Helping the Middle-Class: How Interest Rates Affect the Distribution of Housing Wealth*

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Abstract

This paper documents that economy-wide declines in interest rates cause middle-income homeowners to experience large gains in housing wealth, while high-income and low-income homeowners experience no gains. Using a novel identification strategy that estimates latent demand for small neighborhoods and exploits minor incidental differences in the distribution of the metropolitan population of renters, I show that a 1.2% decline in mortgage interest rates leads to an average increase of 6% to 7% in housing wealth for middle-income homeowners, which translates to an average monetary increase of $7,600 to $8,900. The decline in interest rates shifts the housing demand schedule of household renters, which in turn causes an increase in house prices in neighborhoods where middle-income homeowners live.

JEL Codes: E52; D14; D31; E21; R21; R31

Keywords: Interest rates; housing wealth; mortgage rates; house prices; housing demand; cost of capital; monetary policy

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1. INTRODUCTION

Economists have become increasingly interested in documenting the effect of interest rates on the distribution of income and wealth (Coibion, Gorodnichenko, Kueng, and Silvia (2012); Auclert (2014); and Doepke and Schneider (2006)). Understanding these effects can help unravel how interest rate policy affects the real economy; and ultimately, who benefits from monetary policy interventions. Since the largest asset that most U.S. households hold in their balance sheet is their home, interest rates can significantly affect household's wealth if changes in interest rates significantly impact house prices. This effect on housing wealth can prove particularly important for the real economy because, after increases in houses prices, homeowners are more likely to borrow against home equity to fund consumption and investment (Mian and Sufi (2011), Adelino, Schoar, and Severino (2015)). This paper shows significant distributional effects of interest rates on housing wealth. Middle-income homeowners experience considerable gains in housing wealth after economy-wide changes in interest rates, while low- and high-income homeowners experience no gains in housing wealth.

Standard neoclassical models of investment assume that the cost of capital is a key determinant of the demand for capital. In the housing market, a change in the mortgage interest rates might shift the demand schedule since households renters may be able to afford better homes after a decline in mortgage interest rates. This shift in housing demand may significantly affect home prices if the supply of housing is not perfectly elastic. Consequently, existing homeowners might experience increases in housing wealth that are indirectly subsidized by renters who can afford better homes at a lower cost of capital. In the first part of this paper, using a novel identification strategy that estimates *latent demand* for neighborhoods[1] in a quasi-experimental fashion, I estimate the average effect of changes in interest rates on housing demand and house prices. In the second part of the paper, I take advantage of the small size and homogeneity of neighborhoods to document the distributional effects of interest rates on housing wealth.

It is, however, non-trivial to identify the effect of changes in interest rates on house prices. First, mortgage interest rates are driven, among other factors, by the future expectations of inflation and output. Second, interest rates tend to simultaneously change for the entire economy, making it difficult to find credible contemporaneous counterfactuals.[2] To address these endogeneity issues,

[1] Following Zillow.com, I define a neighborhood as one of the terciles of the zip code in price. A neighborhood is then the collection of non-contiguous houses in the zip code that have similar house prices. This proves advantageous for the purposes of this analysis because it makes the neighborhoods homogeneous despite the fact that the houses might not be contiguous. A neighborhood contains an average population of 2,500 people.

[2] Romer and Romer (2004) address the time varying endogeneity problem by developing a time series measure of U.S. monetary policy shocks from 1969 to 1996 that is relatively free of anticipatory movements. Their methodology could have been used in this paper; however, it is not feasible because, to measure changes in house prices, the units

this paper introduces a novel empirical design that exploits the incidental differences in the distribution of the metropolitan population around pre-determined affordability income thresholds.

The key intuition of the empirical design is the concept of a minimum income to afford living in a neighborhood, and that the reduction in interest rates allows marginal households to overcome this affordability barrier. The crucial ingredient is the *neighborhood affordability threshold*, defined prior to the interest rate change as the income level below which renter households cannot afford to make mortgage payments on the average house in the neighborhood.[3] This paper refers to the fraction of metropolitan household renters below this neighborhood specific threshold as *mortgaged-out*. When interest rates fall, renter households whose income falls immediately to the left of a neighborhood affordability threshold can afford to make mortgage payments in that neighborhood. This fraction of metropolitan renters represents the measure of *latent demand* for the neighborhood. The identification strategy relies on the comparison of latent demand in neighborhoods in different metropolitan areas in the same U.S. state, holding constant the fraction of mortgaged-out, and the level of house prices in the neighborhood prior to the interest rate change.[4]

The identification assumption is that, after controlling for the fraction of mortgaged-out and the level of house prices, the source of variation for latent demand comes from small incidental differences in the distribution of the metropolitan population, which are plausibly exogenous to house price growth. The metropolitan areas of Cleveland, OH, and Cincinnati, OH provide one good example of this concept. Figure 1 presents the income distribution of renter households for these two metropolitan areas in 2000[5]. Except for minor differences, the two distributions are remarkably similar. The empirical design of this paper exploits these relative minor differences to causally estimate the effect of changes in interest rates on changes in house prices. To see this, consider two hypothetical neighborhoods in each metro area: neighborhood A in Cleveland and neighborhood B in Cincinnati, depicted at the bottom of Figure 1. Both neighborhoods have the same house price level and the same fraction of mortgaged-out in July 2000 (light-blue area). Neighborhoods A and B appear to be subject to similar metro-level housing demand; however, the fraction of the population in Cleveland that is immediately to the left (following income bin) of the affordability

of observation must be small geographical areas. These areas may have substantially changed between 1969 and 1996. These changes would not be problematic if suitable data at the micro level during these years existed. However, that is not the case, starting with house price data, which is only available at a granular level starting in the mid-1990s. Therefore, the ideal experiment to study distributional effects exploits one policy intervention, possibly unanticipated, across a rich cross section of micro geographical units.

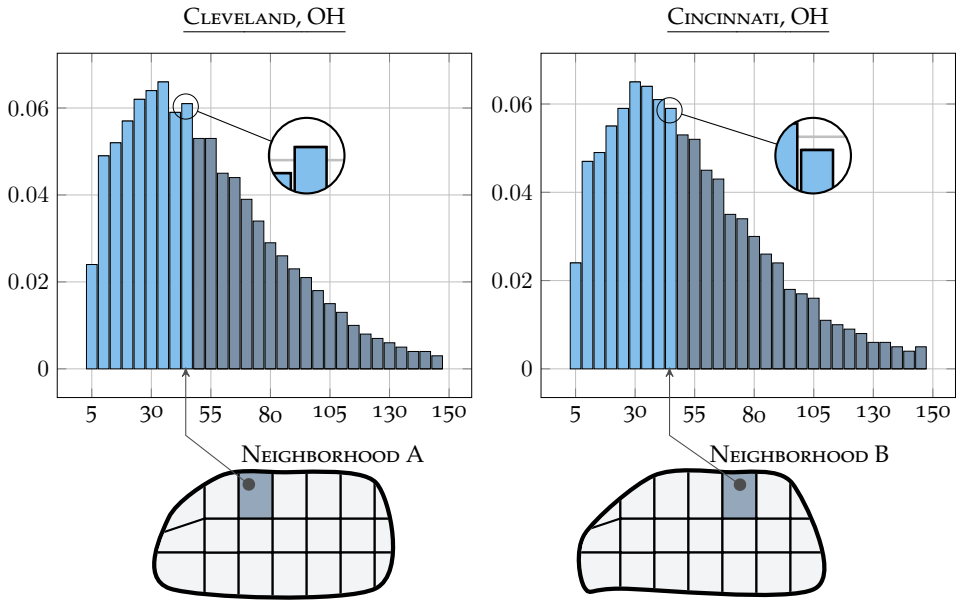
[3] Section 2.3.1 discusses in detail the computation of the affordability threshold.

[4] Other demographics at the neighborhood, zip code, and metropolitan level are also held constant, namely, income level, income growth, past house price growth, unemployment, age, population size, race, immigration, and education levels.

[5] This income distribution is obtained from the 2000 decennial census.

threshold for neighborhood A in Cleveland is larger than its counterpart fraction for for neighborhood B in Cincinnati. That is, latent demand for neighborhood A is larger than latent demand for neighborhood B. When interest rates drop, neighborhood A in Cleveland will experience a larger demand shock than neighborhood B in Cincinnati, despite the similarities between the neighborhoods in other dimensions. If the supply of housing is not perfectly elastic, neighborhood A in Cleveland will more likely experience a larger house price growth.

FIGURE 1: SOURCE OF VARIATION FOR CLEVELAND, OH VERSUS CINCINNATI, OH



Latent demand may appear always larger for neighborhoods in Cleveland than neighborhoods in Cincinnati, due to systematic differences between Cleveland and Cincinnati that make neighborhoods in Cleveland always experience higher demand shifts after changes in interest rates. This possibility could be a critical threat to the exclusion restriction. However, it requires little effort to find another example using the same income distributions in which latent demand is larger for a neighborhood in Cincinnati than the one in Cleveland. For instance, if one chooses a neighborhood with an income affordability threshold further to the left than the previous example, latent demand would be larger in the neighborhood in Cincinnati. Section 2.2 further discusses these two examples in detail.

The empirical design of this paper can theoretically work with any macro interest rate decline, as long as the interest rate change is unrelated with the housing market. Between July 2000 and

December 2001, the Federal Reserve Board introduced an expansionary monetary intervention, mainly motivated by the burst of the *dot-com* bubble and the geopolitical uncertainty brought about by the 9/11 terrorist attacks. During this 17-month period, the Fed funds rate dropped from 6.5% to 1.7%, and the 30-year mortgage fixed rate dropped from 8.3% to 7.1%. I use the mortgage interest rate change during this period to examine the effect of interest rate changes on housing wealth, employing the novel empirical methodology of this paper.[6]

The first step to validating the methodology of this paper involves estimating the correlation between latent demand for a neighborhood and the growth in mortgage applications for home purchase in that neighborhood. In fact, a more precise validation is to verify the correlation between latent demand and the growth in mortgage applications for home purchase from households who are on the left of the income affordability threshold. This is a fairly restrictive test; nonetheless, the measure of latent demand constructed in this paper is positively correlated with the growth in mortgage applications and mortgage originations for home purchase from applicants with income immediately on the left of the neighborhood affordability threshold. More specifically, a decline of 1.2% in mortgage rates between July 2000 and December 2001 is associated with an increase of approximately 7.5% in mortgage applications for home purchase from applicants whose income falls on the left of the affordability threshold.

The estimated effect of interest rates on average home prices is economically large. The contemporaneous average effect of the change in mortgage interest rates from July 2000 to December 2001 on home price growth is approximately 1.7%.[7] On the one hand, the effect on the sub-sample of neighborhoods located in metropolitan areas with high housing supply elasticity is statistically zero; in these cities, residential construction compensates for the demand shock due to the abundance of space, preventing home prices from adjusting. On the other hand, in neighborhoods located in low housing supply elasticity metro areas the effect of interest rates on home price growth is economically large and statistically significant. Mostly, the effect of interest rates on house price growth only happens in metropolitan areas with low housing supply elasticity.

After establishing that changes in interest rates shift the schedule of housing demand and affect house prices, this paper turns to the distributional effects of interest rates on housing wealth to understand who gains and who loses from changes in interest rates. The effects on different quintiles of income varies by a striking amount.[8] Middle-income homeowners gain all the housing wealth

[6]This interest rate intervention is also ideal for this study because, coincidentally, the decennial census of 2000 provides a comprehensive metropolitan level income distribution in 2000, the year of the monetary policy intervention.

[7]The target federal funds rate was quickly lowered in response to the 2001 recession, from 6.5% in late 2000 to 1.75% in December 2001. During the same period, the 30-year fixed rate increased by approximately 1.3%. The reported effects are the result of the change in the 30-year fixed mortgage rate.

[8]The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile, $57,721 in the second quintile, $67,790 in the third quintile, $80,169 in the fourth quintile, and $102,347

benefits from the shift in housing demand led by household renters. The effect for homeowners in the lowest and highest quintile of income is statistically zero. In contrast, the effect for homeowners in the middle income quintiles is economically large and statistically significant. A 1.2% decline in mortgage interest rates leads to an average increase of between 6% and 7% in housing wealth for the second and third income quintiles of income; in monetary terms, this is an average increase between $7,600 and $8,900 in housing wealth. Given that households have high marginal propensities of consumption out of their housing wealth (Mian and Sufi (2011)), these results suggest that the housing market represent a relevant transmission mechanism of interest rates to the real economy.

The remainder of this paper is organized as follows: the rest of this section reviews related literature; the following section reviews the monetary policy intervention in the 2000s, describes the empirical design, and outlines the regression methodology; section 3 presents the micro data and the construction of the dataset used in the analysis; section 4 presents an analysis of the results; and section 5 concludes the paper.

1.1. Related Literature

This paper relates closely to three strands of literature. First, it relates to recent literature that investigates the impact of monetary policy shocks on wealth and income inequality (Coibion, Gorodnichenko, Kueng, and Silvia (2012); Auclert (2014); and Doepke and Schneider (2006)). Coibion, Gorodnichenko, Kueng, and Silvia (2012) use the Consumer Expenditure Survey and find that expansionary monetary policy shocks lower income inequality. Auclert (2014) shows that lower income agents, who maintain higher margins of propensities of consumption, may increase aggregate demand following falls in interest rates. Using the Survey of Consumer Finances, Doepke and Schneider (2006) estimate the wealth redistribution caused by a moderate inflation episode through changes in the value of nominal assets. They show that the main losers from inflation are rich and old households, and that the main winners are young, middle-class households with fixed-rate mortgage debt. Others have studied how monetary policy shocks affect households' saving and consumption behavior (Di Maggio, Kermani, and Ramcharan (2014) and Bhutta and Keys (2014)). Bhutta and Keys (2014) show that policy-driven short-term mortgage rates significantly impact home equity-based borrowing because homeowners take advantage of low interest rates to refinance their mortgages. Di Maggio, Kermani, and Ramcharan (2014) investigate how indebted households' consumption and saving decisions are affected by anticipated changes in monthly interest payments. This paper is the first to study the role of monetary policy in redis-

in the highest quintile.

tributing housing wealth through the household cost of capital channel. The results of this paper are consistent with those of Doepke and Schneider (2006), Auclert (2014), and Di Maggio, Kermani, and Ramcharan (2014), since here low- and middle-income homeowners are the major winners of expansionary monetary policies.

