-year treasuries in determining mortgage backed security pricing, and hence retail mortgage interest rates. The Federal Reserve can influence these longer-maturity yields via forward guidance on the future path of the federal funds rate, or by its large-scale asset purchase (LSAP) policies. In this paper I use the series of monetary policy shocks estimated by Swanson (2021), which splits shocks into three factors: federal funds rate (short term), forward guidance, and LSAP. These same shocks have also been used by Gorea, Kryvtsov and Kudlyak (2022) to estimate the effect of interest rates on house prices.

To estimate the short-run effect of these shocks, I model the probability that each home purchase loan,  $i$ , with a rate lock on date  $t$  went to a certain type of borrower (an LMI household, for example). I regress an indicator for the borrower belonging to that category,  $Y$ , on the prime mortgage rate,  $r$ , prevailing that day (i.e. the median interest rate paid by well qualified borrowers). To deal with the endogeneity of  $r$ , I limit the sample to 6 week windows centered around each monetary policy shock  $s$ . I instrument for  $r$  with the vector  $\mathbf{M}$ , representing the magnitudes of the factors making up shock  $s$ , times an indicator,  $D$  for  $t$  falling after the date of the shock,  $t_s$ . I also include fixed effects for each shock,  $s$ , to control for any correlation between the direction of shocks and prevailing borrower composition. Separately controlling for  $D$ , the estimator is equivalent to a difference-in-differences estimator, with a continuous (rather than binary) treatment whose magnitude is determined by the size of the forward guidance and LSAP shocks.<sup>11</sup> The first stage estimating equation is:

$$r_t = \alpha_1 \mathbf{M}_s \times D_t + \alpha_{2,s} + \alpha_3 D_t + \nu_t \quad (1)$$

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<sup>11</sup>Time in this framework should be thought of as time since or until the nearest FOMC announcement, rather than absolute calendar time. The post-announcement indicator,  $D$ , controls for any predictable change in the composition of home purchase applicants around FOMC announcements (see Giacoletti, Ramcharan and Yu, 2019, for example). Results are robust to dropping this control.

and the second stage is:

$$Y_{i,t} = \beta_1 r_t + \beta_2 s + \beta_3 D_t + \epsilon_{i,t} \quad (2)$$

where the coefficient on the prime rate,  $\beta_1$ , is the estimate of interest.<sup>12</sup>

## 2.2 Longer-Run Effects

Our interpretation of the importance of monetary policy to home buying inequality is very different if the effect disappears quickly after the shock than if it persists for many months. The estimator described above uses high-frequency changes around shocks, which has the advantage of tightening the case for consistency of the estimator but comes at the cost of identifying only short-run effects. To try and estimate the persistence of the effect of monetary policy shocks on the composition of home buyers, I use the local projection estimator of Jordà (2005). In this framework, effects of a shock at time  $t$  are estimated by directly estimating the partial correlation with the outcome variable at different time windows, while controlling for lagged values of the outcome variable to deal with autocorrelation.

To estimate the longer-run effects of monetary policy, I model the fraction of home purchase loans originated in each week  $t+k$  that went to certain types of borrowers,  $W_{t+k}$  as a function of shocks to the prime rate,  $r$ , and pre-shock lags of  $Y$ . As before, I use the LSAP and forward guidance shocks from Swanson (2021) to predict exogenous changes to  $r$ ,  $\Delta\hat{r}$  as in equation 1. I choose the number of lags of  $W$ ,  $L$ , to minimize the Akaike information criteria (AIC) and estimate:

$$W_{t+k} = \delta_{1,k} \hat{\alpha}_1 \mathbf{M}_s + \sum_{l=1}^{l=L} \delta_{2,k,l} W_{t-l} + \mu_k \quad (3)$$

for each week  $k = 1$  to  $k = 52$  after a monetary policy shock.

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<sup>12</sup>Reduced-form estimates of the direct effects of the monetary policy shocks on borrower composition are shown in the appendix.

### 3 Data

Individual mortgage data for this paper come from two sources: rate locks data provided by Optimal Blue LLC and mortgage application data collected under the Home Mortgage Disclosure Act (HMDA). Optimal Blue provides a platform that connects lenders and investors through which borrowers can lock their rates.<sup>13</sup> They cover approximately one quarter of the mortgage market. Crucially, these data include the actual date of rate lock, which allows me to observe the exact rate environment in which the interest rate on a particular loan was set. Residential mortgages usually take over a month between initial application and loan origination, with the rate lock occurring some variable time in between. It is quite common for several weeks to pass between the initial application and rate lock, and for several more weeks to pass between rate lock and origination. Either application or origination date, therefore, would serve as poor proxies for identifying whether a particular loan had its rate set just before or just after a particular monetary policy shock. In contrast, because they record the date of rate lock, the Optimal Blue data are uniquely well suited for the high frequency identification strategy I employ to estimate short-run effects in this paper.

Optimal Blue records a number of important characteristics of each loan locked through their platform, including its purpose, the requested loan amount, the property location (5-digit ZIP code), and what (if any) form of government mortgage insurance it carries. The data lack information on borrower income, race, or ethnicity, however. I therefore augment the Optimal Blue data by performing a loan-level merge with HMDA data. HMDA covers the vast majority of the residential mortgage market, and directs lenders to report a wealth of application-level information, including borrower income, race, and ethnicity. Along with purpose, loan amount, property location (census tract) and government mortgage insurance, the confidential version of the HMDA data include application date and loan origination date. I use all of the common information between the two data sets to perform the merge.<sup>14</sup>

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<sup>13</sup>All the data from Optimal Blue presented in this paper are aggregated and anonymized. No lender or customer identities, or any complete rate sheets, were used in this research or are presented here.

<sup>14</sup>For observations in the two data sets to be a match, I require that the lock date falls on or after the HMDA application date and before the HMDA origination date, and that there is some overlap between the ZIP code recorded in Optimal Blue and census tract recorded in HMDA (identified using the Census Bureau's ZCTA/tract crosswalk).

To minimize false-positive matches, I require that loans be unique combinations of these fields in each data set and have a unique match between data sets to be included in the final estimation sample. The loans I use in this study are limited to home purchase loans for owner-occupied homes, for which the borrower had a reported annual income less than \$1 million and greater than zero.

Borrowers are classified into income categories according to the definitions provided by the regulations implementing the Community Reinvestment Act (which mirror the income categories used by Fannie Mae and Freddie Mac’s affordable housing goals). A borrower is low income if their annual income falls below 50 percent of the area median family income (AMFI), and is moderate income if their annual income falls between 50 and 80 percent of AMFI. AMFI is estimated every year by the Federal Financial Institution Examination Council as the median family income in the borrower’s metropolitan statistical area (MSA), or the non-MSA portion of the borrower’s state if the property is not located in an MSA.<sup>15</sup> Borrowers are classified as an underrepresented minority if either the applicant or co-applicant (if present) is identified in the HMDA data as being Black or African American, Hispanic or Latino, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, or mixed race.

As mentioned in Section 2, I use the series of monetary policy shocks estimated by Swanson (2021). Shocks are estimated using changes in debt yields of various maturities in the 30-minute time window around FOMC announcements. Shocks are decomposed into LSAP, forward guidance, and federal funds factors based on the restrictions that forward guidance and LSAP shocks should not affect the current federal funds rate, and that LSAP shocks should be close to zero before the the zero-lower bound era when the Federal Reserve began its Quantitative Easing (QE) policies in earnest. That series covers shocks identified from FOMC announcements from July 1991 through June 2019. Each shock series is normalized to have a unit standard deviation.<sup>16</sup> Expansionary and contractionary shocks are roughly

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<sup>15</sup>Relative income is used to provide a better measure of disadvantage than a categorization by nominal income, which would fail to account for variation in the cost of living in the cross section and over time.

<sup>16</sup>This normalization was done over the period 1991-2008 for the federal funds shock factor, for 2009-2015 for the LSAP factor, and over the entire 1991-2019 period for the forward guidance factor to match the time period over which each component of monetary policy was effectively in use.

equally balanced. Notable shocks that appear in the time series include the announcement of QE, which appears as an expansionary forward guidance shock and a much larger expansionary LSAP shock, the taper tantrum, which appears as a large contractionary shock to both LSAP and forward guidance, and Operation Twist, which appears as an expansionary LSAP shock offset by a contractionary forward guidance shock.

The Optimal Blue data start in 2013, so my estimation of short-run effects covers the period over which this data source and the shock series overlap. During this time I have 53 monetary policy shocks to provide identifying variation and nearly 3.5 million uniquely matched home purchase loans, from an original set of 8 million Optimal Blue observations. Just under 3 million of these matched observations locked their rate within 3 weeks of an FOMC announcement. Summary statistics for these loans are presented in Table 1.<sup>17</sup> Approximately 7 percent of home purchase loans went to low-income borrowers during the sample period, 22 percent went to moderate-income borrowers, and 13 percent went to underrepresented minorities. Just over one third of the loans went to first-time homebuyers.

To estimate longer-run effects of a monetary policy shock, the rate locks data are not necessary. This is because the ambiguity over whether a loan originated after a shock locked its rate before or after that shock is only acutely relevant in the short run—loans originated many months later overwhelmingly locked their rates in the post-shock environment.<sup>18</sup> The local projection estimator can therefore be run on the HMDA data alone, allowing me to use a longer sample period for estimation.<sup>19</sup> I use HMDA data from 1994 (when HMDA’s coverage of the market approached near-universality) through 2019, covering 212 monetary policy shocks identified by Swanson (2021) and consisting of over 90 million home purchase loans.

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<sup>17</sup>Statistics for the underlying HMDA and Optimal Blue data sets are also shown in separate columns for comparison. The merged data generally look representative, although missing some very high income and very large loan amount borrowers present in the HMDA data.

<sup>18</sup>Loans originated prior to the shock had their rates locked in the pre-shock environment, of course, and so are suitable to use as lagged controls.

<sup>19</sup>This also allows me to compare estimates derived from the full, unmatched HMDA data to those from the more selected matched HMDA and Optimal Blue sample. The similarity of the estimates from these two approaches (discussed in Section 5) suggests that the merge with Optimal Blue data did not bias the short-run estimates through sample selection.