Second, this paper establishes a causal relationship between changes in interest rates and home prices and housing demand, a link to which macroeconomists and policy-makers have given considerable attention (Christiano, Eichenbaum, and Evans (1996); Glaeser, Gottlieb, and Gyourko (2010); Del Negro and Otrok (2007)). After the 2000s housing boom and subsequent financial crisis, the interest in how monetary policy affects home prices has heightened. Iacoviello and Neri (2010) develop and estimate a DSGE model to show that monetary factors explain less than 20% of the volatility of housing investment and housing prices but played a more significant role in the housing cycle at the turn of the century. Jiménez, Ongena, Peydró, and Saurina (2014) show that a lower overnight interest rate induces low-capitalized banks to grant more loan applications to ex-ante risky firms and to commit larger loan volumes with fewer collateral requirements to these firms despite the higher ex-post likelihood of default. Exploiting a discrete jump in interest rates generated by the conforming loan limit, DeFusco and Paciorek (2014) estimate the interest rate elasticity of mortgage demand. They find that a one percentage point increase in the rate on a 30-year fixed-rate mortgage reduces first mortgage demand by between two and three percent. This paper complements the existing literature by providing additional evidence that changes in interest rates affect housing demand and home prices, but it is the first to do so using a micro geographical cross-sectional and a quasi-experimental setting that allows the study of one monetary policy intervention.

Finally, this paper contributes to the literature that studies the causes of the early 2000s housing boom. The seminal works of Mian and Sufi (2009) and Keys, Mukherjee, Seru, and Vig (2010) show that in the beginning of the 2000s, the U.S. economy experienced an outward shift in the supply of credit. Mian and Sufi (2009) document that less-creditworthy borrowers experienced between 2002 and 2005 easier access to mortgage credit despite their negative income growth. Keys, Mukherjee, Seru, and Vig (2010) suggest that existing securitization practices adversely affected the screening incentives of subprime lenders. Adelino, Schoar, and Severino (2012) use exogenous changes in the conforming loan limit as an instrument for lower cost of financing and higher supply to show that easier access to credit significantly increases home prices. Agarwal and Ben-David (2014) show that, by changing loan officers' compensation structure from fixed to volume-based pay, more and larger loans are originated despite leading to higher default rates. Nadauld and Sherlund (2013) show that the increased securitization activity of investment banks lowered lenders' incentives to carefully screen borrowers. Although the low level of interest rates in the early 2000s was not suffi-

cient to cause the housing boom, this paper shows that the low-interest rate environment explains part of the home price growth in low-income neighborhoods in the beginning of the 2000s.

2. EMPIRICAL METHODOLOGY

2.1. Mechanism

Standard neoclassical models of investment assume that the *cost of capital* is a key determinant of the demand for capital. When interest rates decline, the user cost of capital declines, and the demand for capital assets increases. In the housing market, the change in mortgage rates might shift the demand schedule, since renters who are more sensitive to changes in the cost of capital may be able to afford mortgage payments after a decline in mortgage interest rates. This shift in the demand schedule might affect home prices if the supply of housing is not perfectly elastic. Consequently, homeowners might experience increases in housing wealth that are indirectly subsidized by renters who can afford better homes due to the decline in their user cost of capital.

To understand the mechanism that underlines this hypothesis, assume that households maximize their preferences and choose to allocate c_H of their budget constraint in housing consumption. Given their cost of capital, they can then maximize the home value that they can purchase; that is:

$$HV(r) = \frac{\overline{c_H}}{r} \times \left(1 - \frac{1}{(1+r)^T}\right) + D$$

where r represents the mortgage interest rate, D represents the down payment, T represents the maturity of the mortgage loan, and $HV(r)$ represents the highest home value that households can purchase, given the their budget constraint and financing options. If mortgage interest rates were to fall from r_{before} to r_{after}, households could purchase more expensive homes up to a value equal to $HV(r_{after})$, and could then bid on homes with values between $HV(r_{before})$ and $HV(r_{after})$. Homeowners with home values between $HV(r_{before})$ and $HV(r_{after})$ could then experience in housing wealth if the supply of housing is not inelastic. A potential reduction in the cost of capital could produce heterogenous effects between renters and homeowners. Homeowners incur in significantly larger transaction costs than do renters. Realtor's fees are usually borne by the seller and can vary between 5% and 6% of the home value. After a decline in the cost of capital, existing homeowners may not adjust their housing consumption because their transaction costs outweighs the financing benefits of lower interest rates. The empirical section shows that, after a decline in the cost of capital, homeowner's demand is significantly weaker than the renter's demand and, as a consequence, has no effect on home prices.

By construction, the empirical design of this paper exploits the households' *cost of capital* chan-

nel. This is because the computation of the monetary policy driven demand shock derives from a notion of affordability based on the relationship between households' income and mortgage payments. That is, when interest rates decline, households can finance the same house at a lower cost of capital. Section 2.2 presents the details of the computation of the monetary policy led demand shock, emphasizing the linkage with the cost of capital channel, and how it differs from other monetary transmission channels.

2.2. Empirical Design

Interest rates incorporate a significant amount of future expectations about the economy, mostly because the Federal Reserve invests a substantial amount of resources in forecasting the likely behavior of output and prices. Subsequently, movements in mortgage interest rates are likely to be a response to future outcomes of the economy.[9] Furthermore, most interest rate shocks affect the whole economy making it difficult to find contemporaneous counterfactuals. As a result, the identification of the effect of changes in interest rates on house prices is challenging. When studying distributional effects on housing wealth, the characteristics of the homeowners and the neighborhoods might change over time, presenting an additional challenge. Thus, the ideal experiment to study distributional effects of interest rate changes on housing wealth exploits the effect of one interest rate shock on a rich cross section of small geographic units where units of observation are subject to different intensities of interest rate shock due to relatively random reasons.[10] This is the spirit of the identification strategy of this paper.

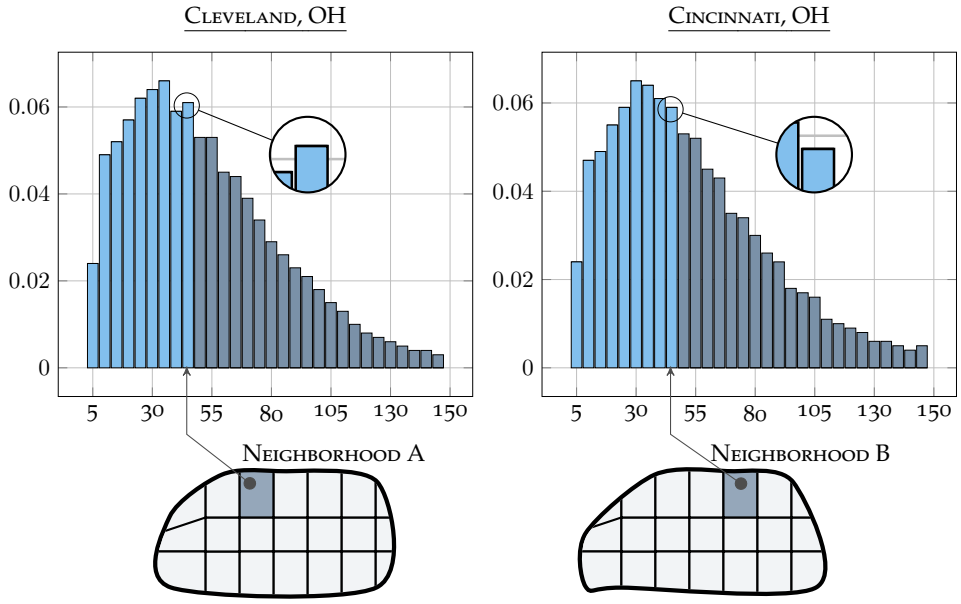
The unit of observation in this paper is a *neighborhood*, defined as one-third of a zip code in size. The empirical design uses a macro interest rate shock to identify *latent demand* for each neighborhood based on an incidental distribution of the metropolitan population around a pre-determined *neighborhood affordability threshold*. The affordability thresholds represent a key concept of the empirical design. A neighborhood affordability threshold is defined as the income level below which

[9] Romer and Romer (2004) address the time varying endogeneity problem by developing a time series measure of U.S. monetary policy shocks from 1969 to 1996 that is relatively free of anticipatory movements. Their methodology could have been used in this paper; however, it is not feasible because, to measure changes in house prices, the units of observation must be small geographical areas. These areas may have substantially changed between 1969 and 1996. These changes would not be problematic if suitable data at the micro level during these years existed. However, that is not the case, starting with house price data, which is only available at a granular level starting in the mid-1990s. Therefore, the ideal experiment to study distributional effects exploits one policy intervention, possibly unanticipated, across a rich cross section of micro geographical units.

[10] Other fields, particularly labor economics, have successfully found ways of exploiting geographical variation to causally identify the impact of macroeconomic shocks on labor outcomes. Most notably, Card (1992) studies the effect of changes in the federal minimum wage on the labor supply of teenagers, and Bartik (1991) proposes an instrument for local labor demand based on national labor demand. The empirical design proposed in this paper is close to that of Card (1992) and Bartik (1991) in spirit, but the methodology used to create the cross-sectional variation is novel and varies greatly from theirs.

households cannot afford to make mortgage payments on the average house in the neighborhood at the current interest rate and house price level. The affordability assumption is that the total mortgage payments must be lower than 40% of the household income. This affordability assumption follows a rule of thumb in the lending industry and the revealed preference is observed in the data. Below, this paper presents the details and validity of this assumption. When interest rates decline, the neighborhood affordability threshold shifts to the left, and households in the metropolitan area immediately to the left of the affordability threshold for a given neighborhood are able to afford to make mortgage payments in that neighborhood. The fraction of households in the metropolitan area that can afford to make the mortgage payments only after the decline in interest rates is the measure of *latent demand*, which is neighborhood-specific. In this paper, the term *mortgaged-out* describes the fraction of the metropolitan population whose income lies below the neighborhood affordability threshold prior to the interest rate change.

Figure 2: Cleveland, OH versus Cincinnati, OH - Example 1



Consider the metropolitan areas of Cleveland, OH, and Cincinnati, OH. Figure 2 presents the income distributions for these two metropolitan areas. Except for minor differences, the two distributions are remarkably similar. The empirical design of this study exploits these minor differences to causally estimate the effect of changes in interest rates on housing prices. Consider neighborhood A in Cleveland and neighborhood B in Cincinnati that have the same house price level and

the same fraction of mortgaged-out in July 2000 (light blue area); that is, the light blue areas are equal, as are the affordability thresholds. However, the fraction of the population in Cleveland that is immediately to the left of the affordability threshold in neighborhood A is larger than the counterpart fraction of the population in Cincinnati; that is, latent demand for neighborhood A is larger than latent demand for neighborhood B. When interest rates drop, neighborhood A in Cleveland will experience a larger demand shock than neighborhood B in Cincinnati, despite the neighborhoods' similarities. If the housing supply is not perfectly elastic, neighborhood A in Cleveland will more likely experience a larger house price growth. From this example, one might think that latent demand is always larger for neighborhoods in Cleveland than for neighborhoods in Cincinnati. This could pose a critical threat to the exclusion restriction, as systematic differences between metropolitan areas confound the identification strategy. However, Figure 3 shows that this is not the case.

Figure 3: Cleveland, OH versus Cincinnati, OH - Example 2

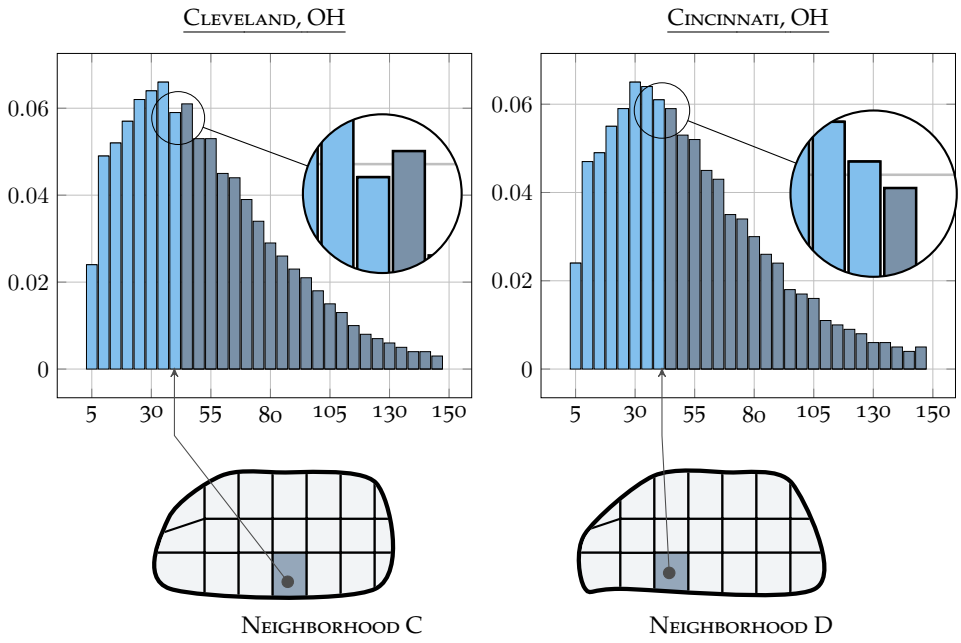
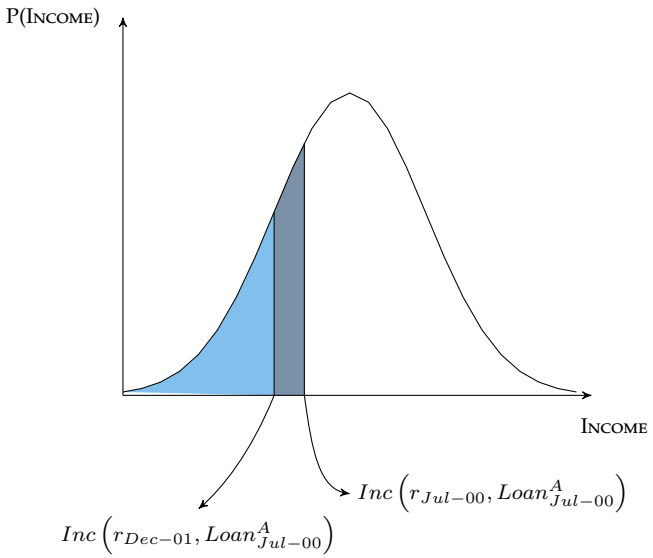


Figure 3 introduces neighborhood C in Cleveland and neighborhood D in Cincinnati. They differ from neighborhood A and B because the affordability threshold is one income bin to the left. The house price level and the fraction of mortgaged-out in July 2000 are identical for C and D, but, in this case, latent demand is larger for neighborhood D in Cincinnati than in neighborhood C in

Cleveland. This is because the fraction of the population immediately to the left of the affordability threshold is larger in neighborhood D. This second example demonstrates that it is very unlikely that the identification of this paper is driven by systematic differences between metropolitan areas.

FIGURE 4: REPRESENTATION OF LATENT DEMAND AND THE INCOME DISTRIBUTION

Notes: This figure sketches the main intuition of how latent demand is computed. Consider that P is the probability distribution of income at the metropolitan-level; r_i is the interest rate level in period i; and $Loan_i^A$ is the average loan that a household requires to purchase an average home in a neighborhood A inside the metropolitan area. The dark blue area is the measure of latent demand after interest rates fall from r_{Jul-00} to r_{Dec-01}.



Alternatively, one could derive the intuition of the empirical design from a theoretical income distribution. Consider that P represents the probability distribution of income for a metropolitan area in 1999, r_{Jul-00} represents the interest rate level in July 2000, and r_{Dec-01} represents the interest rate level in December 2001. $Loan^A_{Jul-00}$ represents the average loan that a household needs to purchase a house in neighborhood A, located in the metropolitan area.[11] Figure 4 depicts this hypothetical income distribution. $Inc\left(r_{Dec-01}, Loan^A_{Jul-00}\right)$ represents the income threshold below which an household cannot afford to make the mortgage payments of an average house in neighborhood A at the interest rate and price level of July 2000. If interest rates decline to r_{Dec-01}, the

[11]The loan to purchase a house in neighborhood A is a function of the house price level in neighborhood A and the down payment amount. For the sake of this example, assume that the down payment is constant across neighborhoods.

affordability threshold, $Inc\left(r_{Dec-01}, Loan^{A}_{Jul-00}\right)$, moves to the left. The dark blue area in Figure 4 represents the measure of latent demand that is sensitive to the interest rate change. Formally, latent demand is defined as:

$$P\left(Inc\left(r_{Jul-01}, Loan^{A}_{Jul-00}\right) < Income < Inc\left(r_{Dec-01}, Loan^{A}_{Jul-00}\right)\right).$$

Lastly, the light blue area added to the dark blue area represents the level of mortgage-out in July 2000. The empirical design compares two neighborhoods with the same level of mortgaged-out, house price level, and income level in July 2000, but different latent demand because in one metropolitan area the population at the margin of affordability is higher.

This paper studies the effects of the expansionary intervention between July 2000 and December 2001. I use this intervention because the methodology described above requires a detailed income distribution at the metropolitan level. The decennial census of 2000, which provides a comprehensive metropolitan level income distribution in 1999, makes the study of this policy intervention feasible.[12] Moreover, this intervention is suitable for my analysis because of its association with the *dot-com* bubble, the geopolitical uncertainty brought about by the 9/11 terrorist attacks, and the mild recession in the second semester of 2001; but, more importantly, this intervention was not associated with shocks in the housing market.

The identification assumption is that the relative differences in the fraction of the population right around the affordability threshold is exogenous to house price growth. That is, the exclusion restriction is guaranteed if the slope of the county income distribution around the neighborhood affordability threshold is exogenous to house price growth. Take the example of an important alternative explanation: the shock in the lending standards due to securitization. If the increase in securitization is a credible alternative, securitization must be more intense when the slope of the county income distribution is higher around the neighborhood affordability threshold. This sounds implausible. To further emphasize that this alternative is unlikely, I show that neighborhoods that experienced large demand shocks due to changes in interest rates, as measured by latent demand, exhibit no difference between the growth of loans that were that were originated and sold to third parties, in particular to securitization. In contrast, neighborhoods with large latent demand are associated with a growth in mortgages that are kept in the lender's balance sheet.

Systematic changes in the distribution of income may create a confounding mechanism. For example, if income grows equally in all metro areas, neighborhoods for which the county income

[12] I assume that the change in mortgage rates from July 2000 to December 2001 was due to the increase in money supply (Romer and Romer (2000); Bernanke and Blinder (1992); Kashyap and Stein (2000); Rudebusch (1995); Cook and Hahn (1989); Ang, Boivin, Dong, and Loo-Kung (2011)). Figure 5 suggests that the relationship between the fed funds rate and the two most important mortgage rates is very strong, especially around the 2000 monetary policy intervention.

slope is steeper on the affordability threshold might experience a higher latent demand because of income reasons, and not due to changes in interest rates. However, in the setting of this analysis, income shocks are only considered confounding if the shock is large and positive.[13] Between 2000 and 2001, the average metropolitan income growth was -3.0%, while the median metropolitan income growth was -2.5%. These income changes are not only negative but also too small in magnitude to be considered confounding. Section 3 shows that an interest rate shock generates a change in the income affordability threshold of almost 16%. Income shocks can only create a significant bias if they change the affordability thresholds on the same order of magnitude as interest rates. To further alleviate any identification concern associated with income changes, I control for a battery of county-level characteristics, including the county income growth.[14]

2.3. Monetary Policy Intervention in the 2000s

In the late 1990s, the stock markets in industrialized countries experienced a rapid growth in equity valuations, particularly in the Internet sector and related fields. This rapid growth in equity prices is commonly referred to as the *dot-com bubble*. The climax of the *dot-com bubble* occurred on March 10, 2000, with the NASDAQ peaking at 5,132.52 in intraday trading; the burst of the stock market bubble transpired in the form of the NASDAQ crash in March 2000. Growth in gross domestic product slowed considerably in the third quarter of 2000 to the lowest rate since a contraction in the first quarter of 1991. Nonetheless, the 2001 recession was the mildest in post-war history; i.e., one of the shortest recessions with the smallest real GDP declines.[15] According to the National Bureau of Economic Research (NBER), the U.S. economy was in recession from March 2001 to November 2001. Unemployment rose from 4.2% in February 2001 to 5.5% in November 2001 but did not peak until June 2003 at 6.3%, after which it declined to 5% by mid-2005. Together with the short 2001 recession, geopolitical uncertainties associated with the terrorist attacks of September 11, 2001 and the invasion of Iraq in March 2003, as well as a series of corporate scandals in 2002, further clouded the economic situation in the early part of the decade. As a result, the target federal funds rate was quickly lowered in response to the 2001 recession, from 6.5% in late 2000 to 1.75% in December 2001 and to 1% in June 2003.[16]

[13] The average income affordability threshold was $34,757 before the monetary policy intervention in July 2000, and $29,409 after the monetary intervention in December 2001. This is a drop of 15.5% in the required income to afford to make mortgages payments in an average U.S. neighborhood. Below, I present more details.

[14] Also note that all regressions specifications include state fixed effects; therefore, I only compare neighborhoods between counties in the same state.

[15] "The U.S. economy suffered a moderate recession between March and November 2001, largely traceable to the ending of the dot-com boom and the resulting sharp decline in stock prices." (Bernanke (2010))

[16] "The aggressive monetary policy response in 2002 and 2003 was motivated by two principal factors. First, although the recession technically ended in late 2001, the recovery remained quite weak and "jobless" into the latter part of 2003.

FIGURE 5: MORTGAGE RATES AND FED FUNDS RATE FROM 1997 TO 2013

Notes: This chart depicts the Fed funds rate (light blue), the one-year adjustable mortgage rate (dark blue), and the 30-year fixed mortgage rate (brown). The mortgage rates are from the Freddie Mac website. The gray areas highlight the monetary policy intervention in the beginning of the 2000s. The intervention started in the summer of 2000 and lasted until the end of 2001—Fed funds rate decreased from 6.5% to 1.75%.

Figure 5 reports the time series of the 1-year adjustable, 30-year fixed, and Fed funds rate. Between the summer of 2000 and the end of 2001, the fed funds rate fell from 6.5% to 1.8%. During this period, the 30-year fixed rate fell by approximately 1.2%, and the one-year adjustable rate fell by a little over 2%. It is important to note that this monetary policy intervention was driven by economic events in the housing market.

2.3.1. AFFORDABILITY

An important assumption of the empirical design is the affordability assumption. It is common practice in the lending industry to require borrowers to maintain their mortgage payments lower than 30% of their annual salary. This affordability assumption is often self-imposed by borrowers, since it becomes significantly harder for a household to manage a monthly budget when housing costs are substantially larger than disposable income. Lenders often recommend a 30% limit

Real gross domestic product (GDP), which normally grows above trend in the early stages of an economic expansion, rose at an average pace just above 2% in 2002 and the first half of 2003, a rate insufficient to halt continued increases in the unemployment rate, which peaked above 6% in the first half of 2003. Second, the FOMC's policy response also reflected concerns about a possible unwelcome decline in inflation. Taking note of the painful experience of Japan, policymakers worried that the United States might sink into deflation and that, as one consequence, the FOMC's target interest rate might hit its zero lower bound, limiting the scope for further monetary accommodation." (Bernanke (2010))

on mortgage payments because homeowners have more housing expenses, namely maintenance costs, property taxes, and insurance. These non-mortgage housing-related costs may account for 10% of disposable income. Under this lender's rule of thumb, total housing costs (mortgage plus non-mortgage) under 40% of the household income. In practice, it is possible to verify if this rule of thumb is followed by households and lenders, since several surveys including the American Community Survey (ACS) collect information on household income and mortgage payments. Figure 7 depicts the box plot of the distribution of the ratio of mortgage payments to household income from the ACS for all households who moved in the year of 2000 and 2001 and purchased a home with a mortgage. There are 16,269, 15,476, and 36,112 households in 2000, 2001, 2005 samples, respectively.

FIGURE 6: DISTRIBUTION OF MORTGAGE PAYMENTS TO HOUSEHOLD INCOME RATIO

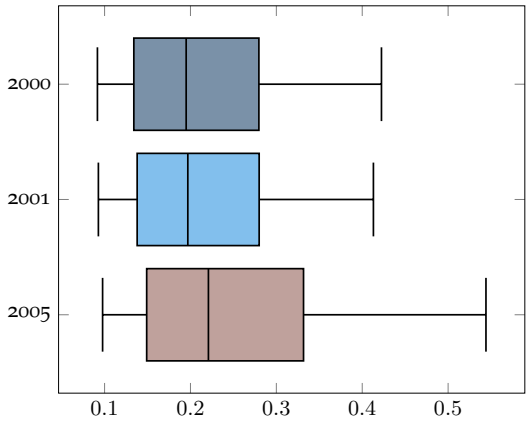
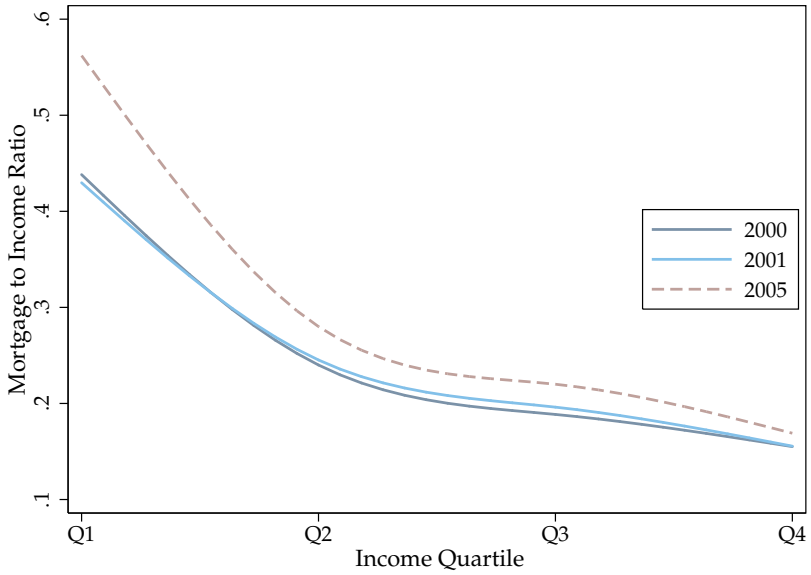


Figure 7 shows two relevant facts. First, the distributions of the ratio of mortgage payments to household income are remarkably similar for households who purchased a home in 2000 and 2001. Second, the majority of households who purchased a home in 2000 and 2001 have mortgage payments lower than 40% of their household income—in both years, the percentile 75% and 90% of the distribution of the ratio of mortgage payments to household income is 28% and 41%, respectively. The fact that the distributions are almost equal in 2000 and 2001 is critical to verify that neither U.S. households nor lenders changed their behavior with respect to the level of mortgage payments relative to the level of household income from 2000 to 2001. Since several innovations in lending standards occurred during the 2000s housing boom, this indicates that lending innovations did not affect the affordability threshold in 2000 and 2001. In contrast, households who moved in 2005 and purchased a home with a mortgage were significantly more likely to have higher mortgages

payments relative to their income. This is consistent with most of the literature on the expansion of the credit supply, which documents that most innovations in the lending standards occurred between 2002 and 2006 (Mian and Sufi (2009) and Nadauld and Sherlund (2013)). Consistent with the lender's rule of thumb and the data observed, I then assume that the affordability threshold is that mortgage payments should not exceed 40% of the household's total income.

Figure 7: Mortgage Payments to Household Income Ratio by Income Quartile



Mortgage payments however vary with the maturity of the mortgage, the level of down payment, and the type of mortgage contract. Typically, households can contract two different mortgage products: adjustable-rate mortgages and fixed-rate mortgages. The baseline model in most tables is that households contract a 30-year fixed-rate mortgage with a 10% down payment. These characteristics are not also are a common option, but also produce the lowest mortgage payments with the lowest down payment, which is consistent with the choice of a household who is at the limit of affordability.

Given these assumptions, the definition of the income affordability threshold for neighborhood

i is as follows:

$$Inc_i\left(r_t, \overline{L}_{i,t}\right) = \frac{1}{40\%} \times 12 \times \underbrace{\frac{r_t \times \overline{L}_{i,t}}{1 - \left(\frac{1}{1+r_t}\right)^{30\times 12}}}_{Monthly\ Payments} \tag{1}$$

where r_t represents the mortgage interest rate in monthly terms; $\overline{L}_{i,t}$ represents the loan amount necessary to purchase the average home in neighborhood i; and t corresponds to July 2000 or December 2001. Given the assumption on the amount of down payment, $\overline{L}_{i,t}$ is a linear function of the house price level in July 2000 in neighborhood i. The definition of mortgaged-out in July 2000 is:

$$\text{Mortgaged-out}_{\ Jul-00,i} = P_j\Big\{Income < Inc_i\left(r_{Jul-00}, \overline{L}_{i,Jul-00}\right)\Big\} \tag{2}$$

where P_j is the probability distribution of income for metropolitan area j where neighborhood i is located. The definition of latent demand in July 2000:

$$\text{Latent Demand}_{\ Jul-00,i} = P_j\Big\{Inc_i\left(r_{Dec-01}, \overline{L}_{i,Jul-00}\right) < Income < Inc_i\left(r_{Jul-00}, \overline{L}_{i,Jul-00}\right)\Big\} \tag{3}$$

Section 3.3 explains the numerical computation of mortgaged-out and latent demand.