## 4 Results

### 4.1 *Monetary Policy Shocks and Mortgage Interest Rates*

As a first stage, I estimate the effect of monetary policy shocks identified by Swanson (2021) on mortgage interest rates. I construct a daily series of the prime rate—that is, the typical rate available to well-qualified borrowers. This value is measured as the median interest rate on loans locked on a given day in the full Optimal Blue data for which the borrower had a FICO score greater than or equal to 720, a DTI ratio below 43 percent, and a loan-to-value ratio of 80 percent or less.

To see the effect of monetary policy shocks on mortgage interest rates graphically, I estimate the effect of a one standard deviation LSAP, forward guidance, and federal funds rate shock on the daily prime rate for each of the 21 days before and after an FOMC announcement. In other words, I estimate:

$$r_t = \sum_{k=-21}^{21} \gamma_{1,k} M_s + \gamma_{2,s} + \gamma_3 D_t + \eta_t \quad (4)$$

separately for each of the three types of shocks (LSAP, forward guidance, and federal funds). Results from these regressions are plotted in Figure 1.

Swanson (2021) found that longer-maturity yields were most affected by LSAP shocks. Consistent with this result, I find that LSAP shocks have a strong effect on mortgage interest rates, which rise approximately 10 basis points in the days following a one standard deviation contractionary shock. There is also no apparent pre-trend, suggesting LSAP shocks may be taken as exogenous to prevailing short-run economic trends. The effect of a policy shock on the mortgage rates borrowers pay seems to take several days to fully appear (i.e. by the Monday following a standard Wednesday FOMC announcement). The process of updating and distributing rate sheets that consumer-facing loan officers use to set note rates for individual loans is quick, but not instantaneous.

The effect of forward guidance looks similar to that of an LSAP shock, although slightly weaker. The post-announcement rise in mortgage rates following a one standard deviation

contractionary shock is approximately 7 basis points. Again, there is little indication of a pre-trend. Finally, as expected, a federal funds rate shock has no obvious effect on mortgage rates. Estimates are very imprecise, but mortgage rates appear to be similar following a one standard deviation contractionary federal funds shock as they were before.<sup>20</sup>

Because LSAP shocks and forward guidance provide large, clean sources of exogenous variation in mortgage rates, I use both of these shocks as the instrument vector  $\mathbf{M}$  throughout the remainder of the paper. Federal funds rate shocks are not relevant to mortgage interest rates, and so I do not use that series in my baseline estimates.<sup>21</sup> First stage estimates of equation 1 are shown in column 1 of Table 2.

## 4.2 *Effects on Borrower Composition*

Next I estimate the effects of policy-induced rate increases on the share of home purchase loans going to low- and moderate-income households. In column 2 of Table 2 I first show the results of a simple OLS regression of LMI status on the prevailing prime rate. There is a significant positive relationship, with a 1 percentage point higher prime rate associated with an approximately 1 percentage point higher LMI share of home purchase borrowers. However, this estimate is likely biased by the endogeneity of mortgage rates to broader economic conditions.<sup>22</sup> In column 3, I show the results of estimating equation 2 via 2SLS, with the first stage described by equation 1 and the LSAP and forward guidance shocks as the exogenous source of variation in the prime rate  $r$ . Using this exogenous variation in  $r$ , we can see that contractionary policy actually has a negative effect on the LMI share of home purchase borrowing. A monetary policy shock equivalent to a 1 percentage point increase in mortgage rates causes the LMI share to fall by 2.1 percentage points, or approximately 7.5 percent. This *relative* decline is in addition to any general decline in home buying among higher-income households caused by a rate hike; see Section 6 for estimates of the magnitude

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<sup>20</sup>Recall that the estimation period covers 2013-2019, when there was very little short-run uncertainty about the federal funds rate, and hence realized shocks to the federal funds rate series were small.

<sup>21</sup>Results are robust to including federal funds shocks in the instrument vector.

<sup>22</sup>Mortgage rates tend to be pro-cyclical, as investors anticipate the Federal Reserve will respond to a weak economy by easing policy. Lower-income households' demand for home buying is also more pro-cyclical than higher-income households (Sakong, 2022), leading to a spurious positive relationship between mortgage rates and the lower-income share of home buyers.

of the absolute effect.

Among the LMI population, households under the low-income threshold may be even more sensitive to borrowing costs. Equivalent results for the effects on the share of home purchase loans going to low-income borrowers are shown in columns 4 and 5. Simple OLS results again show a positive correlation between interest rates and the low-income share. However, column 5 reveals that a contractionary shock of 1 percentage point would lower the low-income share by 1.1 percentage points, or approximately 16 percent. Despite representing less than one quarter of all LMI home purchase borrowers, low-income households account for approximately half of the effect on the LMI share of lending.

The direct effect of a contractionary monetary policy shock on borrowing by LMI home buyers can also be seen graphically. I take the predicted change in  $r$  estimated from equation 1 by the combined influence of the LSAP and forward guidance shock from each FOMC announcement as the net shock to rates ( $\hat{\alpha}_1 \mathbf{M}_s$ ). I then repurpose equation 4, estimating the effect of a one percentage point mortgage rate shock on the LMI and low-income shares of home purchase borrowers for each of the 21 days before and after an FOMC announcement. Results from these regressions are plotted in Figure 2. Estimates for individual days are noisy, but the simple average of daily estimates is lower in the post-shock than in the pre-shock period for both income groups (averages of the daily estimates are represented by the dashed horizontal lines). There is also little indication of any pre-trends in the share of loans going to LMI or low-income households.

Underrepresented minority households have lower incomes, on average, than non-Hispanic white households, and when they obtain mortgages tend to have higher DTI ratios. Consequently, we might expect underrepresented minority borrowers to be more sensitive to mortgage rates than other borrowers. To test this prediction, I re-estimate equation 2 using an indicator for underrepresented minority status as the dependent variable,  $Y$ . OLS and 2SLS results are shown in columns 6 and 7 of Table 2, respectively. As with low-income and LMI borrowers, I find a positive correlation between the prime rate and the share of loans going to underrepresented minorities. However, the 2SLS estimates are also positive and far from statistically significant. This somewhat counterintuitive finding may at least partially



be explained by geography. Underrepresented minority home buyers disproportionately live in lower-income metro areas and, as I describe in the appendix, mortgage rate increases seem to depress demand particularly in *higher* income metro areas. Indeed, when I control for MSA fixed effects in equation 2, the estimated effect of a rate increase on the underrepresented minority share becomes negative (not shown). However, it remains statistically insignificant.

### ***4.3 First-Time Home Buyers***

Barriers to home purchase are particularly consequential for households that do not already own their home. Obtaining a home loan can set these families on the path of decades of steady wealth accumulation, as their payments amortize and the property appreciates in value, while providing insurance against rental inflation. For repeat home buyers, the wealth effects are likely less meaningful as they would mostly be exchanging ownership of one home for another. The importance of monetary policy's role in the inequality of home ownership therefore depends on its effect among first-time home buyers specifically.

I split the sample into first-time and repeat home buyers, and reestimate the effects of monetary policy shocks on the LMI and low-income share of home buyers among these groups. Results are presented in Table 3. The estimated effects are particularly strong among the first-time home buyer population. A 1 percentage point rate shock reduces the LMI share of first-time buyers by 4 percentage points (column 1), and the low-income share alone by almost 3 percentage points (column 3). Estimated effects by day are shown in Figure 3. While the individual daily estimates are again noisy, the LMI and low-income shares of first-time home buyers clearly fall on average after a positive rate shock. Estimated effects for repeat home buyers, shown in columns 2 and 4 of Table 3 are smaller and not statistically significant. Interestingly, mortgage rates also don't appear to significantly alter the balance of first-time versus repeat home buyers in the overall pool of home purchase borrowers. The estimated effect of  $r$  on the proportion of first-time home buyers, irrespective of income, is shown in column 5.

These findings suggest monetary policy is an important determinant of the composition of home owners. It has a powerful effect on which families make up the inflow to homeownership, while exerting less influence on the churn of home buying among the stock of families who already belong to the home owning population.

#### ***4.4 Borrower Adjustments to Higher Rates***

Mortgage applicants have a number of options they can pursue to lower their monthly payments in the face of rising mortgage rates. These adjustments include paying points upfront to obtain a lower interest rate, or putting more money down to lower the loan amount (and potentially avoid mortgage insurance). If an applicant faces credit denial due to a too-high DTI ratio, lowering the scheduled payment in this manner could allow them to qualify for credit. However, these options require additional liquid funds which some lower-income households in particular may not have.

In Table 4, I show the effect of a 1 percentage point mortgage rate shock on borrower's use of these options. Effects are estimated as before, using equation 1 as a first stage and equation 2 as the second stage. In columns 1 and 2, I show the effect on the probability of paying any points, and on the total amount of points paid. Borrowers clearly respond to higher rates by buying down their rate: a 1 percentage point rate increase is estimated to increase the probability of paying points by 32 percentage points, and to increase the average amount of points paid by 0.61 percent of the total loan amount. The tradeoff between points and interest rates varies by lender and over time, but a borrower can typically expect to lower their interest rate by around 0.12 percentage points for every full percentage point of the total loan amount paid upfront. These findings suggest borrowers only offset around 7 percent of rate increases by paying points.

In column 3, I show the estimated effect of a 1 percentage point rate shock on borrower loan-to-value (LTV) ratio. There is no significant effect (and the point estimate is slightly positive). This suggests borrowers do not respond to higher rates by putting more money down. However, the unchanged average LTV ratio could mask offsetting changes in both

the numerator and denominator. In columns 4 and 5 I show the estimated effect on log loan amounts and purchase prices. The point estimates suggest both amounts fall by about 2 percentage points. While these estimates are not statistically significant, the magnitudes are closely in line with other estimates of the intensive margin semi-elasticity of mortgage demand to interest rates (see DeFusco and Paciorek, 2017 and Bhutta and Ringo, 2021, for example).