2.4. Estimation Methodology

2.4.1. Average Effects

Using the empirical design from the previous section, I first estimate the contemporaneous effect of a monetary policy on home prices, mortgage applications, and mortgage originations. I use a cross-sectional Ordinary Least Squares (OLS) model to regress changes of housing outcomes on the *change in mortgaged-out* from July 2000 to December 2001, the level of *mortgaged-out* in July 2000, and other control variables, which include the level of home prices in the neighborhood in July 2000 and the income level in 1998.[17] All regression models include state-fixed effects, unless noted otherwise. All standard errors are clustered at the county level and robust. Equation (4)

[17] The Internal Revenue Service only provided zip-code-level income for 1998 and 2001. In the baseline model, I use the income level in 1998; in robustness tests, I also use the income level in 2001. The results remain unchanged.

summarizes the baseline regression model:

$$\begin{aligned} \text{Y}_{Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Latent Demand}_{Jul/00,i} + \theta_2 \times \text{Mortgaged-out}_{Jul/00,i} \\ &+ \theta_3 \times \text{House Prices}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

where $\text{Y}_{2000 \to 2001}$ is either the home price growth from *July 2000* to *December 2001*, the growth in mortgage applications from 2000 to 2001, or the growth in mortgage origination from 2000 to 2001.[18] This model specification estimates the average treatment effects during the monetary policy intervention. When studying the persistence of the effects of monetary interventions, I substitute the outcome variable with the home price growth for years after 2001.

2.4.2. Measuring the Effect of Interest Rate

To measure the interest rate effect on house prices, one needs to consider house prices as a function of latent demand, and that latent demand, in turn, is a function of interest rates; that is:

$$\text{House Prices} = f(\text{Housing Demand}(r)).$$

Thus, when measuring the impact of changes in interest rates on house prices, one needs to take into account that:

$$\frac{\partial \text{House Prices}}{\partial r} = \underbrace{\frac{\partial \text{House Prices}}{\partial \text{Housing Demand}}}_{\theta_1} \times \underbrace{\frac{\partial \text{Housing Demand}}{\partial r}}_{\text{Average Latent Demand}}$$

θ_1 from model (4) is an estimator for the partial derivative of house prices with respect to housing demand, while the average of latent demand across neighborhoods is a good estimator for the partial derivative of housing demand with respect to interest rates.

2.4.3. Low Versus High Supply of Housing

The home price effect only exists if the supply of housing does not fully adjust to the shift in demand driven by low interest rates. Thus, no effect should exist if the supply of housing can fully adjust, and there should be a comparatively large home price effect if the supply of housing is inelastic. To test this, the effect of monetary policy on home prices and mortgage applications is estimated in two sub-samples: high and low housing supply elasticity metropolitan areas. I use the topology-based

[18] HMDA, the provider of the loan application data, aggregates the data at the annual level; as a result, I can only study the effect of monetary policy on the annual growth from 2000 to 2001.

measure of housing supply elasticity from Saiz (2010). The regression specification is the same than (4), but the model is estimated for two subsamples, one when housing supply elasticity is lower than 1.5, the median elasticity in my sample, and another when the housing supply elasticity is higher than 1.5.

2.4.4. Distributional Effects

Lastly, I study the distributional effects associated with monetary policy. Who in the income distribution benefits from the changes in home prices? Since each neighborhood in the sample is a small geographical unit—approximately three times smaller than a zip code—I assume that homeowners in each neighborhood are homogeneous. This assumption is a very reasonable since a neighborhood is defined as a zip-code house price tercile; hence, a neighborhood is a small geographical unit with similar house prices, and most likely similar homeowners. Then, I estimate the average homeowners' income in each neighborhood,[19] and organize the neighborhoods into income quintiles by county. The empirical exercise is then equivalent to estimate the monetary policy effect on house prices by comparing two neighborhoods in different counties, but positioned in the same income quintile. The regression specification is the same than (4), but the model is estimated for five subsamples of income quintiles. The average household income is $45,774 in the lowest quintile, $57,721 in the second quintile, $67,790 in the third quintile, $80,169 in the fourth quintile, and $102,347 in the highest quintile.

2.4.5. Controls

The vector X_i in regression model (4) includes several controls of levels and changes at the neighborhood, zip code, and metropolitan level. In an ideal randomized experiment the control and treatment groups are balanced on all covariates besides the treatment, as a result the addition of control variables does not affect the estimated treatment effect. The empirical design presented in this paper tries to separate neighborhoods by latent demand that is fairly random and exogenous to growth in house prices. It is then useful to verify that the addition of several controls at the neighborhood, zip code, and metropolitan level does not change the effect on interest rates on house prices relative to the estimated effect without control variables.

Neighborhood-level Controls. I observe home prices, income, and loan outcomes at the neighborhood level. In the context of the identification presented in this paper, controlling for these

[19] The 2000 decennial census is used to estimate the income at the neighborhood level. Since the neighborhoods are defined as zip-code-level terciles of house prices, I use the tabulation of income by house price level by house tenure from the census to estimate the average income of homeowners in each neighborhood.

variables is important for several reasons. First, past home price growth is likely to drive future home price growth. Furthermore, borrowers and lenders could observe past house growth and revise their beliefs on future house prices growth, which can lead to an increase in the willingness to enter in a mortgage contract on both sides. In this case, the relationship between latent demand and house price growth would have been driven by the expectations of house price growth (Foote, Gerardi, and Willen (2012)). To show that this alternative does not drive the results, I control for past home price growth and show that the effect of the interest rate on house prices and mortgage applications remains unchanged with the addition of several controls of the past house prices, including the house price growth from December 1999 to July 2000—the seven months prior to the monetary policy intervention. Moreover, between July 2000 and December 2001, past house price growth is uncorrelated with the house price growth in the previous years.

Second, since the empirical design exploits variation between metropolitan areas, it is possible that a neighborhoods with the same house price and mortgaged-out levels have different income levels. Although it is unclear through what mechanism the income level of the residents in the neighborhood could affect the fraction of the total population in the metro area that is at the margin of being able to afford a house in the neighborhood, I control for the income at the neighborhood level to guarantee that income is held constant when comparing neighborhoods.

Finally, I also control for the level of mortgage applications in 2000 and the change in denial rates from 2000 to 2001. Controlling for the level of mortgage applications in 2000 is an indirect way of measuring demand for the neighborhood prior to the macro interest rate change. Although estimations of pre-treatment effects and placebo tests in the periods prior to the interest rate change are also conducted, it is useful to guarantee that the number of mortgage applications is held constant while comparing neighborhoods in the regression framework. Finally, I also control for the change in denial rates at the neighborhood level. Lenders lowered credit standards in the beginning of the 2000s and extended credit to less credit worthy borrowers (Mian and Sufi (2009) and Nadauld and Sherlund (2013)). Controlling for the change in denial rates is the simplest attempt to rule out the credit expansion alternative. Far from being a conclusive test, this indicates that the estimated effect of interest rates is not affected after controlling for the change in denial rates. I conduct an additional series of tests that are presented in the results and robustness sections to show that the credit expansion does not explain the effect of interest rates documented in this paper.

Zip code-level Controls. At the zip code level, it is possible to observe more demographics that could be important variables to control for in the regression, namely: average income from IRS, median income from the decennial Census, median age, fraction of renters, immigration, fraction of blacks, and fraction of college educated. It would provide more accurate results to observe these

variables at the neighborhood level, but due to lack of available data, this is not possible. The additional income variables are useful to reinforce the comparability point made above. The fraction of renters is useful to ensure that the possible supply of houses for sale is equivalent between two neighborhoods. It is relevant to control for the immigration flow in the year prior to the interest rate change because it proxies for the demand for the zip code where the neighborhood is located. Finally, the fraction of college educated and fraction of non-whites are important controls because these summary statistics have been shown to be determinants for zip code level housing demand. They are also alternative proxies for the level of income and house prices.

MSA-level Controls Since the identification of the interest rate effect on house prices relies on comparing neighborhoods across metropolitan areas in the same state, systematic differences between metro areas might explain the dependent and independent variables simultaneously. As explained in section 2.2, the construction of the empirical design in itself makes it unlikely that systematic differences between metropolitan areas might confound the identification. Nonetheless, to ensure that this is unlikely, I control for several metropolitan area variables such as: median age, fraction of non-whites, fraction of college educated individuals, unemployment rate, and flows of immigration in the year prior to the interest rate change.

3. DATA

3.1. Data Sources

Home prices are publicly available on the Zillow Real Estate Research website.[20] Zillow provides a home price index for the bottom, middle, and top terciles of a zip code—as long as sufficient transactions exist. I use this division to form the unit of observation: a *neighborhood*. A neighborhood is then roughly one-third the size of a zip code. This is not a neighborhood in the common sense. Although the houses are in the same zip code, their commonality is the price level; as a result, the unit of observation might be dispersed within the neighborhood. Each Zillow Home Value Index (ZHVI) is a time series tracking the monthly median home value. In general, each ZHVI time series begins in April 1996, but for some newer zip codes, data is only available starting at the beginning of the 2000s. Instead of using a repeat sales methodology, Zillow uses the same underlying deed data as the Case-Shiller index but creates a hedonically adjusted price index. The Zillow index uses detailed information on properties collected from county public records, including the size of

[20] http://www.zillow.com/research/data/

the house, the number of bedrooms, and the number of bathrooms.[21] To assess the quality of the ZHVI, Guerrieri, Hartley, and Hurst (2013) show that the zip-code-level correlation between the Case-Shiller Index and the Zillow Index where the two samples overlap is equal to 94%. Monthly home prices are available from 1996 to 2012 for 10,187 zip codes.

Loan-level data is provided by the Home Mortgage Disclosure Act (HMDA). Application-level data is available from all lenders that meet a disclosure criteria defined by HMDA.[22] Each loan application provides information on *year* of application; *lender*; *type of loan*; *loan amount*; *action taken* by the lender; *reason for denial*, if the loan is denied; *race*, *sex* and *income* of the applicant and co-applicant; *census tract*, *county FIPS*, and *state FIPS* where the loan was originated; *owner occupancy*; and *purpose*. Loans have four types of purpose: *home purchase*, *home improvement*, *refinancing*, and *multifamily dwelling*. I only use loans that are originated for home purchase and are owner-occupied as a principal dwelling.

The Internal Revenue Service (IRS) makes zip-code-level income data publicly available on their website.[23] Income data is available for the years 1998 and 2001, and from 2004 to 2012. The IRS uses tax returns to create the zip-code-level data. Several income items are available, including the adjusted gross income, number of returns, and wage income. Throughout the paper, income per capita represents the ratio of adjusted gross income to number of returns.

Finally, I use the census data to obtain the household income distribution at the county level. The IRS also makes county-level income data publicly available, but regarding the scope of this analysis, there are two shortcomings with such data. First, the number of income brackets that the IRS uses to aggregate the data is significantly smaller than those provided by the census, resulting in a courser distribution. Second, the IRS income does not provide income distributions by categories such as age or house value. Because it is self-reported, the income data from the census is less precise than the data from the IRS, but it overcomes the two aforementioned shortcomings of the IRS data. I use the census county income distribution from the 2000 decennial census. The income distributions by age, house value, and housing tenure are available on the census website.

3.2. Construction of the Dataset

I start with the Zillow home price dataset and create three units of observation for each zip code, corresponding to the bottom, middle, and top tercile of the zip code. The paper refers to these units of observation as *neighborhoods*. For each neighborhood, as long as enough transaction data

[21] More information about the computation methodology of the Zillow home price index can be found here: http://www.zillow.com/research/zhvi-methodology-6032/.

[22] More details can be found at the following weblink: http://www.goo.gl/oRm0KQ

[23] http://www.irs.gov/uac/SOI-Tax-Stats-Individual-Income-Tax-Statistics-ZIP-Code-Data-(SOI)

exists, Zillow provides a monthly home price index from 1996 to 2014. There are 24,146 data points in 1996, 27,310 in 2000, and 29,056 in 2010.

Next, I use loan-level data from HMDA to compute the number of annual applications, originations, and denial rates for mortgage loans. I only use loans for home purchase. HMDA provides the census tract for each loan application. Using this identifier, I match each loan to a zip code using a crosswalk provided by the Census Bureau. I then match the loan application to a neighborhood within the zip code using the loan amount from the application. To perform this match, I must determine the home price associated with the loan application. This information is not directly provided by HMDA. Thus, if the loan is marked as conventional, I assume that the borrowers made a 20% down payment, and if the loan is marked as FHA, I assume that the borrowers made a 5% down payment.

I then match each neighborhood to the income data provided by the IRS using the zip code identifier. This implies that the IRS income data is the same across neighborhoods within zip codes. Finally, I match each neighborhood to a county from the 2000 decennial census. This indicates the county income distribution in which a neighborhood is located.

3.3. Latent Demand and Mortgaged-out: Numerical Details

To compute the level and change of *mortgaged-out*, I start by computing the *neighborhood affordability thresholds*. In the baseline specification, a household obtains a 30-year fixed rate mortgage, providing a 10% down payment; therefore, to purchase a house in a given neighborhood, it needs to obtain a loan equal to 80% of the average price level in that neighborhood. The 30-year fixed rate in July 2000 was 8.3% and in December 2001 was 6.6%. I use these mortgage rates to compute the income affordability threshold in July 2000 and December 2001, respectively. Using the definitions presented in section 2.2, the average income affordability threshold was $34,757 in July 2000, before the monetary policy intervention, and $29,409 in December 2001, after the monetary intervention. This is a drop of 15.5% in the required income to afford to make mortgage payments in an average U.S. neighborhood. Using the two income thresholds for each neighborhood and the county income distribution in 1999, I compute the fraction of the population in the county that is below the affordability threshold. With these two fractions, I then compute the level and change in *mortgaged-out* as specified in section 2.2.

3.4. Metropolitan Income Distribution: Computation

To compute the income distribution at the metropolitan level, I use the Public Use Micro Data from the decennial census of 2000 that is available in the IPUMS-USA website. IPUMS-USA makes

available the census data for each household. I download all data entries for heads of household. I drop all households who do not live in a metropolitan area and all households in which the head is older than 75. I then form bins of $5,000 and assign households to each bin. The process is repeated separately for renters and homeowners. Some households who are homeowners might own the house clear of a mortgage. To compute the frequency in each income bin, I aggregate all households in each bin using the household weight from the decennial census.

3.5. Mortgage Applications: Computation

When computing the mortgage applications for a neighborhood, one could use the total number of applications. However, the hypothesis of this paper predicts that the number of applications from renters whose income falls to the left of the income affordability threshold should increase. The loan database used in the paper contains virtually all individual mortgage applications in US metropolitan areas, and for each application, it contains the loan amount and the borrower's income. Thus, when computing the mortgage applications for a neighborhood, I only consider the applications of borrowers with incomes that fall immediately at the left of the affordability threshold for each neighborhood. That is, only mortgage applications with incomes consistent with the income of the renters that compose the latent demand.

3.6. Summary of Statistics

Tables 1.1 to 1.3 report the summary statistics for neighborhood, zip code, and metropolitan level variables, respectively. Given the interest rate level in July 2000, the average ratio of household renters (as a fraction of the total metropolitan population) who cannot afford to make mortgage payments in the average neighborhood is 14%. After the mortgage interest rate change from July 2000 to December 2001, on average, 1.5% of metropolitan household renters can afford to make mortgage payments in an average neighborhood. That is, after the change in interest rates the latent demand for an average neighborhood is equal to 1.5% of households in the metropolitan area. For an average neighborhood in a metropolitan area with 1 million households[24], the average latent demand is equal to 15,000. Thus, latent demand in absolute terms equals an average of 15,000 households who can afford mortgage payments in an average neighborhood after the decline in interest rates. This can potentially represent a large demand shock since an average neighborhood has approximately 1,000 households.

Table 1.1 also shows that home price growth was positive before, during, and after the monetary policy intervention. From 2000 to 2001, mortgage applications grew by only 1.2% on average, but

[24]The median metropolitan area in the sample has approximately one million households.

the standard deviation is significantly large—38%. Mortgage origination grew by 7.9%, with a very large standard deviation as well—45%. The median housing supply elasticity is 1.5; this is the threshold used to divide the low and high housing elasticity neighborhoods.

4. RESULTS

4.1. Latent Demand and Mortgage Applications

First, we must confirm that the measure of latent demand constructed in this paper actually measures a demand shock. To this end, I first compute, for each neighborhood, the growth in mortgage applications for households who are sensitive to the change in cost of capital. I use the universe of applications from HMDA to compute the growth in mortgage applications in which the applicant's income falls between the neighborhood affordability threshold before and after the change in interest rates. That is, I compute the growth in mortgage applications for home purchase for neighborhood i by using mortgage applications in which the applicant's income respects the following constraint:

$$\frac{12}{40\%} \times \frac{r_{Jul/00} \times \overline{L}_{i,Jul/00}}{1 - \left(\frac{1}{1+r_{Jul/00}}\right)^{360}} < \text{Income}_i < \frac{12}{40\%} \times \frac{r_{Dec/01} \times \overline{L}_{i,Jul/00}}{1 - \left(\frac{1}{1+r_{Dec/01}}\right)^{360}}$$

I add a margin of \$5k on each side because reported incomes are subject to some level of error. The growth in these mortgage applications from 2000 to 2001 is almost 6%, as reported in Table 1.1.

Table 2 reports the estimated coefficients of the regression model in which the outcome variable is the growth in mortgage applications or origination for home purchase when the applicant's income respects the above rule. Table 2 confirms that neighborhoods with higher renters latent demand experienced a larger growth in mortgage applications and a larger growth in mortgage originations for home purchase. Column (1) to (3) report the correlation between latent demand and growth in mortgage applications in a model without controls, with neighborhood-level controls, and with neighborhood-, zip code-, and MSA-level controls, respectively. Columns (4) to (6) present similar regression models to those of (1) to (3), but the outcome variable is mortgage origination for home purchase. These coefficients imply, as explained in section 2.4.2, that a decline in interest rates of 1.2% leads to an average increase in mortgage applications for home purchase of 8% (=-5.347×-0.015), and an increase in 7.2% in mortgage origination for home purchase. There are two important conclusions from Table 2. First, the measure of latent demand constructed in this paper is associated with a demand shock. Second, a change in mortgage interest rates leads to a shift in the housing demand schedule driven by households renters who experience a cut in

their cost of capital.

4.2. Average Effects on House Prices

I first investigate what is the average effect of changes in mortgage interest rates on home price growth between July 2000 and December 2001, a period during which the Fed funds rate dropped from 6.5% to 1.7%, while the 30-year mortgage fixed rate dropped from 8.3% to 7.07%. This change in mortgages interest rates is used to construct a measure of latent demand that is plausibly exogenous to house price growth, as explained in section 2.2. Latent demand is constructed separately for renters and homeowners, and the results are also presented separately. This is because renters are likely to be more sensitive than existing homeowners to changes in the cost of capital. Existing homeowners have higher moving costs, mainly due to selling costs associated with realtor fees.

Table 3 reports the estimated coefficients of the regression model (4) for the latent demand of household renters. Column (1) of Table 3 presents the estimated coefficients of model (4) without controls and without state-fixed effects, which leads to a comparison of neighborhoods across the country. The coefficient on renter's latent demand is -1.233 and statistically different from zero at the 5% level. This coefficient implies, as explained in section 2.4.2, that a decline in interest rates of 1.2% leads to an average increase in house prices of 1.85% (=-1.233$\times$-0.015). The model in column (2) controls for the house price growth from December 1998 and July 2000. The model in column (3) controls income growth at the zip code level from 1998 and 2001, income level at the zip code level in 1998, the income level at the neighborhood level in 2000, the change in denial rate for home purchase from 2000 to 2001, and the housing supply elasticity from Saiz (2010). The estimated coefficient on latent demand from renters hardly changes from the model without controls. The estimated coefficients in column (2) and (3) imply that a change of 1.2% in interest rates leads to an increase in house prices from 1.65% to 1.81%.

The model in column (4), in addition to the controls of the model in column (3), controls for several demographic variables at the zip code level, namely, population size, median age of the population, fraction of the population who has a college degree, fraction of the non-white population, fraction of the population who immigrated into the zip code in the previous year, and fraction of households who are renters. Using the coefficient on latent demand from column (4), the effect of a 1.2% decline in interest rates leads to an average increase in house prices of 1.7%. The model in column (5), in addition to the controls of the model in column (4), controls for several demographic variables at the MSA level; namely, median age of the population, fraction of the population who has a college degree, fraction of the non-white population, fraction of the population who immigrated into the zip code in the previous year, and the unemployment rate in 2000.

Using the coefficient on latent demand from column (5), the effect of a 1.2% decline in interest rates leads to an average increase in house prices of 1.64%.

Finally, the model in column (6), relative to the model in column (5), additionally controls for state-fixed effects. In this last model, in which neighborhoods are compared within the same U.S. state, the estimated effect of changes in interest rates on house price growth is 1.59% and is statistically significant at the 1% level. Across the board, the coefficient on renters latent demand is always between -1.233 and -1.066, and always statistically different than zero at the 5% level. The addition of state-fixed effects reduces the variation of the standard errors making the estimated coefficient significantly different than zero at the 1% level. The implied average effect of a change in 1.2% in mortgage interest rates on house prices is always between 1.59% and 1.81%.

After controlling for the change in denial rates for home purchase, the coefficient on renter's latent demand hardly changes. This is relevant because it is the first piece of evidence that shows that the effects documented here are unlikely to be driven by changes in the lending technology, which were documented to have happened between 2002 and 2005 (Mian and Sufi (2009)) and between 2004 and 2006 (Mayer, Pence, and Sherlund (2009)). Table 4 also illustrates that house price growth from December 1998 to July 2000, one year and half years before the interest rate policy shock, is uncorrelated with the house price growth from July 2000 and December 2001, and does not affect the estimated coefficient on renter's latent demand.

4.3. Pre-treatment Average Effects on House Prices

One possible identification concern is that the effect of interest rates documented in the previous section is driven by housing policies or innovations in the lending industry implemented in the early 2000s. A housing policy or lending innovation that allows households to reduce their monthly payments, similar to the reduction of the cost of capital, can potentially drive the interest rate effects documented in the previous section. To rule out this possibility, I conduct several tests that impose an increasing number of restrictions on alternative explanations. This section tests the timing. Any possible alternative explanation needs to respect the same timing; that is, the correlation of a possible unobservable variable with house price growth and the measure of latent demand of this paper needs to exist between July 2000 and December 2001, but neither between December 1999 and July 2000 nor December 1998 and December 1999.

Table 4 shows the measure of renter's latent demand is uncorrelated with house price growth from December 1998 and December 1999, and with house price growth from December 1999 and July 2000. The effects of latent demand on house price growth in the seven months prior to the interest rate change are not only statistically, but also economically insignificant. The same is also

true for the entire 19 months prior to the change in interest rates. This is roughly equivalent to the parallel trends verification usually conducted in differences-in-differences studies. The timing of the housing policy or lending innovation has to coincide precisely with the timing of the interest rate change. The robustness section below reports several placebo tests that show the same result as this section. I show that latent demand is correlated with the growth in mortgage originations that are kept in the lender's balance sheet, while it is completely uncorrelated with the growth in mortgage originations that were sold off the balance sheet, mostly through securitization. In the online appendix, I also show that renters' latent demand is only associated with the increase in mortgage applications for conventional loans and not for FHA insured loans.

4.4. High Versus Low Supply of Housing

The home price effect reported in the previous section only exists if the supply of housing does not fully adjust to the shift in demand driven by the decline in interest rates. To test this, I estimate the effect of changes in mortgages interest rates on home prices in two sub-samples: high- and low-housing supply elasticity metropolitan areas.[25] Table 6 reports the results of this estimation. Columns (1) and (2) report the estimation when the neighborhood is located in a metropolitan area with low elasticity of housing supply, while columns (3) and (4) report the estimation when the neighborhood is located in a metropolitan area with low elasticity of housing supply. I choose the median housing supply elasticity in the sample to separate the two sub-samples. For the working sample, the median elasticity is 1.5. Table 6 presents two reassuring facts. The effect on home price growth is as predicted. The effect on the sub-sample of neighborhoods located in metropolitan areas with high housing supply elasticity is statistically zero. Cities with high elasticity of housing supply construction can adjust to the demand shock because there is space for construction. On the other hand, in neighborhoods located in low housing supply elasticity areas, the effect of a decline in mortgage interest rates on home price growth is economically large and statistically different from zero. This is because, due to geographical constraints, such as bodies of water and mountains, the supply of housing cannot fully adjust to the demand shock, and, as a result, home prices adjust upward.

4.5. Distributional Effects on Housing Wealth

After establishing the average effects, the paper analyzes the distributional effects, to study who in the income distributions benefits from the increase in home prices caused by the decline in interest rates. Each neighborhood in the sample is a small geographical unit—approximately three times

[25] I use the housing supply elasticity from Saiz (2010).

smaller than a zip code. This is because the definition of a neighborhood follows the zip code terciles in house prices, as defined by Zillow. While there is a shortcoming with this definition of neighborhood because the houses are not adjoined, there is a large advantage to study distributional effects along the income distribution, since homeowners are likely to maintain similar incomes within the neighborhood.

Using the decennial census of 2000, which measures the household income distribution of homeowners by home value in 2000, I estimate the average income for homeowners in each neighborhood in the sample. Then, I organize the neighborhoods into quintiles of income within the same metropolitan area and estimate the effect of changes in mortgage interest rates on home prices for each subsamples of income quintile, as specified in (**??**). This exercise compares neighborhoods in the same income quintile across metropolitan areas in the same state. The average household income is $45,774 in the lowest quintile, $57,721 in the second quintile, $67,790 in the third quintile, $80,169 in the fourth quintile, and $102,347 in the highest quintile.

Column (1) to (5) of Table 7 report the effect of changes in mortgage interest rates on housing wealth from the lowest to the highest income quintile. The regression specification in each column includes for all the neighborhood, zip code, and MSA controls. It also includes state-fixed effects. This is the most restrictive specification. The effects on housing wealth for a decline in mortgage interest rates of 1.2% is remarkably different across quintiles. The lowest income quintiles neighborhoods show no effect of changes from interest rates on housing wealth, since the effect is statistically insignificant. The second and third income quintile experience the highest increase in housing wealth, 6.5% and 5.75%, respectively. The fourth income quintile experiences a small increase in housing wealth of 4%, while the highest income quintile experiences no gains in housing wealth.

Tables A.6 and A.7 in the online appendix present the effect in a sub-sample of low and high housing supply elasticity. As in results for the average effects, the effects are only significant statistically and economically in the areas where the elasticity of housing supply is low. The fact that the supply of housing can easily adjust to the increasing demand is an important factor to define who wins from the declines in interest rates.

4.6. Pre-treatment Distributional Effects on Housing Wealth

Section 4.3 shows that the averages effects of interest rates on house prices are inexistent in the seven months prior to the interest rates policy change. Even though the average effect is zero, it could still be that there are non-zero distributional prior to the interest rate policy change. Table 8 shows that the pre-treatment distributional effects are inexistent. In fact, for the second and

fourth quintile there are some negative in effects in housing wealth. That is, prior to interest rate change, neighborhoods in these quintiles experienced some small declines in housing wealth. On the other hand, the neighborhoods in the other three quintiles—first, third, and fifth—experienced no change in housing wealth prior to the change in interest rates. This provides reassuring evidence that the changes in housing wealth documented in this paper result from the changes in mortgage interest rates.

5. ROBUSTNESS TESTS

5.1. Is the Effect Explained by the Expansion of Credit Supply?

In the beginning of the 2000s, the U.S. economy experienced an outward shift in the supply of credit (Mian and Sufi (2009); Keys, Mukherjee, Seru, and Vig (2010); Adelino, Schoar, and Severino (2012); and Agarwal and Ben-David (2014)). One potential identification concern is that the effect documented in this paper is picking up the credit supply shock. It has been shown that the credit supply shock was driven by an innovation in the securitization market (Mian and Sufi (2009); Keys, Mukherjee, Seru, and Vig (2010)), and, thus, during the early 2000s, lenders increasingly originated mortgages that that they did not keep in their balance sheets. To show that this effect does not drive my results, I estimate the effect changes on interest rates on mortgages applications kept in the lender's balance sheets, and mortgages applications sold off the lender's balance sheet—mainly through securitization. If the documented effect is driven by the credit supply shock in the early 2000s, the effect of change in interest rates on mortgage loan applications sold from the lender's balance sheet must be significantly larger than the effect on mortgage loans applications kept in the lender's balance sheet. Table 9 shows that the estimated effect is only present in the loans that were kept in the lenders balance sheet. This provides reassuring evidence that the securitization alternative does not drive the effect of interest rate on housing wealth. In fact the effect of changes in interest rates on mortgage applications that were not kept in the lender's balance sheet is statistically and economically insignificant.