There are several possible interpretations of these findings, assuming they represent a real effect and not simply estimation error. One possibility is that homes are selling more cheaply, either because sellers are asking less or buyers are negotiating them down in response to higher rates. However, the literature has generally found that house prices are quite slow to react to mortgage rate changes (see Kuttner, 2014, for example). An exception is Gorea, Kryvtsov and Kudlyak (2022), who find the initial asking price of new listings falls quickly in response to monetary policy shocks. However, they find no effect on sale price for listings already active at the time of the shock. The substantial majority of home purchase rate locks that occur in a 3-week window after a monetary policy shock are likely for the purchase of homes that initially listed prior to the announcement. Homes generally take many weeks to find a buyer, and there is often a further delay between the purchase agreement and the rate lock. A response by sellers therefore seems unlikely to be able to explain the drop in average sale prices I estimate in the short term. Furthermore, Gorea, Kryvtsov and Kudlyak (2022) find no effect of monetary policy shocks on sale price conditional on list price, so tougher negotiating by buyers also seems unlikely to explain lower prices. The effect could be explained, however, by a shift in borrower composition. If applicants attempting to buy more expensive houses are more likely to be discouraged or denied credit due to higher rates, then a quick negative response in the average sale price is not surprising.

#### **4.4.1 Reliability of Reported Income**

Another adjustment loan applicants could make in response to higher rates—and one that could change the interpretation of the main results in Section 4.2—would be to lower their DTI ratio by reporting additional sources of income to their lender. Applicants with a

working spouse, for example, could add that spouse as a co-applicant to have their income counted as well. Applicants with a side job could choose to include the second source of income if their primary income is not sufficient to get their loan approved. The applicant might not have bothered to report the additional source of income under a more favorable rate environment if it was difficult to document, i.e. if it was self-employment income. If applicants report additional sources of income in response to higher rates, then the finding of reduced borrowing by low- and moderate-income households could be an artifact of the same set of households simply reporting higher incomes.

To test for evidence that applicants add sources of income to their applications in response to higher rates, I estimate the effect of a monetary policy shock on the probability a loan includes more than one applicant, and on the probability that the borrower's income is reported as coming from self-employment.<sup>23</sup> In the estimation sample, approximately 44 percent of loans have more than one applicant and 7 percent flag the borrower as being self employed. I re-estimate equation 2 with indicators for multiple applicants and self-employment as the outcome variables. Results are reported in Table 5. These tests provide no evidence of adjustments in the reporting of incomes. Positive rate shocks are estimated to have small and statistically insignificant effects on the probabilities that a loan has multiple applicants or is underwritten based on self-employment income. The reduction in lending to low- and moderate-income borrowers found in Section 4.2 seems to reflect a true change in the composition of borrowers, rather than a change in how much of their income is recorded.

In addition to the results presented in this subsection, in the appendix I show evidence that monetary policy shocks affect home purchase borrowing differently by location, with borrowing in lower-income neighborhoods being particularly sensitive. This finding further suggests an actual shift in the composition of borrowers. Lower-income borrowers would be quite unlikely to quickly change their neighborhood of choice toward a *higher* income (and more expensive) location in response to a positive rate shock. I also show evidence of a shift in home buying across different metro areas. This further suggests a true compositional

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<sup>23</sup>Through Optimal Blue, lenders mark a loan as self employed if any portion of the income used to qualify the borrower comes from self employment.

change in home buyers, as it seems very unlikely that many households' choice of which broad labor market to move to is sensitive to interest rates in the short run.

#### 4.5 *The Role of Borrower Leverage*

In section 4.2 I found that tighter monetary policy particularly reduces borrowing among households with lower-incomes, while the results presented in section 4.4 suggest a relative reduction among those attempting to buy higher-priced homes. Together, these findings suggest a role for budget constraint pressure, either internal to the borrower or imposed by the lender in the form of DTI ratio limits. Lower income borrowers tend to have higher DTI ratios, and may be more likely to be discouraged or denied when a monetary policy shock pushes their prospective DTI ratio even higher.

To test for the importance of this form of borrower leverage, I estimate the effect of a monetary policy shock on the presence of highly leveraged borrowers in the population of home buyers. Rate increases mechanically raise the DTI ratio of all new borrowers *ceteris paribus*, so to test for a change in the composition of borrowers I need to construct a measure of leverage that is invariant to rate shocks for a given applicant. I first construct a counterfactual DTI ratio, calculated as the DTI ratio the borrower would have obtained if they had locked the prime rate prevailing on the day prior to the nearest monetary policy shock,  $t = -1$ . To avoid selection bias from other adjustments the borrower could make, I assume that the loan gets a 95 percent LTV ratio and the typical 30 year (360 month) term and fixed rate for purposes of calculating the counterfactual DTI.<sup>24</sup> The counterfactual DTI for a given borrower should therefore not change in response to a monetary policy shock—although the distribution of counterfactual DTIs could change as the monetary policy shock affects the composition of borrowers. The counterfactual DTI ratio,  $\widetilde{DTI}$ , for a given borrower,  $i$ , is

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<sup>24</sup>I assume a high LTV ratio, as most LMI borrowers have an LTV of 95 percent or higher. Furthermore, the applicants who are on the margin of denial and unable to buy down their rate are likely those who also do not have large amounts of liquid wealth for a down payment.

calculated as:

$$\widetilde{DTI}_i = DTI_i + \left[ \frac{0.95P_i(r_m(1+r_m)^{360} - payment_i)}{(1+r_m)^{360} - 1} \right] I^{-1} \quad (5)$$

where  $DTI$  is the factual DTI ratio,  $payment$  is the factual monthly principal and interest payment,  $P$  is the sale price,  $r_m$  is the pre-shock prime rate expressed in monthly terms, and  $I$  is the borrower's monthly income.

Bhutta and Ringo (2021) found evidence of binding underwriting constraints at DTI ratios of 45, 50, 55, and 57 percent. I therefore define highly-leveraged applicants as those with a  $\widetilde{DTI}$  greater than 44 percent, as these applicants are at risk of either being pushed above a binding DTI threshold by a positive rate shock, or dropped below a threshold by a negative shock. Using this definition, approximately 30 percent of home purchase loan borrowers are highly leveraged. I test for the importance of borrower leverage as the channel through which monetary policy affects borrower composition by estimating the effect of a rate shock on the presence of highly-leveraged borrowers in the population of home buyers. Using an indicator for high leverage as the outcome variable, I reestimate equation 2.

Results are presented in column 1 of Table 6. The estimated effect is very strong: a 1 percentage point increase in mortgage rates reduces the presence of highly leveraged borrowers by about 5 percentage points. To see the effect graphically, the top panel of Figure 4 shows daily estimates of a 1 percentage point rate shock on the fraction of borrowers with  $\widetilde{DTI}$  greater than 44 percent in the 3 weeks before and after the shock. There is a clear drop following the shock, and no apparent pre-trend. The estimated effect of a monetary policy contraction on highly leveraged borrowers is considerably larger than the effect on low- or moderate-income borrowers found in Section 4.2. LMI borrowers are more likely to be highly leveraged than other borrowers (34 versus 22 percent have DTI ratios above 44 percent, respectively), so the compositional effects of monetary policy shocks described in Section 4.2 may be a corollary of this tendency, with lower-income status serving as a proxy for high borrower leverage.

In section 4.4 I argued that the purchase price for a given house is unlikely to be affected

by monetary policy shocks in the short run, and that the estimates of an effect on average sale price are likely due to composition effects. However, it is possible that this argument is wrong and rate shocks do have some immediate effect on individual home prices conditional on selling. If so, the assignment to leverage groups in the above analysis would be biased, as the sale price is used to calculate  $\widetilde{DTI}$ . To deal with this issue, I construct a second counterfactual DTI ratio,  $\widetilde{\widetilde{DTI}}$ , that does not use the actual sale price of each home. Instead, I substitute the median sale price of homes sold in the borrower’s ZIP code in the quarter prior to the relevant rate shock for the actual sale price,  $P$ , in equation 5. Past local sale prices cannot be affected by current monetary policy shocks, so the proxy can be taken as exogenous.

I reestimate equation 2 using an indicator for  $\widetilde{\widetilde{DTI}}$  being greater than 44 percent as the outcome variable, and show results in column 2 of Table 6. Estimated effects are somewhat attenuated relative to column 1, which is unsurprising as  $\widetilde{\widetilde{DTI}}$  is a less accurate proxy for the leverage ratio a borrower is likely to obtain than  $\widetilde{DTI}$ . Nevertheless, a 1 percentage point rate shock is estimated to have a strong negative effect, reducing the presence of highly leveraged borrowers by 3.3 percentage points. The daily estimated effects of a rate shock on highly leverage borrowers, measured via  $\widetilde{\widetilde{DTI}}$ , is shown in the bottom panel of Figure 4.

## 5 Longer-Run Results

To estimate the effect of monetary policy shocks on the composition of home purchase borrowers in the longer run, I use the local projections method of Jordà (2005), as described in Section 2.2. The AIC for estimated effects in the first week post-shock was minimized when three lags of the dependent variable were included (for all three outcomes I consider in this section), so results are shown for  $L = 3$ . In Figure 5 I show the estimated effect of a monetary policy shock equivalent to a 1 percentage point tightening of mortgage rates on the share of home purchase loans going to LMI, low-income, and underrepresented minority borrowers for each week in the year following the shock. The shaded area corresponds to the 95 percent confidence interval, calculated from Huber-White heteroskedasticity robust

standard errors as recommended by Montiel Olea and Plagborg-Møller (2021).

Estimated effects on LMI and low-income borrowers seem quite persistent. After a few weeks the coefficients drop to around the same levels estimated in Table 2 (i.e. a 1 percentage point decline for low-income households and a 2 percentage point decline for LMI households), and stay around that level throughout most of the subsequent year, before returning to zero around 49 weeks after a monetary policy shock. The precision of the estimates does deteriorate with time, however, and the estimates cannot be statistically distinguished from zero late in the year post-shock. Note that there is no evidence of an effect on borrower income composition in the first two weeks following the shock, in contrast with Figure 2. This is likely due to my use of origination date rather than rate lock date in this section. As described in Section 3, loans originated in the weeks immediately following a monetary policy shock mostly had their rate locked in the pre-shock environment. A delay of some weeks before an effect is apparent is therefore to be expected. As in Section 4.2, there is little evidence of an effect on the racial makeup of borrowers.