5.2. Placebo Test from December 1999 to July 2000

An alternative way to test the validity of the paper's empirical design is to run a placebo test. That is, one can simulate that the drop in mortgage interest rates from July 2000 to December 2001 happen between December 1999 and July 2000. Effectively, this translates into reconstructing latent demand with the interest rate change from July 2000 to December 2001 assuming that the house

price level is the level of December 1999, and then regressing the house price growth between December 1999 and July 2000 on the reconstructed measure of latent demand. Table 10 presents the results of this estimation. The regression model is similar in controls and fixed effects to that of Table 7 except that it does not include the change in denial rate from 2000 to 2001, but rather, it controls for the house price level in December 1999, and it controls for the house price growth between December 1998 and December 1999. The reported results show that there are no effects in this placebo test. The estimated coefficients are insignificant both statistically and economically, except in the second quintile, in which there is a negative effect on house prices. Table A.9 in the online appendix reports a placebo test between December 1998 and December 1999.

5.3. Does the Effect Extend Past the Latent Demand?

The hypothesis presented in this paper assumes that household renters whose income lies immediately to the left of the income affordability threshold will overcome the affordability barrier and potentially become homeowners after the decline in interest rates. For households who are further away to the left of the thresholds, the change in interest rates should not affect their housing demand. That is, the decline in interest rates is not enough to make their income high enough relative to the mortgages payments to be able to purchase a house in the neighborhood. I test this rationale by computing the fraction of metropolitan population that is between the affordability threshold after the changes in interest rates and $10,000 to the left of that point. For example, if the affordability threshold prior to the interest rate change is $37k, and after the change in interest rates, the affordability changes to, say, $31k, then I will compute the fraction of the metropolitan renters whose income is between $21k and $31k. I refer to this fraction as *'left' latent demand*. Table 11 reports the estimated coefficients of the regression of mortgage applications and mortgage originations on *'left' latent demand*. The results are reassuring. The coefficients are not statistically significant and they are two to three orders of magnitude smaller than the coefficients of the regression of these mortgage outcomes on latent demand, as reported in Table 2.

6. CONCLUSIONS

Economists have become increasingly interested in documenting the effect of interest rates on the distribution of income and wealth (Coibion, Gorodnichenko, Kueng, and Silvia (2012); Auclert (2014); and Doepke and Schneider (2006)). Understanding these effects can help unravel how interest rate policy affects the real economy; and ultimately, who benefits from monetary policy interventions. Since the largest asset that most U.S. households hold in their balance sheet is their home, interest rates can have a significant effect on a household's wealth if changes in interest rates significantly affect house prices. This effect on housing wealth can prove particularly important for the real economy because, after increases in houses prices, homeowners are more likely to borrow against home equity to fund consumption and investment (Mian and Sufi (2011), Adelino, Schoar, and Severino (2015)). This paper shows significant distributional effects of interest rates on housing wealth. Middle-income homeowners experience large gains in housing wealth after economy-wide changes in interest rates, while low- and high-income homeowners experience no gains in housing wealth.

In the first part of this paper, using a novel identification strategy that estimates *latent demand* for neighborhoods in a quasi-experimental fashion, I estimate the average effect of changes in interest rates on housing demand and house prices. In the second part of the paper, I exploit of the small size and homogeneity of neighborhoods to document the distributional effects of interest rates on housing wealth. It is, however, non-trivial to identifying the effect of changes in interest rates on house prices. Mortgage interest rates are driven, among other factors, by future expectations of inflation and output. Moreover, interest rates tend to simultaneously change for the whole economy, making it difficult to find credible contemporaneous counterfactuals. To address these endogeneity issues, this paper introduces a novel empirical design that exploits the incidental differences in the distribution of the metropolitan population around pre-determined affordability income thresholds.

This paper shows that a 1.2% decline in mortgage interest rates leads to an average increase from 6% to 7% in housing wealth for the second and third income quintiles of income; in monetary terms, this is an average increase between $7,600 and $8,900 in housing wealth. Given that households have high marginal propensities of consumption out of their housing wealth (Mian and Sufi (2011)), these results suggest that the housing market can be a relevant transmission mechanism of interest rates to the real economy. An interesting line of future research is to show that the effect of interest rates on housing wealth spills over to the real economy through increases in consumption.

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Table 1.1: Summary of Statistics: Neighborhood Level

Renters latent demand in July 2000 is computed as presented in the empirical section, it measures the number of renter households in July 2000 as a fraction of total households in the metropolitan that could afford to make mortgage payments in a given neighborhood after the decline in interest rates from July 2000 to December 2001. The homeowners latent demand in July 2000 is computed similarly to the renter's later demand. Mortgage applications and originations are loans for home purchase and are measured using HMDA loan data. Denials change is the change in denial rates for mortgage applications for home purchase. HP Growth is the growth in the Zillow price index for all houses in the neighborhood. Neighborhood income is the income for the neighborhood using Decennial census data. All fractions are presented in decimals.

	N	Mean	Std	10th	90th
Renters Latent Demand $_{\text{Jul}/00}$	17762	-0.015	0.0079	-0.023	-0.0072
Renters Mortgaged-out $_{\text{Jul}/00}$	17762	0.14	0.082	0.054	0.26
Homeowners Latent Demand $_{\text{Jul}/00}$	17762	-0.022	0.013	-0.038	-0.0087
Homeowners Mortgaged-out $_{\text{Jul}/00}$	17762	0.14	0.096	0.048	0.28
Mortgage Origination Growth $_{00\to01}$	17025	0.060	0.95	-0.70	1
Mortgage Applications Growth $_{00\to01}$	17762	0.0078	0.85	-0.65	0.84
Denial Rate Change $_{00\to01}$	17762	-0.036	0.28	-0.33	0.25
HP Growth $_{\text{Jul}/01\to\text{Dec}/02}$	17762	0.077	0.063	0.0086	0.16
HP Growth $_{\text{Jul}/00\to\text{Dec}/01}$	17762	0.11	0.083	0.020	0.22
HP Growth $_{\text{Dec}/96\to\text{Jul}/00}$	16243	0.25	0.17	0.083	0.46
HP Growth $_{\text{Dec}/98\to\text{Jul}/00}$	17657	0.13	0.094	0.031	0.24
House Price (in tens of thousands) $_{\text{Jul}/00}$	17762	16.4	11.2	6	28
Neigh. Inc. (Homeowners) $_{2000}$	17762	70.2	23.2	41.5	104.4
Population (in thds.) $_{2000}$	17762	2.55	1.72	0.59	4.85

Table 1.2: Summary of Statistics: Zip code Level

The definitions of the variables is presented in appendix. All fractions are presented in decimals. The first panel presents the summary of statistics for the variables available at the neighborhood-level; the second panel reports the summary of statistics for the variables available at the zip code-level; and the last panel shows the summary of statistics for the variables available at the MSA-level. In the sample, there are 7898 unique zipcodes, and 204 unique metropolitan areas.

	N	Mean	Std	10th	90th
Median Age $_{2000}$	17762	36.5	5.09	30.8	41.5
Fraction of Black $_{2000}$	17762	0.10	0.17	0.0040	0.28
Fraction of College $_{2000}$	17762	0.55	0.16	0.34	0.77
Immigration Outside County $_{2000}$	17762	0.18	0.090	0.080	0.30
Fraction of Renters $_{2000}$	17762	0.30	0.17	0.12	0.54
IRS Income Growth $_{98\rightarrow01}$	17762	0.088	1.23	0.018	0.18
IRS Income (in thousands) $_{2000}$	17762	47.1	27.1	27.5	70.1

Table 1.3: Summary of Statistics: MSA Level

The definitions of the variables is presented in appendix. All fractions are presented in decimals. The first panel presents the summary of statistics for the variables available at the neighborhood-level; the second panel reports the summary of statistics for the variables available at the zip code-level; and the last panel shows the summary of statistics for the variables available at the MSA-level. In the sample, there are 7898 unique zipcodes, and 204 unique metropolitan areas.

	N	Mean	Std	10th	90th
Elasticity Saiz $_{2000}$	16817	1.61	0.85	0.76	2.75
Population $_{2000}$	17762	4947146.8	6130826.4	284539	16373645
Median Age $_{2000}$	17762	34.6	5.39	32.3	38
Fraction of Black $_{2000}$	17762	0.13	0.089	0.030	0.26
Fraction of College Education $_{2000}$	17762	0.55	0.068	0.47	0.65
Unemployment Rate $_{2000}$	17762	0.056	0.014	0.042	0.072
Immigration $_{2000}$	17762	0.18	0.057	0.11	0.26

Table 2: Latent Demand and Mortgage Applications

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{Mortgage Applications}_{2000\to2001,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Applications Growth: 2000 to 2001			Origination Growth: 2000 to 2001		
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	-4.539**	-4.460**	-4.486**	-4.733*	-4.168**	-3.919*
	(-2.19)	(-2.19)	(-2.18)	(-1.97)	(-2.05)	(-1.90)
Renters Mortgaged-out $_{Jul/00}$	-0.498	-0.730	-0.332	-0.456	-0.646	-0.335
	(-1.07)	(-1.64)	(-0.74)	(-0.91)	(-1.52)	(-0.75)
House Price $_{Jul/00}$	0.239***	0.266***	0.170***	0.230***	0.255***	0.166***
	(5.12)	(4.65)	(3.06)	(4.25)	(4.36)	(2.77)
HP Growth $_{Dec/98 \to Jul/00}$		-0.540***	-0.414***		-0.676***	-0.508***
		(-2.96)	(-2.70)		(-3.30)	(-2.69)
IRS Income Growth $_{98\to01}$		0.005***	0.004***		-0.002**	-0.002***
		(3.46)	(3.79)		(-2.01)	(-2.82)
Denial Rate Change $_{00\to01}$		0.046	0.050		-1.183***	-1.186***
		(1.46)	(1.56)		(-23.05)	(-23.00)
Neigh. Inc. (Homeowners) $_{2000}$		0.098**	0.262***		0.114***	0.281***
		(2.43)	(5.44)		(2.63)	(5.03)
Elasticity Saiz $_{2000}$		0.054***	0.001		0.067***	0.017
		(3.06)	(0.05)		(3.47)	(0.72)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip Controls	No	No	Yes	No	No	Yes
MSA Controls	No	No	Yes	No	No	Yes
#Zip codes	16817	16716	16716	16143	16045	16045
R-squared	0.025	0.029	0.037	0.022	0.124	0.129

Table 3: Effect of Interest Rates on Home Prices: Renters Demand

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{\,Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2001 to Dec-2001					
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	-1.233**	-1.211**	-1.105**	-1.106**	-1.065**	-1.025***
	(-2.53)	(-2.25)	(-2.17)	(-2.17)	(-2.23)	(-2.88)
Renters Mortgaged-out $_{Jul/00}$	-0.011	0.004	-0.021	-0.055	-0.177	-0.194***
	(-0.07)	(0.02)	(-0.19)	(-0.47)	(-1.60)	(-3.09)
House Price $_{Jul/00}$	0.030	0.005	-0.022	-0.019	-0.009	0.010
	(1.40)	(0.31)	(-1.65)	(-1.18)	(-0.75)	(1.21)
HP Growth $_{Dec/98 \to Jul/00}$		0.266**	0.204**	0.189*	0.199**	0.024
		(2.50)	(2.10)	(1.96)	(2.10)	(0.38)
ZIP IRS Income Growth $_{98 \to 01}$			0.000	-0.000	-0.000	-0.000*
			(0.05)	(-0.01)	(-0.03)	(-1.84)
Neigh. Inc. (Homeowners) $_{2000}$			0.000*	0.000	0.001**	0.000
			(1.66)	(1.40)	(2.33)	(1.34)
Denial Rate Change $_{00 \to 01}$			0.006**	0.006**	0.007**	0.002
			(2.34)	(2.36)	(2.48)	(1.18)
Elasticity Saiz $_{2000}$			-0.035***	-0.033***	-0.029***	-0.016***
			(-6.85)	(-6.39)	(-5.91)	(-2.79)
State Fixed Effects	No	No	No	No	No	Yes
Zip Controls	No	No	No	Yes	Yes	Yes
MSA Controls	No	No	No	No	Yes	Yes
#Neighborhoods	16817	16716	16716	16716	16716	16716
R-squared	0.073	0.141	0.246	0.253	0.268	0.457

Table 4: Effects Prior to the Interest Rate Policy Change

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{Dec/99\rightarrow Jul/00,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: The Table below also reports the coefficients when the outcome variable is House Price $_{Dec/98\rightarrow Dec/99,i}$. Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	HPI Dec-1999 to Jul-2000			HPI Dec-1998 to Dec-1999		
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	0.151	0.242	0.136	0.117	0.044	0.126
	(0.52)	(1.07)	(1.12)	(0.51)	(0.24)	(1.52)
Renters Mortgaged-out $_{Jul/00}$	0.152**	0.158***	0.064	0.273***	0.195**	0.173*
	(2.58)	(3.80)	(1.13)	(2.95)	(2.00)	(1.83)
House Price $_{Dec/99}$	0.013	-0.007	-0.005			
	(1.25)	(-0.95)	(-0.83)			
HP Growth $_{Dec/98\rightarrow Dec/99}$		0.176***	0.070**			
		(3.50)	(2.39)			
House Price $_{Dec/98}$				0.001	-0.015	-0.012
				(0.06)	(-1.43)	(-0.94)
HP Growth $_{Dec/96\rightarrow Dec/98}$					0.140***	0.072**
					(3.23)	(2.39)
ZIP IRS Income Growth $_{98\rightarrow 01}$		0.000	0.000		0.000	0.000
		(1.17)	(1.52)		(0.81)	(0.72)
Denial Rate Change $_{00\rightarrow 01}$		-0.000	-0.001		0.006***	0.004***
		(-0.24)	(-1.14)		(3.38)	(2.94)
Neigh. Inc. (Homeowners) $_{2000}$		0.000	0.000***		0.000*	0.000***
		(0.40)	(3.22)		(1.91)	(3.17)
Elasticity Saiz $_{2000}$		-0.006***	-0.005*		-0.013***	-0.013***
		(-3.53)	(-1.82)		(-4.12)	(-4.79)
State Fixed Effects	No	No	Yes	No	No	Yes
Zip Controls	No	Yes	Yes	No	No	No
MSA Controls	No	Yes	Yes	No	No	No
#Zip codes	16786	16716	16716	16716	15413	15413
R-squared	0.178	0.333	0.436	0.150	0.223	0.350