## 6 Rate Semi-Elasticity of Demand

The primary research question of this paper is how monetary policy affects the distribution of home buying (and hence home ownership) across different income and demographic groups. I therefore measure outcomes in terms of the percentage of loans going to various types of borrowers, rather than the total count of loans. This approach has several advantages: it offers a natural way to test for differential responses to rate shocks across groups and eliminates noise from the estimates caused by aggregate changes in the demand for or supply of home purchase loans.

Nevertheless, we may be interested in estimates of the effect of monetary policy shocks on the total number of loans going to these various groups directly. The rate semi-elasticity of housing demand is an important parameter for the pass-through of monetary policy to real activity. Furthermore, my interpretation of the results in Sections 4.2 and 5 hinges on the idea that they indicate a decline in lending to lower-income groups. If the relative decline



in lower-income home buying was actually a result of an absolute *increase* in borrowing by higher-income households, a very different explanatory mechanism would be needed.

To estimate semi-elasticities, I again use a local projections method, estimating the effect of a rate shock in week  $t$  on the log number of loans going to borrowers in each group in week  $t + k$ . Home buying is predictably seasonal, so I use the 52-week difference in log loans as the outcome variable to eliminate seasonality. The AIC was minimized for this specification when  $L = 2$ , so I use two lags of the outcome variable as controls. I show results for low-income, low- and moderate-income, and underrepresented minority borrowers in Figure 6. For comparison, I also show results for middle- and upper-income borrowers (those whose income is greater than 80 percent of AMFI).

Low-income and low- and moderate-income borrowing is substantially lower following a positive rate shock. Weekly point estimates are only sporadically statistically significant, but the average point estimates across the 52 weeks post-shock indicate a 21 percent and 18 percent decline for these two income groups, respectively, in response to a 1 percentage point tightening of mortgage rates. These results are very close to the semi-elasticity of 19 Bhutta and Ringo (2021) found among borrowers reliant on FHA loans when that agency unexpectedly lowered monthly insurance premiums (analogous to a rate cut) in 2015. Underrepresented minorities are estimated to have an average semi-elasticity of 10 over the year following the shock, although the point estimates are generally not statistically significant. Middle- and upper-income borrowers are estimated to have an average semi-elasticity of 6, although these estimates are also generally far from significant. Overall, it seems that the negative effect of monetary tightening on the share of loans going lower-income households is due to an actual reduction in their borrowing, rather than an increase in borrowing by higher-income households.

## 7 Conclusion

Monetary policy affects not only the value of assets, but who is able to purchase those assets. While low-wealth households may not experience an immediate appreciation of financial

assets when the stance of monetary policy is expansionary, that stance can allow them to get their foot in the door of homeownership. The forced-savings nature of amortizing mortgage payments and house price appreciation together can be a powerful wealth building tool for these families over the decades. Tighter policy, on the other hand, appears to prevent many lower-income families from buying homes.

## 8 Bibliography

- Amberg, Niklas, Thomas Jansson, Mathias Klein, and Anna Rogantini Picco.** 2022. “Five Facts about the Distributional Income Effects of Monetary Policy Shocks.” *American Economic Review: Insights*, 4(3): 289–304.
- Ampudia, Miguel, Dimitris Georgarakos, Jiri Slacalek, Oreste Tristani, Philip Vermeulen, and Giovanni Violante.** 2018. “Monetary policy and household inequality.”
- Andersen, Asger Lau, Niels Johannesen, Mia Jørgensen, and José-Luis Peydró.** 2022. “Monetary policy and inequality.” *Journal of Finance, Forthcoming*.
- Anenberg, Elliot, and Edward Kung.** 2017. “Interest rates and housing market dynamics in a housing search model.” *Available at SSRN 3062113*.
- Avery, Robert B, and Kenneth P Brevoort.** 2015. “The subprime crisis: Is government housing policy to blame?” *Review of Economics and Statistics*, 97(2): 352–363.
- Bank of International Settlements.** 2021. “The Distributional Footprint of Monetary Policy.” *BIS Annual Economic Report 2021*.
- Bartscher, Alina K, Moritz Kuhn, Moritz Schularick, and Paul Wachtel.** 2021. “Monetary policy and racial inequality.” *FRB of New York Staff Report*, , (959).
- Bernstein, Asaf, and Peter Koudijs.** 2021. “The mortgage piggy bank: Building wealth through amortization.” National Bureau of Economic Research.
- Bhutta, Neil.** 2011. “The community reinvestment act and mortgage lending to lower income borrowers and neighborhoods.” *The Journal of Law and Economics*, 54(4): 953–983.
- Bhutta, Neil.** 2012. “GSE activity and mortgage supply in lower-income and minority neighborhoods: The effect of the affordable housing goals.” *The Journal of Real Estate Finance and Economics*, 45(1): 238–261.

- Bhutta, Neil, and Daniel Ringo.** 2021. “The effect of interest rates on home buying: Evidence from a shock to mortgage insurance premiums.” *Journal of Monetary Economics*, 118: 195–211.
- Bostic, Raphael W, and Stuart A Gabriel.** 2006. “Do the GSEs matter to low-income housing markets? An assessment of the effects of the GSE loan purchase goals on California housing outcomes.” *Journal of Urban Economics*, 59(3): 458–475.
- Cloyne, James, Clodomiro Ferreira, and Paolo Surico.** 2020. “Monetary policy when households have debt: new evidence on the transmission mechanism.” *The Review of Economic Studies*, 87(1): 102–129.
- Cochrane, John H, and Monika Piazzesi.** 2002. “The fed and interest rates—a high-frequency identification.” *American economic review*, 92(2): 90–95.
- Coibion, Olivier, Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia.** 2017. “Innocent Bystanders? Monetary policy and inequality.” *Journal of Monetary Economics*, 88: 70–89.
- 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*, 9(1): 210–40.
- Di Maggio, Marco, Amir Kermani, Benjamin J Keys, Tomasz Piskorski, Rodney Ramcharan, Amit Seru, and Vincent Yao.** 2017. “Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging.” *American Economic Review*, 107(11): 3550–88.
- Ding, Lei, and Leonard Nakamura.** 2021. ““Don’t Know What You Got till It’s Gone”: The Community Reinvestment Act in a Changing Financial Landscape.” *Journal of Real Estate Research*, 43(1): 96–122.
- Friedman, Milton.** 1961. “The lag in effect of monetary policy.” *Journal of Political Economy*, 69(5): 447–466.

- Giacoletti, Marco, Rodney Ramcharan, and Edison G Yu.** 2019. “The FOMC Cycle and Consumer Decision Making: Evidence from the Residential Housing Market.” *USC Marshall School of Business Research Paper Sponsored by iORB, No. Forthcoming.*
- Glaeser, Edward L, Joshua D Gottlieb, and Joseph Gyourko.** 2012. “Can cheap credit explain the housing boom?” In *Housing and the financial crisis*. 301–359. University of Chicago Press.
- Gorea, Denis, Oleksiy Kryvtsov, and Marianna Kudlyak.** 2022. “House Price Responses to Monetary Policy Surprises: Evidence from the US Listings Data.”
- Jordà, Òscar.** 2005. “Estimation and inference of impulse responses by local projections.” *American economic review*, 95(1): 161–182.
- Kuttner, Kenneth N.** 2014. “Low interest rates and housing bubbles: still no smoking gun.” *The Role of Central Banks in Financial Stability: How Has It Changed*, 30: 159–185.
- Lee, Hyojung, and Raphael W Bostic.** 2020. “Bank adaptation to neighborhood change: Mortgage lending and the Community Reinvestment Act.” *Journal of Urban Economics*, 116: 103211.
- Luetticke, Ralph.** 2021. “Transmission of monetary policy with heterogeneity in household portfolios.” *American Economic Journal: Macroeconomics*, 13(2): 1–25.
- Montiel Olea, José Luis, and Carolin Pflueger.** 2013. “A robust test for weak instruments.” *Journal of Business & Economic Statistics*, 31(3): 358–369.
- Montiel Olea, José Luis, and Mikkel Plagborg-Møller.** 2021. “Local projection inference is simpler and more robust than you think.” *Econometrica*, 89(4): 1789–1823.
- Mumtaz, Haroon, and Angeliki Theophilopoulou.** 2017. “The impact of monetary policy on inequality in the UK. An empirical analysis.” *European Economic Review*, 98: 410–423.

- Nakamura, Emi, and Jón Steinsson.** 2018. “High-frequency identification of monetary non-neutrality: the information effect.” *The Quarterly Journal of Economics*, 133(3): 1283–1330.
- Ringo, Daniel.** 2017. “Mortgage lending, default, and the Community Reinvestment Act.” *Journal of Money, Credit and Banking*.
- Ringo, Daniel.** 2022. “Declining Affordability and Home Purchase Borrowing by Lower Income Households.” *FEDS Notes*.
- Saadi, Vahid.** 2020. “Role of the community reinvestment act in mortgage supply and the US housing boom.” *The Review of Financial Studies*, 33(11): 5288–5332.
- Sabelhaus, John, and Austin Clemens.** 2020. “A generational perspective on recent U.S. homeownership divergence by income and race.” Washington Center for Equitable Growth, Washington, D.C.
- Sakong, Jung.** 2022. “Cyclical Transactions and Wealth Inequality.” *Cyclical Transactions and Wealth Inequality (February 16, 2022)*. *FRB of Chicago Working Paper*, , (2022-05).
- Swanson, Eric T.** 2021. “Measuring the effects of federal reserve forward guidance and asset purchases on financial markets.” *Journal of Monetary Economics*, 118: 32–53.
- Wainer, Allison, and Jeffrey Zabel.** 2020. “Homeownership and wealth accumulation for low-income households.” *Journal of Housing Economics*, 47: 101624.

Table 1: Summary Statistics

Variable	HMDA	Optimal Blue	Merged
Income	99.4 (81.7)		94.0 (68.3)
Moderate Income (categorical)	0.21 (0.41)		0.22 (0.42)
Low Income (categorical)	0.07 (0.26)		0.07 (0.25)
Underrepresented Minority (categorical)	0.19 (0.39)		0.20 (0.40)
First-Time Home Buyer (categorical)		0.35 (0.48)	0.37 (0.48)
Loan Amount	253 (206)	252 (168)	248 (153)
Loan-to-Value Ratio		88.7 (13.6)	88.9 (13.4)
DTI Ratio		36.8 (10.3)	36.9 (10.1)
Median ZIP Code House Price		279.8 (160.9)	278.5 (162.4)
Interest Rate		4.24 (0.58)	4.29 (0.56)
Prime Rate		4.08 (0.36)	4.11 (0.35)
N	23,210,924	8,061,650	3,435,223

**Note:** This table reports summary statistics for individual loans in the 2013-2019 HMDA data, Optimal Blue data, and merged estimation sample. Incomes, loan amounts, and house prices are reported in thousands of nominal dollars. Loan-to-value ratios, DTI ratios, and interest rates are reported in percentage points. HMDA sample limited to first-lien, home-purchase loans for owner-occupied properties with a reported borrower income between zero and \$1 million. Optimal Blue sample limited to home purchase rate locks for owner-occupied properties.

Table 2: Effect of Rate Shock on Borrower Composition

	$r$	LMI		Low Income		URM	
		OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$r$		0.012**	-0.021*	0.006**	-0.011**	0.035**	0.008
		(0.003)	(0.009)	(0.002)	(0.004)	(0.005)	(0.008)
LSAP $\times D$	0.073**						
	(0.025)						
FG $\times D$	0.060**						
	(0.012)						
FEs for $s$ and $D$	X		X		X		X
$F$ stat			19.208		19.208		19.208
N = 2,912,379							

**Note:** This table reports estimates of  $\alpha_1$  and  $\beta_1$  from equations 1 and 2. Outcome variables are the prime mortgage rate,  $r$ , and the low- and moderate-income share (LMI), the low-income share, and the underrepresented minority share (URM) of new home purchase loans. Instruments are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate,  $r$  is measured in percentage points and the borrower composition outcomes are measured in fractions.

\*\* :  $p < 0.01$

\* :  $p < 0.05$

† :  $p < 0.10$



Table 3: Effect of a Rate Shock on Borrower Composition, by First-Time and Repeat Home Buyers

	LMI		Low Income		First Time Home Buyer
	(1)	(2)	(3)	(4)	(5)
$r$	-0.039*	-0.018 <sup>†</sup>	-0.029*	-0.005	0.018
	(0.017)	(0.011)	(0.011)	(0.004)	(0.021)
Full Sample					X
First-time home buyer sample	X		X		
Repeat home buyer sample		X		X	
$F$ stat	18.653	18.479	18.653	18.479	19.214
N	1,050,304	1,856,500	1,050,304	1,856,500	2,906,804

**Note:** This table reports estimates of  $\beta_1$  from equations 1 and 2. Outcome variables are the low- and moderate-income share (LMI) and the low-income share of new home purchase loans, and the share that go to first-time home buyers. Instruments are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate is measured in percentage points and the borrower composition outcomes are measured in fractions. Columns 1 and 3 are limited to first-time home buyers. Columns 2 and 4 are limited to repeat home buyers. Regressions additionally control for fixed effects for  $s$  and  $D$ .

\*\* $: p < 0.01$

\* $: p < 0.05$

† $: p < 0.10$

Table 4: Borrower Adjustments to a Rate Shock

	Any Points	Points Paid	LTV	Log Amount	Log Price
	(1)	(2)	(3)	(4)	(5)
$r$	0.292**	0.647**	0.127	-0.018	-0.020
	(0.080)	(0.155)	(0.381)	(0.018)	(0.021)
$F$ stat	18.791	18.791	19.208	19.208	19.208
N	2,692,301	2,692,301	2,912,379	2,912,379	2,912,379

**Note:** This table reports estimates of the effect of a one-percentage point mortgage rate increase on various loan characteristics. Instruments for the prime rate,  $r$ , are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate is measured in percentage points and the borrower composition outcomes are measured in fractions. Columns 1 and 2 omit the 327,779 observations that are missing information about discount points. Regressions additionally control for fixed effects for  $s$  and  $D$ .

\*\* $: p < 0.01$

\* $: p < 0.05$

† $: p < 0.10$

Table 5: Effect of a Rate Shock on Source of Income

	Multiple Applicants	Self-Employed
	(1)	(2)
$r$	0.001	-0.004
	(0.009)	(0.004)
$F$ stat	19.208	19.208
N	2,912,379	2,912,379

**Note:** This table reports estimates of the effect of a one-percentage point mortgage rate increase on indicators for multiple applicants on the loan and borrower self-employment. Instruments for the prime rate,  $r$ , are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate is measured in percentage points. Regressions additionally control for fixed effects for  $s$  and  $D$ .

\*\* $: p < 0.01$

\* $: p < 0.05$

† $: p < 0.10$

Table 6: Effect of a Rate Shock on Highly-Leveraged Borrowers

	Using $\widetilde{DTI}$	Using $\widetilde{\widetilde{DTI}}$
	(1)	(2)
$r$	-0.047**	-0.032**
	(0.009)	(0.007)
$F$ stat	19.208	19.208
N	2,912,379	2,912,379

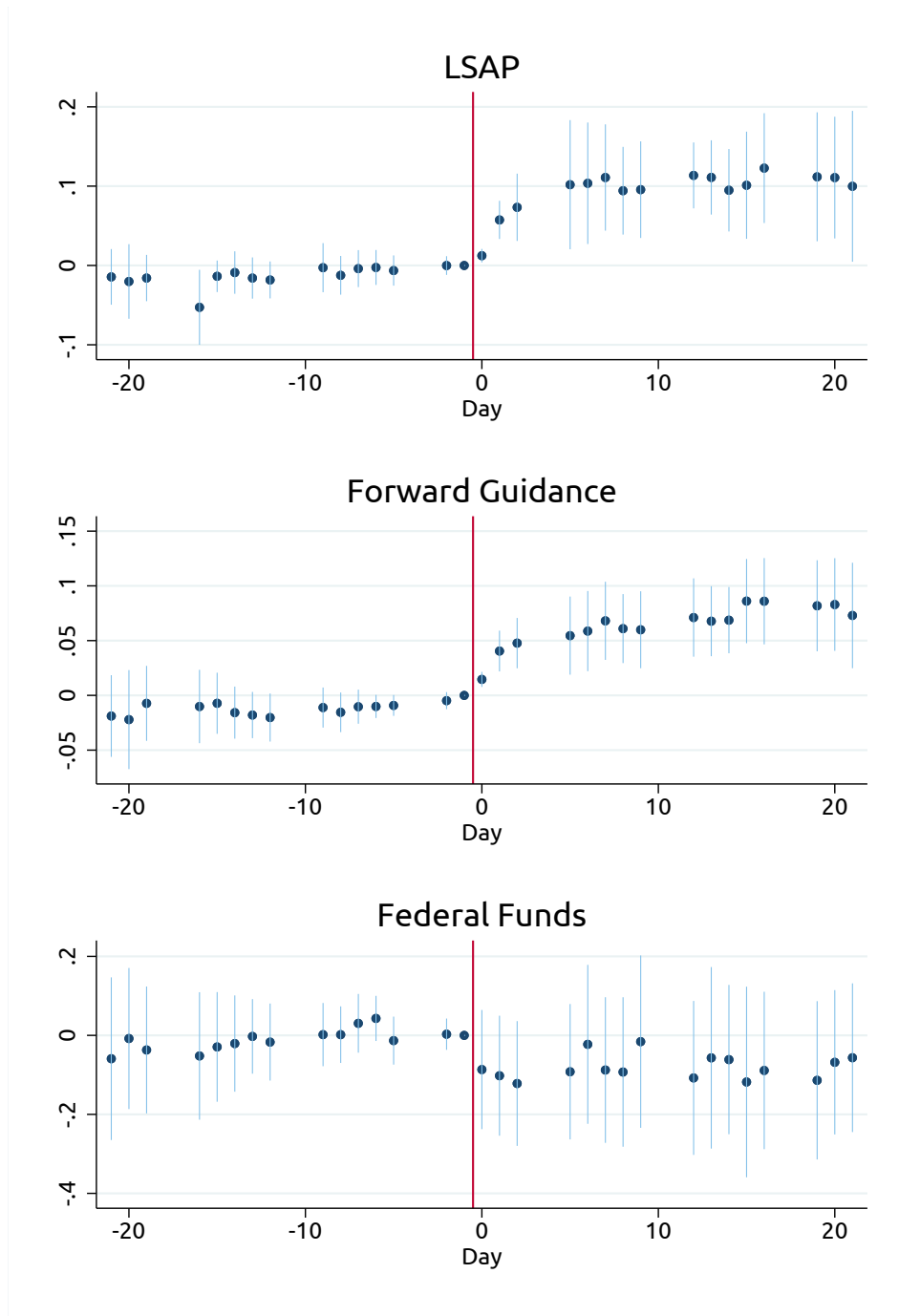
**Note:** This table reports estimates of the effect of a one-percentage point mortgage rate increase on an indicator for the borrower having a counterfactual DTI ratio greater than 44 percent. Calculation of counterfactual DTIs is described in Section 4.5. The counterfactual DTI used in column 1,  $\widetilde{DTI}$ , is calculated using realized sale price. The counterfactual DTI used in column 2,  $\widetilde{\widetilde{DTI}}$ , is calculated using the median sale price in the borrower’s ZIP code from the previous quarter. Instruments for the prime rate,  $r$ , are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate is measured in percentage points. Regressions additionally control for fixed effects for  $s$  and  $D$ .