Table 5: Effect of Interest Rates on Home Prices: Homeowners Demand

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{Mortgage Applications}_{2000\to2001,i} &= \theta_0 + \theta_1 \times \text{Homeowners Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Homeowners Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: Homeowners latent demand and homeowners mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, homeowners latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Homeowners mortgaged-out measures the fraction of homeonwers whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2001 to Dec-2001					
	(1)	(2)	(3)	(4)	(5)	(6)
Homeowners Latent Demand $_{Jul/00}$	0.032	-0.166	-0.196	-0.202	-0.237	-0.321
	(0.06)	(-0.38)	(-0.52)	(-0.54)	(-0.67)	(-1.36)
Homeowners Mortgaged-out $_{Jul/00}$	-0.379***	-0.332***	-0.283***	-0.298***	-0.312***	-0.239***
	(-3.03)	(-2.68)	(-2.79)	(-2.96)	(-3.19)	(-3.38)
House Price $_{Jul/00}$	0.091***	0.062***	0.020	0.019	0.016	0.024*
	(4.63)	(3.26)	(1.25)	(1.20)	(1.05)	(1.92)
HP Growth $_{Dec/98 \to Jul/00}$		0.227**	0.180*	0.170*	0.186**	0.029
		(2.20)	(1.88)	(1.79)	(2.03)	(0.47)
ZIP IRS Income Growth $_{98\to01}$			0.000	0.000	0.000	-0.000**
			(0.11)	(0.11)	(0.11)	(-2.19)
Neigh. Inc. (Homeowners) $_{2000}$			0.001**	0.001**	0.001***	0.000**
			(2.08)	(2.05)	(3.14)	(2.07)
Denial Rate Change $_{00\to01}$			0.006**	0.006**	0.006**	0.002
			(2.31)	(2.40)	(2.52)	(1.30)
Elasticity Saiz $_{2000}$			-0.033***	-0.032***	-0.028***	-0.015***
			(-7.42)	(-7.09)	(-6.22)	(-2.71)
State Fixed Effects	No	No	No	No	No	Yes
Zip Controls	No	No	No	Yes	Yes	Yes
MSA Controls	No	No	No	No	Yes	Yes
#Neighborhoods	16817	16716	16716	16716	16716	16716
R-squared	0.118	0.167	0.262	0.270	0.285	0.459

Table 6: Effects on High and Low Housing Supply Elasticity Areas

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The regression model is estimated for a sub-sample of low housing supply elasticity (Elasticity of (Saiz)<1.5) and for a sub-sample of high housing supply elasticity (Elasticity of (Saiz)>1.5). Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Elasticity Saiz(2010)<1.5			Elasticity Saiz(2010)>1.5		
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	-1.197**	-1.153*	-1.055**	1.770*	1.344	1.072
	(-2.14)	(-1.99)	(-2.04)	(1.76)	(1.39)	(1.24)
Renters Mortgaged-out $_{Jul/00}$	-0.110	-0.162	-0.203*	-0.160	-0.203	-0.093
	(-0.79)	(-1.28)	(-1.80)	(-1.01)	(-1.11)	(-0.58)
House Price $_{Jul/00}$	0.012	-0.009	-0.012	0.057***	0.032**	0.008
	(0.56)	(-0.49)	(-0.82)	(2.64)	(2.21)	(0.54)
HP Growth $_{Dec/98 \to Jul/00}$		0.265**	0.231*		0.142**	0.123**
		(2.33)	(2.00)		(2.49)	(2.33)
ZIP IRS Income Growth $_{98 \to 01}$		0.003	0.002		0.017	0.013
		(0.54)	(0.35)		(1.30)	(1.23)
Denial Rate Change $_{00 \to 01}$		0.012**	0.013**		0.002	0.002
		(2.47)	(2.59)		(1.10)	(0.80)
Neigh. Inc. (Homeowners) $_{2000}$		0.000	0.000*		0.001	0.001
		(0.92)	(1.67)		(1.14)	(1.43)
Elasticity Saiz $_{2000}$			-0.080			-0.026***
			(-1.66)			(-3.90)
State Fixed Effects	No	No	No	No	No	No
Zip Controls	No	Yes	Yes	No	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes	Yes
#Zip codes	8612	8559	8559	8204	8156	8156
R-squared	0.060	0.143	0.171	0.151	0.200	0.250

Table 7: Distributional Effects on Home Prices: Renters Demand

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{\,Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2000 to Dec-2001				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Jul/00}$	-2.524	-4.544***	-3.839***	-2.642***	-0.205**
	(-1.20)	(-2.90)	(-4.30)	(-2.91)	(-2.39)
Renters Mortgaged-out $_{Jul/00}$	-0.554**	-0.360**	-0.239**	-0.205*	-0.011
	(-2.28)	(-2.24)	(-2.36)	(-1.82)	(-0.24)
House Price $_{Jul/00}$	0.013	-0.018	-0.019	0.017	-0.005
	(0.98)	(-1.25)	(-1.18)	(0.91)	(-0.52)
HP Growth $_{Dec/98 \to Jul/00}$	0.075	-0.031	-0.079	-0.049	-0.010
	(1.45)	(-0.60)	(-1.39)	(-0.82)	(-0.14)
ZIP IRS Income Growth $_{98 \to 01}$	-0.000*	0.053**	0.019	0.051*	0.012
	(-1.93)	(2.54)	(1.19)	(1.73)	(0.46)
Neigh. Inc. (Homeowners) $_{2000}$	0.002***	0.003***	0.003***	0.001***	0.001***
	(3.97)	(5.70)	(4.92)	(3.40)	(3.37)
Denial Rate Change $_{00 \to 01}$	0.001	0.004	0.003	-0.001	0.001
	(0.26)	(0.98)	(1.05)	(-0.18)	(0.32)
Elasticity Saiz $_{2000}$	-0.014***	-0.013**	-0.012**	-0.011*	-0.013*
	(-3.08)	(-2.60)	(-2.24)	(-1.94)	(-1.83)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	3381	3326	3329	3362	3318
R-squared	0.512	0.504	0.519	0.527	0.537

Table 8: Pre-treatment Distributional Effects of Interest Rates on Home Prices

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{Dec/99 \to Jul/00,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Dec-1999 to Jul-2001				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Jul/00}$	-0.543	1.589**	0.680	0.968**	0.046
	(-0.63)	(2.54)	(1.42)	(2.16)	(0.52)
Renters Mortgaged-out $_{Jul/00}$	0.153*	0.347***	0.234***	0.167**	-0.006
	(1.73)	(5.58)	(4.44)	(2.46)	(-0.12)
House Price $_{Dec/99}$	-0.022***	-0.032***	-0.028***	-0.016*	0.003
	(-3.02)	(-4.39)	(-3.34)	(-1.74)	(0.42)
Income $_{1998}$	0.006	-0.001	0.003	0.008**	0.010***
	(1.38)	(-0.15)	(0.64)	(2.15)	(2.81)
HP Growth $_{Dec/98 \to Dec/99}$	0.027	0.013	0.060*	0.015	0.142***
	(0.73)	(0.47)	(1.75)	(0.70)	(3.78)
Neigh. Inc. (Homeowners) $_{2000}$	0.001***	0.002***	0.001***	0.001***	0.000**
	(4.09)	(9.25)	(7.40)	(5.09)	(2.21)
Elasticity Saiz $_{2000}$	-0.004	-0.003	-0.003	-0.004*	-0.004
	(-1.59)	(-1.28)	(-1.64)	(-1.89)	(-1.19)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	3380	3326	3329	3362	3318
R-squared	0.397	0.489	0.500	0.486	0.517

Table 9: Effect on Applications Kept in the Balance Sheet versus Loans Sold

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{Mortgage Applications}_{2000\to2001,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The model is estimated for three outcome variables. First, growth in all mortgage applications for the neighborhood; second, growth in mortgage applications that were kept in the lender's balance sheet; and third, growth in mortgage applications that were sold and therefore not kept on the lender's balance sheet. Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Mortgage Applications from 2000 to 2001					
	(1) All	(2) All	(3) Kept	(4) Kept	(5) Not-Kept	(6) Not-Kept
Renters Latent Demand $_{Jul/00}$	-4.416**	-5.045**	-4.576**	-5.324**	0.306	-0.315
	(-2.18)	(-2.26)	(-2.35)	(-2.33)	(0.14)	(-0.16)
Renters Mortgaged-out $_{Jul/00}$	-0.492	-0.588	-0.588	-0.532	0.770	-0.060
	(-1.14)	(-1.28)	(-1.33)	(-1.21)	(1.60)	(-0.12)
House Price $_{Jul/00}$	0.240***	0.266***	0.244***	0.203***	0.175***	0.348***
	(5.44)	(4.69)	(5.66)	(3.79)	(2.84)	(4.97)
HP Growth $_{Dec/98 \to Jul/00}$		-0.473***		-0.460***		-0.763***
		(-2.96)		(-3.37)		(-3.35)
ZIP IRS Income Growth $_{98\to01}$		0.004***		-0.009		0.022
		(3.96)		(-1.13)		(0.93)
Neigh. Inc. (Homeowners) $_{2000}$		0.001		0.002		0.001
		(1.58)		(1.63)		(1.44)
Denial Rate Change $_{00\to01}$		0.052		0.478***		-0.979***
		(1.62)		(11.58)		(-17.54)
Elasticity Saiz $_{2000}$		0.026		0.001		0.081**
		(1.32)		(0.06)		(2.39)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip Controls	No	Yes	No	Yes	No	Yes
MSA Controls	No	Yes	No	Yes	No	Yes
#Zip codes	17762	16716	15850	14908	13968	13170
R-squared	0.024	0.034	0.020	0.046	0.031	0.071

Table 10: Placebo Test between December 1999 and July 2000

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{Dec/99 \to Jul/00,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Dec/99,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Dec/99,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in December 1999 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001, but in this case it is constructed assuming the price level in December 1999. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Dec-1999 to Jul-2001				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Dec/99}$	0.582	2.112***	0.713	0.353	-0.011
	(0.91)	(3.43)	(1.57)	(0.93)	(-0.17)
Renters Mortgaged-out $_{Dec/98}$	-0.125*	0.081	-0.057	-0.119	-0.076*
	(-1.66)	(1.32)	(-0.86)	(-1.41)	(-1.73)
House Price $_{Dec/99}$	0.013	0.006	0.012	0.024**	0.011*
	(1.56)	(0.68)	(1.14)	(2.18)	(1.83)
Income $_{1998}$	0.004	-0.002	0.000	0.005	0.007**
	(0.92)	(-0.46)	(0.10)	(1.43)	(2.12)
HP Growth $_{Dec/98 \to Dec/99}$	0.026	0.011	0.054*	0.008	0.138***
	(0.72)	(0.42)	(1.71)	(0.31)	(3.77)
Neigh. Inc. (Homeowners) $_{2000}$	0.001***	0.002***	0.001***	0.001***	0.000**
	(5.09)	(9.88)	(7.25)	(5.58)	(2.45)
Elasticity Saiz $_{2000}$	-0.003	-0.002	-0.003	-0.004*	-0.004
	(-1.37)	(-1.01)	(-1.26)	(-1.67)	(-1.28)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	3380	3326	3329	3362	3318
R-squared	0.395	0.478	0.491	0.482	0.520

Table 11: Interest Rates on Applications and Originations for the 'left' of Latent Demand

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{"Left" Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{"Left" Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: "Left" Renters latent demand and "left" renters mortgaged-out in July 2000 is computed as described in the section 5. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Applications Growth: 2000 to 2001			Origination Growth: 2000 to 2001		
	(1)	(2)	(3)	(4)	(5)	(6)
"Left" Renters Latent Demand $_{Jul/00}$	-1.656	-1.349	-1.417	-2.082	-1.649	-1.695
	(-0.69)	(-0.57)	(-0.61)	(-0.80)	(-0.65)	(-0.68)
"Left" Renters Mortgaged-out $_{Jul/00}$	-0.188	-0.475	-0.206	-0.578	-0.731	-0.509
	(-0.35)	(-0.94)	(-0.40)	(-1.04)	(-1.32)	(-0.91)
House Price $_{Jul/00}$	0.291***	0.241***	0.168**	0.390***	0.254***	0.227***
	(5.77)	(4.10)	(2.50)	(8.35)	(4.85)	(3.49)
HP Growth $_{Dec/98 \to Jul/00}$		-0.375*	-0.265		-0.308*	-0.250
		(-1.90)	(-1.39)		(-1.70)	(-1.45)
ZIP IRS Income Growth $_{98 \to 01}$		0.007	0.010		0.009	0.015
		(1.08)	(1.21)		(0.90)	(1.65)
Denial Rate Change $_{00 \to 01}$		0.024	0.026		-0.976***	-0.973***
		(1.08)	(1.15)		(-27.20)	(-27.73)
Neigh. Inc. (Homeowners) $_{2000}$		0.221***	0.331***		0.293***	0.289***
		(4.52)	(4.17)		(5.26)	(3.03)
Elasticity Saiz $_{2000}$		0.044*	0.004		0.015	-0.009
		(1.76)	(0.14)		(0.61)	(-0.31)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip Controls	No	No	Yes	No	No	Yes
MSA Controls	No	No	Yes	No	No	Yes
#Zip codes	11092	11019	11019	9673	9605	9605
R-squared	0.026	0.029	0.033	0.039	0.155	0.157