\*\* $: p < 0.01$

\* $: p < 0.05$

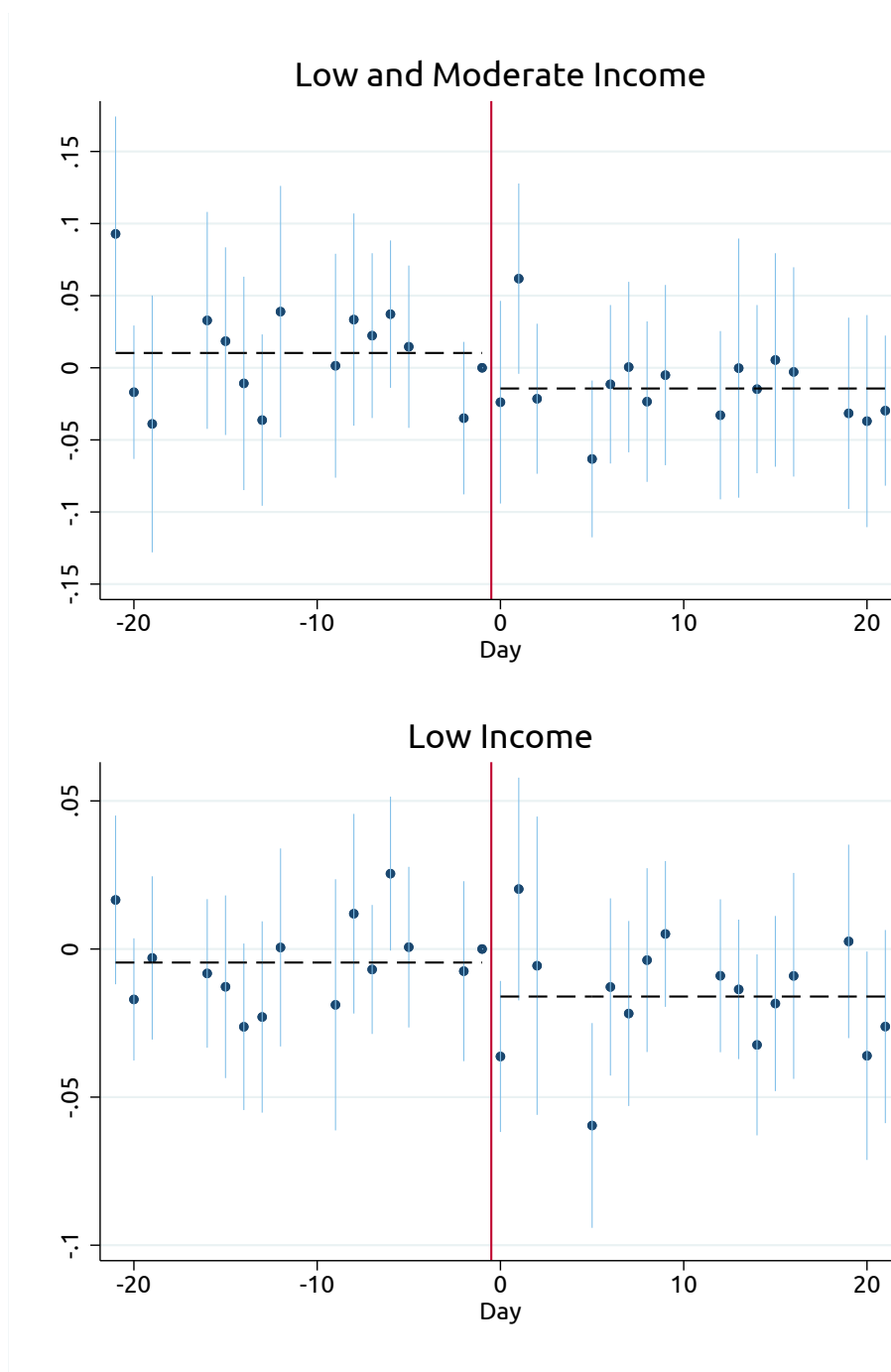
† $: p < 0.10$

Figure 1: Effect of Monetary Policy Shocks on Mortgage Rates, by Day



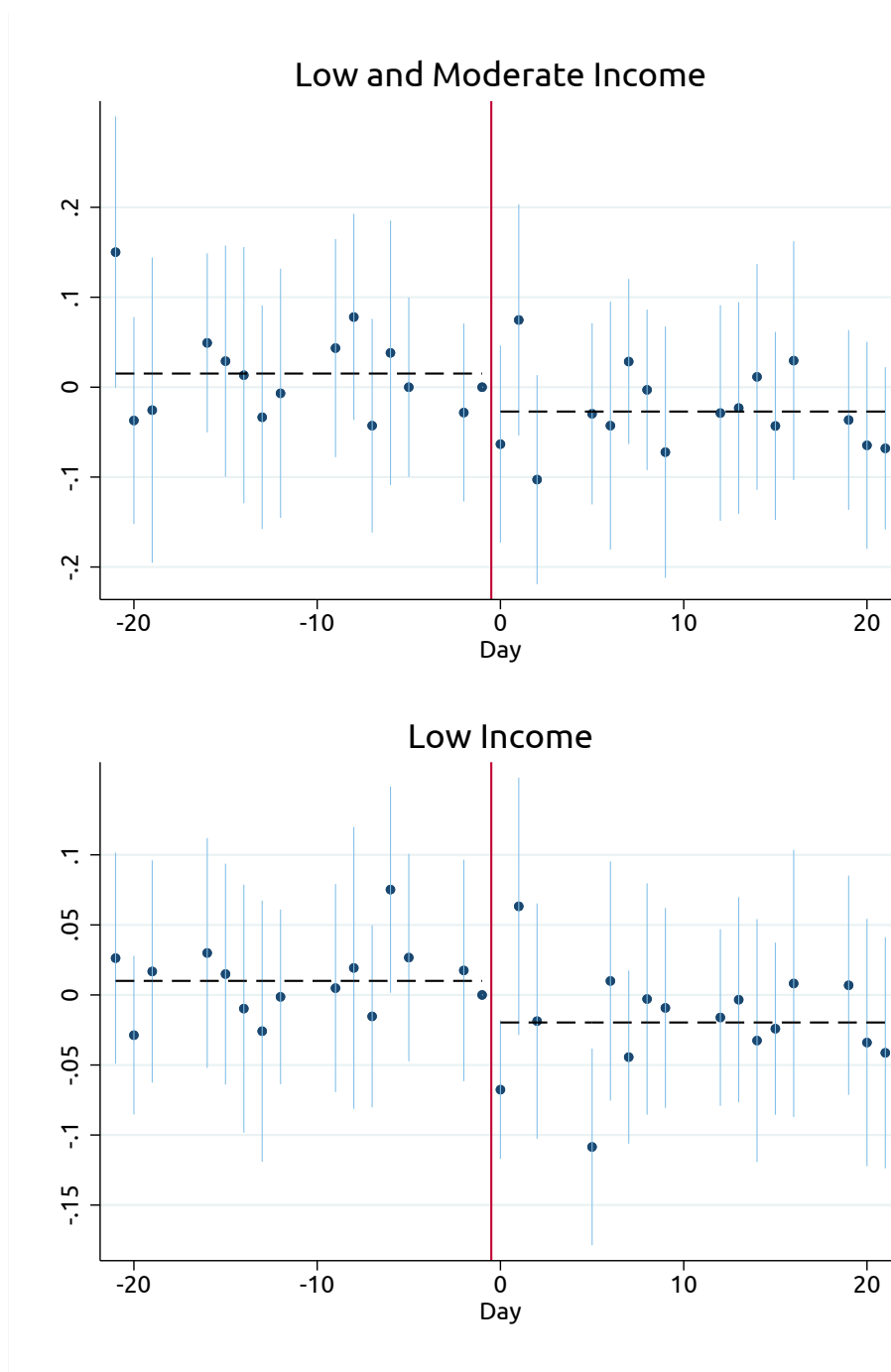
**Note:** Figure shows the estimated effect of a one standard deviation contractionary monetary policy shock on day  $t = 0$  on the daily prime mortgage rate (measured in percentage points) for the 3 weeks before and after the shock. Effects on day  $t = -1$  are normalized to zero. Only weekday estimates are shown, and the estimation sample is limited to observations around the 50 FOMC announcements that occurred on Wednesdays (out of 53 total in the full sample period). Values of the monetary policy shocks, split into LSAP, forward guidance, and federal funds shocks, are sourced from Swanson (2021). Blue vertical lines represent the 95 percent confidence intervals, with Huber-White standard errors adjusted for clustering within the 6-week window around each monetary policy shock,  $s$ .

Figure 2: Effect of Mortgage Rates on Fraction of Home Purchase Loans to Lower-Income Households, by Day



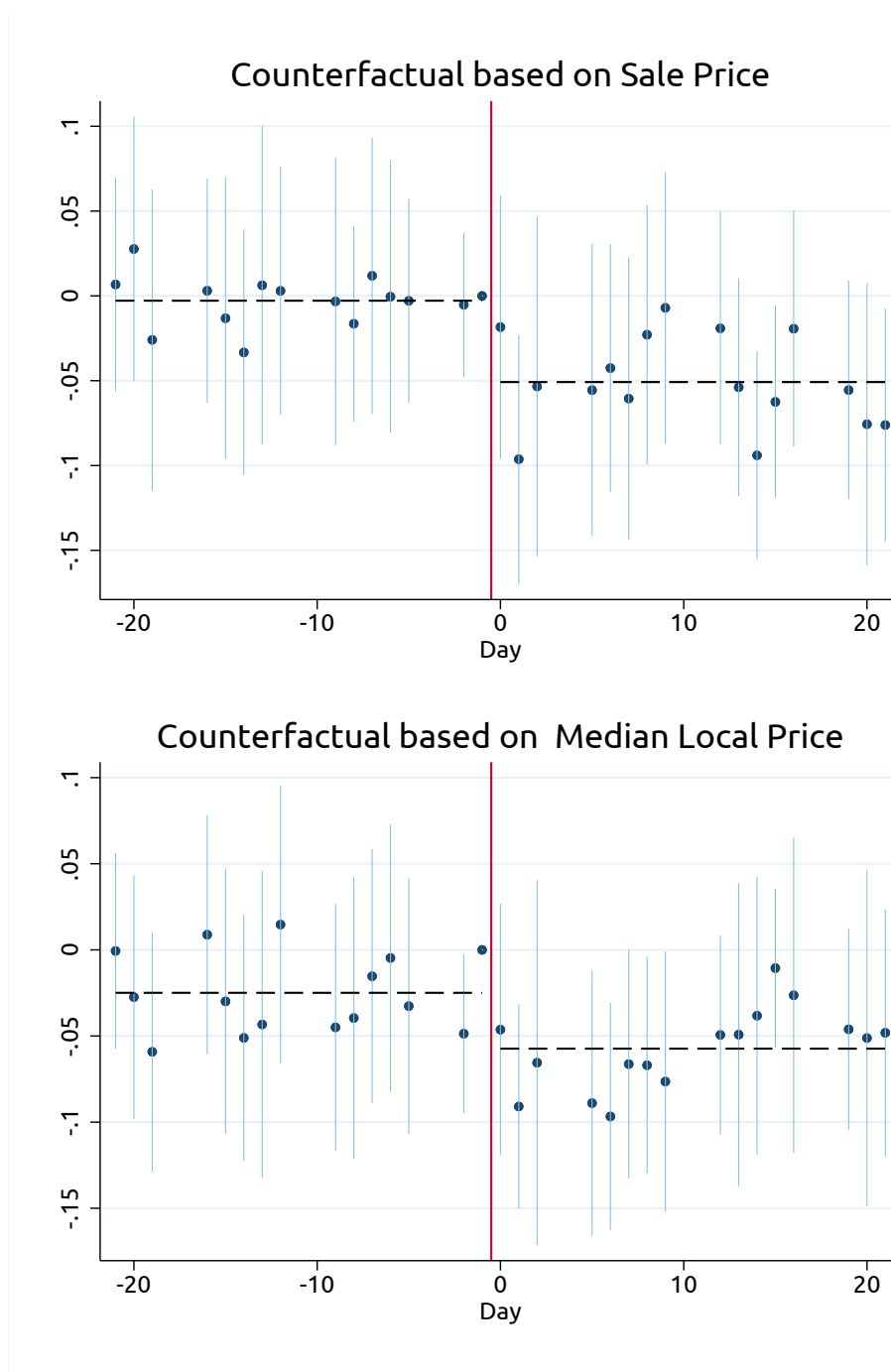
**Note:** Figure shows the estimated effect of a monetary policy shock on day  $t = 0$  on the daily fraction of home purchase mortgage loans going to LMI and low-income borrowers for the 3 weeks before and after the shock. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Effects on day  $t = -1$  are normalized to zero. Only weekday estimates are shown, and the estimation sample is limited to observations around the 50 FOMC announcements that occurred on Wednesdays (out of 53 total in the full sample period). Blue vertical lines represent the 95 percent confidence intervals, with Huber-White standard errors adjusted for clustering within the 6-week window around each monetary policy shock,  $s$ . Dashed horizontal lines represent the simple averages of the daily estimates for the period before and following the shock.

Figure 3: Effect of Mortgage Rates on Fraction of Home Purchase Loans to Lower-Income Households, by Day, First-Time Home Buyer Sample



**Note:** Figure shows the estimated effect of a monetary policy shock on day  $t = 0$  on the daily fraction of home purchase mortgage loans going to LMI and low-income borrowers for the 3 weeks before and after the shock among the population of first-time home buyers. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Effects on day  $t = -1$  are normalized to zero. Only weekday estimates are shown, and the estimation sample is limited to observations around the 50 FOMC announcements that occurred on Wednesdays (out of 53 total in the full sample period). Blue vertical lines represent the 95 percent confidence intervals, with Huber-White standard errors adjusted for clustering within the 6-week window around each monetary policy shock,  $s$ . Dashed horizontal lines represent the simple averages of the daily estimates for the period before and following the shock.

Figure 4: Effect of Mortgage Rates on Fraction of Home Purchase Loans to Highly-Leveraged Households, by Day



**Note:** Figure shows the estimated effect of a monetary policy shock on day  $t = 0$  on the daily fraction of home purchase mortgage loans going to borrowers with counterfactual DTIs greater than 44 percent for the 3 weeks before and after the shock. Calculation of counterfactual DTIs is described in Section 4.5. The counterfactual DTI used in the top panel,  $\widetilde{DTI}$ , is calculated using realized sale price. The counterfactual DTI used in the bottom panel,  $\widetilde{DTI}$ , is calculated using the median sale price in the borrower's ZIP code from the previous quarter. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Effects on day  $t = -1$  are normalized to zero. Only weekday estimates are shown, and the estimation sample is limited to observations around the 50 FOMC announcements that occurred on Wednesdays (out of 53 total in the full sample period). Blue vertical lines represent the 95 percent confidence intervals, with Huber-White standard errors adjusted for clustering within the 6-week window around each monetary policy shock,  $s$ . Dashed horizontal lines represent the simple averages of the daily estimates for the period before and following the shock.

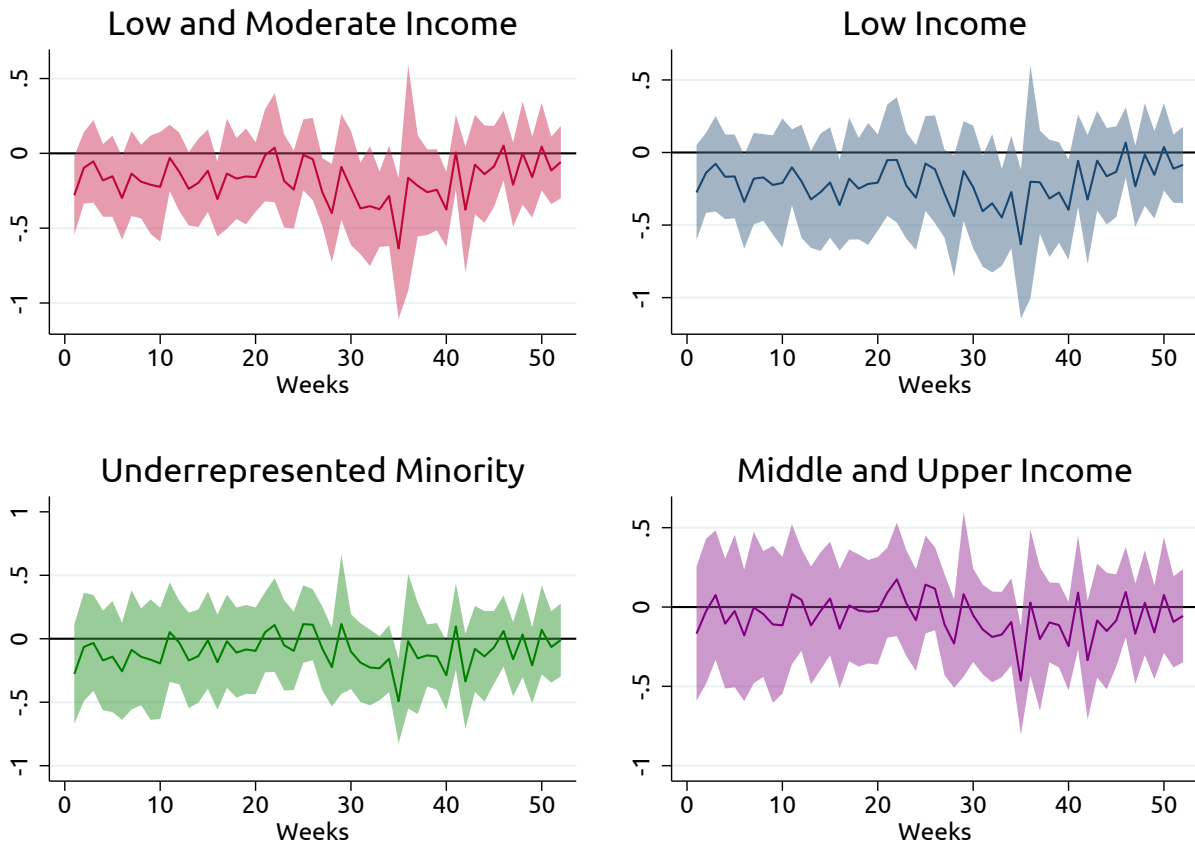


Figure 5: Longer-Term Effect of Mortgage Rates on Borrower Demographics, by Week



**Note:** Figure shows the estimated effect of a monetary policy shock on week  $t = 0$  on the weekly fraction of home purchase mortgage originations going to borrowers with low-incomes, low- and moderate-incomes, and to underrepresented minorities for the 52 weeks after the shock. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Estimates are obtained using the local projection method of Jordà (2005). Shaded area represents the 95 percent confidence interval, calculated from Huber-White heteroskedasticity robust standard errors, following Montiel Olea and Plagborg-Møller (2021).

Figure 6: Effect of Mortgage Rates on Log Loan Counts, by Week



**Note:** Figure shows the estimated effect of a monetary policy shock on week  $t = 0$  on the weekly log number of home purchase mortgage originations going to borrowers with low-incomes, low- and moderate-incomes, middle- and upper-incomes, and to underrepresented minorities for the 52 weeks after the shock. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Estimates are obtained using the local projection method of Jordà (2005). Shaded area represents the 95 percent confidence interval, calculated from Huber-White heteroskedasticity robust standard errors, following Montiel Olea and Plagborg-Møller (2021).

Internet Appendix for  
“Monetary Policy and Home Buying Inequality”

Daniel Ringo

January 12, 2023

## A Appendix

This section provides some supplementary results demonstrating the effect of monetary policy shocks on borrower composition. First, Table A.1 shows estimates of the reduced-form effects of the LSAP and forward guidance shocks from Swanson (2021) directly on the share of borrowers that are LMI, low-income, or highly leveraged. Columns 1 and 2 show that contractionary shocks to both LSAP and forward guidance are associated with a reduced share of lending going to LMI and low-income borrowers. Columns 3 and 4 limit the sample to first-time home buyers, and the estimated relationships strengthen. Columns 5 and 6 show the reduced-form effects of the shocks on the share of loans going to highly-leveraged borrowers are negative, whether counterfactual DTI ratios are calculated using actual sale price or last-quarter’s median sale price from the same ZIP code.

Next, I estimate the effect of a monetary policy shock on the location of home purchases. Again following the Community Reinvestment Act, I define low-income census tracts as those with a median family income less than 50 percent of area median family income, and moderate income tracts as those with a median family income less than 80 percent of area median family income. Estimates of the effect of a monetary policy shock on the share of home purchase loans going to these neighborhoods in the short- and longer-run are shown in columns 1 and 3 of Table A.2, and in Figure A.1, respectively. Results are suggestive of a reduction in lending in low- and moderate-income tracts, although generally not statistically significant.

I also estimate how the average location of home buying may have shifted across metro areas. To do so, I use the log of area median family income as the outcome variable and rerun the short- and longer-run estimators.<sup>1</sup> As shown in column 5 of Table A.2 and in Figure A.1, monetary tightening appears to reduce the MSA median income of the average purchase loan by 1 to 2 percentage points in both the short and longer run, indicating that demand is particularly depressed in higher-income metro areas. This finding is superficially at odds

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<sup>1</sup>In the local projection estimator for the longer-run estimates, I additionally control for an origination-year fixed effect as the outcome variable is no longer a relative income term, creating a time trend that could be a potential confounder.

with the census tract estimates, which find a reduction in lower-income areas. However, while lower incomes relative to area median family income are associated with higher leverage for both individuals and neighborhoods, a lower absolute income at the metro level is associated with *lower* leverage, likely due to correlations with house prices.

To see the importance of borrower leverage in mediating the effect on the location of borrowing, I rerun the short-run estimates above on the sample of highly-leveraged borrowers. Restricting the sample to those with a high counterfactual DTI ( $\widetilde{DTI} > 44$ ), I estimate the effect of a 1 percentage point rate increase on the share of lending going to LMI and low-income tracts, and on the average MSA income of new loans. Results are shown in columns 2, 4, and 6 of Table A.2. The effect on location within the set of borrowers at risk of denial due to leverage is much stronger: the share going to LMI and low-income tracts drops by 3.6 and 2.6 percentage points, respectively, although the estimated effect on low-income tracts remains insignificant. The reduction in the average MSA income for this group is also larger, falling 2.9 percentage points. Home buyers in lower relative-income neighborhoods and higher absolute income MSAs tend to be more highly leveraged. Among those borrowers who are already highly leveraged, this risk seems to compound and in these locations the effective rate elasticity of demand is particularly high.

Table A.1: Reduced-Form Effect of Monetary Policy Shocks on Borrower Compositions

	LMI	Low Income	LMI	Low Income	$\widetilde{DTI} > 44$	$\widetilde{\widetilde{DTI}} > 44$
	(1)	(2)	(3)	(4)	(5)	(6)
LSAP $\times D$	-0.0018 (0.0012)	-0.0015** (0.0006)	-0.0048 (0.0029)	-0.0040* (0.0019)	-0.0038 <sup>†</sup> (0.0022)	-0.0018 (0.0015)
FG $\times D$	-0.0012 (0.0008)	-0.0003 (0.0003)	-0.0023 <sup>†</sup> (0.0012)	-0.0015** (0.0006)	-0.0027* (0.0010)	-0.0022** (0.0007)
Full sample	X	X			X	X
First-time home buyer sample			X	X		
N	2,912,389	2,912,389	1,050,307	1,050,307	2,912,389	2,912,389

**Note:** This table reports estimates of the reduced-form effects of monetary policy shocks on borrower composition immediately following FOMC announcements. Outcome variables in columns 1 through 4 are the low- and moderate-income share (LMI) and the low-income share of new home purchase loans. Outcome variables in columns 5 and 6 are the highly leveraged share of new home purchase loans. Shocks are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . All regressions include fixed effects for  $D$  and each 6-week window surrounding each monetary policy shock,  $s$ . Huber-White standard errors are adjusted for clustering within  $s$ . Borrower composition outcomes are measured in fractions. Shocks are measured in standard deviations. Columns 3 and 4 restrict the sample to first-time home buyers. Highly leveraged borrowers are those with a counterfactual DTI ratio above 44 percent, as described in Section 4.5. In column 5, counterfactual DTI is calculated using the actual sale price of the purchased home. In column 6, counterfactual DTI is calculated using the median sale price of homes in the same ZIP code the previous quarter.

\*\* :  $p < 0.01$

\* :  $p < 0.05$

† :  $p < 0.10$

Table A.2: Effect of Rate Shock on Borrower Location

	LMI Tract		Low Income Tract		Log MSA Income	
	(1)	(2)	(3)	(4)	(5)	(6)
$r$	-0.009	-0.035**	-0.001	-0.025	-0.019**	-0.028**
	(0.007)	(0.013)	(0.014)	(0.020)	(0.006)	(0.006)
Full sample	X		X		X	
$\widetilde{DTI} > 44$		X		X		X
sample						
$F$ stat	19.213	19.781	19.213	19.781	19.213	19.781
N	2,911,492	851,945	2,911,492	851,945	2,911,492	851,945

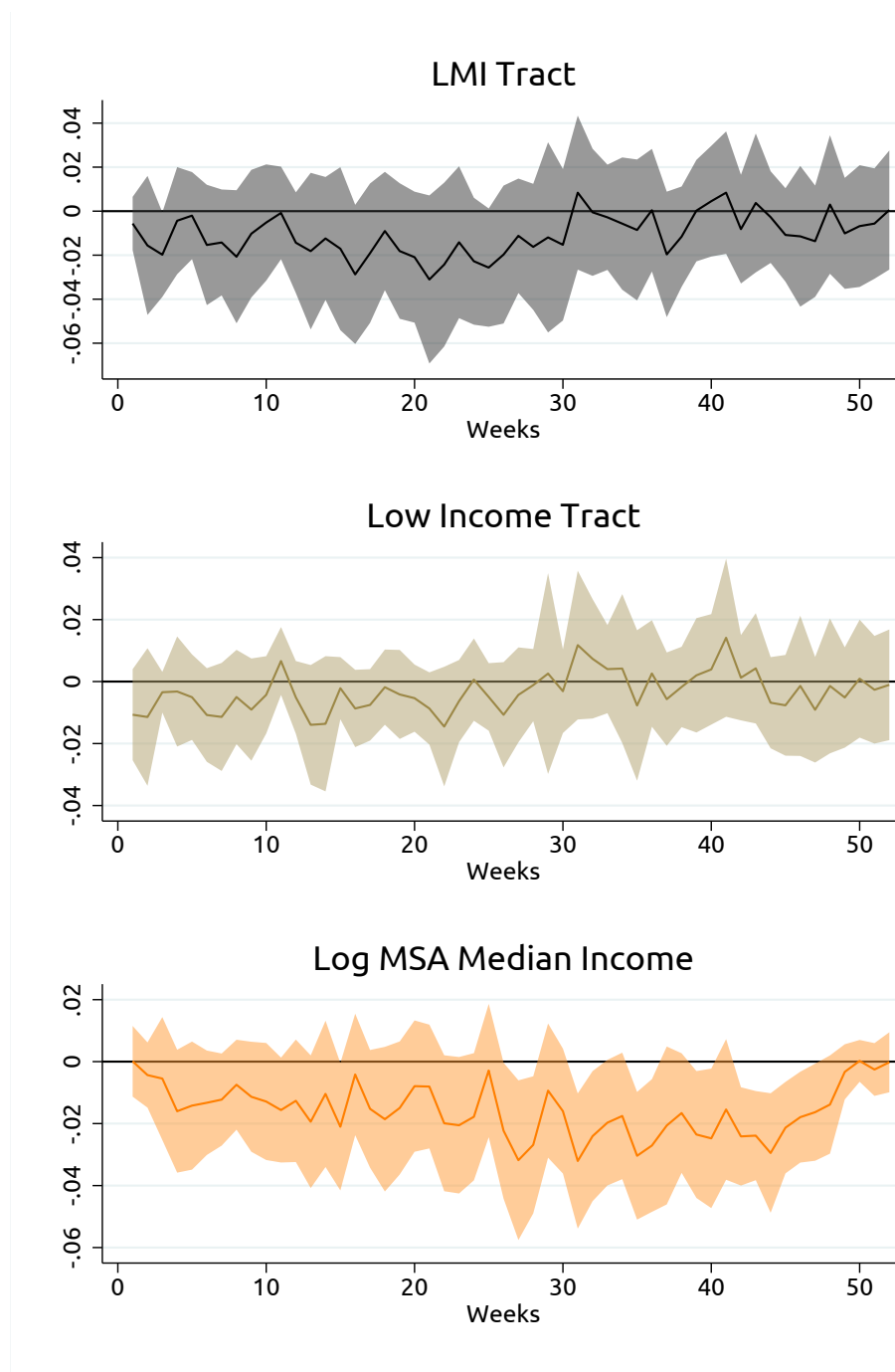
**Note:** This table reports estimates of the effect of a 1 percentage point rate increase on indicators of borrower location. Outcome variables in columns 1 and 2 are an indicator for the loan being in an LMI tract; for columns 3 and 4 an indicator for the loan being in a low-income tract; and for columns 5 and 6 the natural log of the area median family income in the MSA (or non-MSA portion of the state) in which the property is located. Columns 1, 3 and 5 show estimates run on the entire estimation sample. Columns 2, 4, and 6 show estimates run on the sample with a counterfactual DTI calculated as greater than 44 percent. Instruments for the prime rate,  $r$ , are the LSAP and forward guidance (FG) monetary policy shocks estimated by Swanson (2021) interacted with an indicator for the post-shock period,  $D$ . Huber-White standard errors are adjusted for clustering within the 6-week window surrounding each monetary policy shock,  $s$ . Reported  $F$  statistic is the cluster-robust effective  $F$  statistic of Montiel Olea and Pflueger (2013). The prime rate is measured in percentage points. Regressions additionally control for fixed effects for  $s$  and  $D$ .

\*\* $: p < 0.01$

\* $: p < 0.05$

† $: p < 0.10$

Figure A.1: Longer-Term Effect of Mortgage Rates on Borrower Location, by Week



**Note:** Figure shows the estimated effect of a monetary policy shock on week  $t = 0$  on the weekly fraction of home purchase mortgage originations going to low-income and low- and moderate-income tracts, and average (log) area median family income for the 52 weeks after the shock. The magnitude of the shock is normalized to predict a one-percentage point increase in the prime mortgage rate in the three weeks following the shock, using the estimates from column 1 of Table 2. Estimates are obtained using the local projection method of Jordà (2005). The number of lags of the outcome variable is chosen via minimizing the AIC. The estimator for LMI tracts includes 4 lags, for low income tracts 2 lags, and for Log MSA Income 3 lags. Shaded area represents the 95 percent confidence interval, calculated from Huber-White heteroskedasticity robust standard errors, following Montiel Olea and Plagborg-Møller (2021).