A.1 Detailed Description of the Computation of Variables

Latent Demand and Mortgage-out

Mortgage Applications for Neighborhood

Neighborhood Income

A.2 Merge of HMDA with IPUMS

ONLINE APPENDIX

Table A.1: Complete version of Table 3

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{\,Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2000 to Dec-2001					
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
Renters Latent Demand $_{Jul/00}$	-1.233**	-1.211**	-1.105**	-1.106**	-1.065**	-1.025***
	(-2.53)	(-2.25)	(-2.17)	(-2.17)	(-2.23)	(-2.88)
Renters Mortgaged-out $_{Jul/00}$	-0.011	0.004	-0.021	-0.055	-0.177	-0.194***
	(-0.07)	(0.02)	(-0.19)	(-0.47)	(-1.60)	(-3.09)
HP Growth $_{Dec/98 \to Jul/00}$		0.266**	0.204**	0.189*	0.199**	0.024
		(2.50)	(2.10)	(1.96)	(2.10)	(0.38)
ZIP IRS Income Growth $_{98 \to 01}$			0.000	-0.000	-0.000	-0.000*
			(0.05)	(-0.01)	(-0.03)	(-1.84)
Neigh. Inc. (Homeowners) $_{2000}$			0.000*	0.000	0.001**	0.000
			(1.66)	(1.40)	(2.33)	(1.34)
Denial Rate Change $_{00 \to 01}$			0.006**	0.006**	0.007**	0.002
			(2.34)	(2.36)	(2.48)	(1.18)
Elasticity Saiz $_{2000}$			-0.035***	-0.033***	-0.029***	-0.016***
			(-6.85)	(-6.39)	(-5.91)	(-2.79)
House Price $_{Jul/00}$	0.030	0.005	-0.022	-0.019	-0.009	0.010
	(1.40)	(0.31)	(-1.65)	(-1.18)	(-0.75)	(1.21)
ZIP Population $_{2000}$				0.000	0.000	0.000**
				(0.56)	(0.46)	(2.35)
ZIP Median Age $_{2000}$				0.000	0.001*	0.000
				(0.84)	(1.83)	(1.57)
ZIP Fraction of Black $_{2000}$				-0.022	-0.006	-0.007
				(-1.48)	(-0.53)	(-0.61)
ZIP Fraction of College $_{2000}$				-0.000	-0.022	0.006
				(-0.02)	(-1.48)	(0.51)
ZIP Immigration Outside County $_{2000}$				-0.011	0.018	0.011
				(-0.34)	(0.76)	(0.46)
ZIP Fraction of Renters $_{2000}$				0.047***	0.039***	0.041***
				(3.56)	(2.64)	(4.39)
MSA Median Age $_{2000}$					0.000	0.000
					(0.58)	(0.35)
MSA Fraction of Black $_{2000}$					-0.049	-0.044
					(-0.70)	(-0.78)
MSA Fraction of College Education $_{2000}$					0.109	0.153
					(1.17)	(1.63)
MSA Unemployment Rate $_{2000}$					0.929**	1.123**
					(2.18)	(2.47)
MSA Immigration $_{2000}$					-0.042	-0.035
					(-0.48)	(-0.23)
State Fixed Effects	No	No	No	No	No	Yes
#Neighborhoods	16817	16716	16716	16716	16716	16716
R-squared	0.073	0.141	0.246	0.253	0.268	0.457

Table A.2: Effect of Interest Rates on Originations 2000 to 2001: Homeowners Demand

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{Mortgage Originations}_{2000\to2001,i} &= \theta_0 + \theta_1 \times \text{Homeowners Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Homeowners Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The model is estimated for three outcome variables. First, growth in all mortgage applications for the neighborhood; second, growth in mortgage applications that were kept in the lender's balance sheet; and third, growth in mortgage applications that were sold and therefore not kept on the lender's balance sheet. Homeowners latent demand and homeowners mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, homeowners latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Homeowners mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Mortgage Originations from 2000 to 2001					
	(1) All	(2) All	(3) Kept	(4) Kept	(5) Not-Kept	(6) Not-Kept
Homeowners Latent Demand $_{Jul/00}$	-4.694*	-2.943	-3.263*	-1.832	-1.260	0.210
	(-1.77)	(-1.47)	(-1.76)	(-1.23)	(-0.54)	(0.14)
Homeowners Mortgaged-out $_{Jul/00}$	-0.331	-0.521	-1.048*	-0.838	0.601	-0.053
	(-0.62)	(-0.93)	(-1.86)	(-1.64)	(1.29)	(-0.10)
House Price $_{Jul/00}$	0.174***	0.247***	0.253***	0.191***	0.137*	0.335***
	(2.95)	(3.28)	(4.17)	(2.75)	(1.86)	(4.24)
HP Growth $_{Dec/98 \to Jul/00}$		-0.492***		-0.004		-0.698***
		(-2.66)		(-0.02)		(-3.09)
ZIP IRS Income Growth $_{98\to01}$		-0.037***		-0.021		-0.011
		(-2.98)		(-1.05)		(-0.43)
Neigh. Inc. (Homeowners) $_{2000}$		0.002***		0.001		0.003**
		(2.90)		(1.01)		(2.53)
Denial Rate Change $_{00\to01}$		-1.184***		-1.026***		-0.977***
		(-23.15)		(-27.90)		(-17.43)
Elasticity Saiz $_{2000}$		0.032		-0.040**		0.076**
		(1.44)		(-2.01)		(2.31)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip Controls	No	Yes	No	Yes	No	Yes
MSA Controls	No	Yes	No	Yes	No	Yes
#Zip codes	17025	16044	13665	12877	13967	13169
R-squared	0.023	0.129	0.025	0.084	0.032	0.072

Table A.3: Effect of Interest Rates on House Prices from Jul 2000 to Jul 2001

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{\,Jul/00 \to Jul/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2001 to Dec-2001					
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	-0.672***	-0.658**	-0.591**	-0.563**	-0.499**	-0.517***
	(-2.70)	(-2.43)	(-2.33)	(-2.27)	(-2.16)	(-3.01)
Renters Mortgaged-out $_{Jul/00}$	-0.018	-0.005	-0.021	-0.043	-0.132*	-0.169***
	(-0.19)	(-0.06)	(-0.29)	(-0.59)	(-1.90)	(-3.07)
House Price $_{Jul/00}$	0.029**	0.008	-0.007	-0.004	-0.000	0.011**
	(2.02)	(0.78)	(-0.87)	(-0.36)	(-0.01)	(2.06)
HP Growth $_{Dec/98 \to Jul/00}$		0.216***	0.178***	0.163***	0.168***	0.029
		(3.83)	(3.42)	(3.11)	(3.07)	(0.81)
ZIP IRS Income Growth $_{98 \to 01}$			0.000	0.000	0.000	-0.000
			(0.45)	(0.38)	(0.36)	(-0.98)
Neigh. Inc. (Homeowners) $_{2000}$			0.000	0.000	0.000**	0.000**
			(1.43)	(0.84)	(2.48)	(2.23)
Denial Rate Change $_{00 \to 01}$			0.005***	0.005***	0.005***	0.003**
			(2.92)	(3.03)	(3.18)	(1.99)
Elasticity Saiz $_{2000}$			-0.021***	-0.021***	-0.017***	-0.010***
			(-6.89)	(-6.56)	(-5.74)	(-2.77)
State Fixed Effects	No	No	No	No	No	Yes
Zip Controls	No	No	No	Yes	Yes	Yes
MSA Controls	No	No	No	No	Yes	Yes
#Neighborhoods	16817	16716	16716	16716	16716	16716
R-squared	0.082	0.162	0.230	0.238	0.256	0.414

Table A.4: Effect of Interest Rates on House Prices from Jul 2001 to Dec 2001

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{\,Jul/01 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2001 to Dec-2001					
	(1)	(2)	(3)	(4)	(5)	(6)
Renters Latent Demand $_{Jul/00}$	-0.488**	-0.481*	-0.446*	-0.473*	-0.495**	-0.442**
	(-2.03)	(-1.93)	(-1.87)	(-1.89)	(-1.98)	(-2.32)
Renters Mortgaged-out $_{Jul/00}$	0.009	0.010	0.002	-0.008	-0.036	-0.014
	(0.15)	(0.17)	(0.04)	(-0.16)	(-0.83)	(-0.62)
House Price $_{Jul/00}$	0.000	-0.003	-0.013**	-0.014**	-0.008**	-0.002
	(0.03)	(-0.51)	(-2.46)	(-2.23)	(-1.99)	(-0.66)
HP Growth $_{Dec/98 \to Jul/00}$		0.037	0.017	0.017	0.021	-0.007
		(0.79)	(0.39)	(0.40)	(0.53)	(-0.27)
ZIP IRS Income Growth $_{98 \to 01}$			-0.000	-0.000	-0.000	-0.000**
			(-1.24)	(-1.21)	(-1.16)	(-2.08)
Neigh. Inc. (Homeowners) $_{2000}$			0.000**	0.000**	0.000*	-0.000
			(1.99)	(2.23)	(1.89)	(-0.21)
Denial Rate Change $_{00 \to 01}$			0.001	0.001	0.001	-0.000
			(0.76)	(0.67)	(0.72)	(-0.35)
Elasticity Saiz $_{2000}$			-0.012***	-0.011***	-0.010***	-0.006**
			(-6.27)	(-5.73)	(-5.34)	(-2.45)
State Fixed Effects	No	No	No	No	No	Yes
Zip Controls	No	No	No	Yes	Yes	Yes
MSA Controls	No	No	No	No	Yes	Yes
#Neighborhoods	16817	16716	16716	16716	16716	16716
R-squared	0.019	0.028	0.108	0.114	0.123	0.236

Table A.5: Interest Rates on Originations Kept in Balance Sheet versus Originations Sold

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{Mortgage Originations}_{2000\to2001,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The model is estimated for three outcome variables. First, growth in all mortgage originations for the neighborhood; second, growth in mortgage originations that were kept in the lender's balance sheet; and third, growth in mortgage originations that were sold and therefore not kept on the lender's balance sheet. Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Elasticity (Saiz) is the measure of housing supply elasticity from Saiz (2010). Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	Mortgage Originations from 2000 to 2001					
	(1) All	(2) All	(3) Kept	(4) Kept	(5) Not-Kept	(6) Not-Kept
Renters Latent Demand $_{Jul/00}$	-4.953**	-4.628**	-5.394**	-4.542**	0.311	-0.303
	(-2.04)	(-2.05)	(-2.43)	(-2.20)	(0.15)	(-0.15)
Renters Mortgaged-out $_{Jul/00}$	-0.445	-0.530	-1.000*	-0.455	0.767	-0.060
	(-0.94)	(-1.15)	(-1.76)	(-0.92)	(1.59)	(-0.12)
House Price $_{Jul/00}$	0.236***	0.265***	0.231***	0.132**	0.175***	0.346***
	(4.65)	(4.22)	(4.49)	(2.44)	(2.83)	(4.90)
HP Growth $_{Dec/98 \to Jul/00}$		-0.562***		-0.061		-0.760***
		(-2.93)		(-0.31)		(-3.34)
ZIP IRS Income Growth $_{98\to01}$		-0.002***		0.009		0.022
		(-2.79)		(0.68)		(0.94)
Neigh. Inc. (Homeowners) $_{2000}$		0.001		-0.000		0.001
		(1.45)		(-0.37)		(1.47)
Denial Rate Change $_{00\to01}$		-1.183***		-1.026***		-0.978***
		(-22.90)		(-27.83)		(-17.50)
Elasticity Saiz $_{2000}$		0.036		-0.039**		0.080**
		(1.59)		(-2.00)		(2.37)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip Controls	No	Yes	No	Yes	No	Yes
MSA Controls	No	Yes	No	Yes	No	Yes
#Zip codes	17025	16045	13665	12877	13967	13169
R-squared	0.023	0.128	0.025	0.084	0.031	0.071

Table A.6: Distributional Effects on Home Prices: Low Elasticity

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{\,Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles when the elasticity of Saiz (2010) is below 1.5. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2000 to Dec-2001				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Jul/00}$	-2.732	-3.953**	-2.782***	-1.946*	-0.171***
	(-1.21)	(-2.58)	(-3.35)	(-1.93)	(-4.34)
Renters Mortgaged-out $_{Jul/00}$	-0.744***	-0.470**	-0.260*	-0.293	-0.070*
	(-2.75)	(-2.52)	(-1.78)	(-1.34)	(-1.71)
House Price $_{Jul/00}$	0.031**	-0.009	-0.024	0.020	-0.015
	(2.09)	(-0.40)	(-1.12)	(0.60)	(-1.33)
HP Growth $_{Dec/98 \to Jul/00}$	0.116	0.008	-0.069	-0.048	-0.017
	(1.41)	(0.11)	(-0.94)	(-0.63)	(-0.24)
ZIP IRS Income Growth $_{98 \to 01}$	-0.000*	0.050	0.017	0.006	-0.015
	(-1.85)	(1.43)	(0.31)	(0.13)	(-0.45)
Neigh. Inc. (Homeowners) $_{2000}$	0.001	0.002***	0.002**	0.000	0.001**
	(1.17)	(2.89)	(2.44)	(1.31)	(2.07)
Denial Rate Change $_{00 \to 01}$	0.011*	0.004	0.005	0.008	-0.003
	(1.80)	(0.85)	(0.91)	(1.62)	(-0.43)
Elasticity Saiz $_{2000}$	-0.064**	-0.037	-0.061	-0.070	-0.107**
	(-2.41)	(-1.01)	(-1.30)	(-1.20)	(-2.15)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	1747	1774	1747	1774	1771
R-squared	0.553	0.520	0.538	0.508	0.521

Table A.7: Distributional Effects on Home Prices: High Elasticity

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{\,Jul/00 \to Dec/01,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles when the elasticity of Saiz (2010) is above 1.5. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Jul-2000 to Dec-2001				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Jul/00}$	2.246	1.507	2.229*	-0.130	-0.109
	(0.99)	(0.91)	(1.91)	(-0.15)	(-0.13)
Renters Mortgaged-out $_{Jul/00}$	0.083	0.037	-0.026	-0.172	-0.239**
	(0.30)	(0.18)	(-0.22)	(-1.65)	(-2.12)
House Price $_{Jul/00}$	-0.004	-0.002	0.010	0.011	0.020
	(-0.35)	(-0.10)	(0.67)	(0.66)	(1.33)
HP Growth $_{Dec/98 \to Jul/00}$	-0.050	-0.114**	-0.066	-0.017	0.066
	(-1.02)	(-2.24)	(-1.59)	(-0.35)	(1.02)
ZIP IRS Income Growth $_{98 \to 01}$	-0.001	0.047**	0.018	0.103***	0.049**
	(-0.38)	(2.47)	(1.35)	(4.32)	(2.36)
Neigh. Inc. (Homeowners) $_{2000}$	0.002***	0.003***	0.003***	0.002***	0.001***
	(3.80)	(4.81)	(5.40)	(4.13)	(3.40)
Denial Rate Change $_{00 \to 01}$	-0.003	0.006	0.001	-0.010**	-0.000
	(-0.77)	(1.28)	(0.34)	(-2.38)	(-0.11)
Elasticity Saiz $_{2000}$	-0.011*	-0.007	-0.005	-0.005	-0.003
	(-1.75)	(-1.15)	(-0.93)	(-0.86)	(-0.61)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	1634	1552	1582	1588	1547
R-squared	0.406	0.454	0.520	0.599	0.680

Table A.8: Pretreatment Effect from December 1998 and December 1999

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned} \text{House Price}_{Dec/98 \to Dec/99,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{Jul/00,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{Jul/00,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i \end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in July 2000 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Dec-1998 to Dec-1999				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Jul/00}$	0.632	1.049	0.843*	0.558	0.126
	(0.57)	(1.27)	(1.75)	(1.24)	(1.43)
Renters Mortgaged-out $_{Jul/00}$	0.549***	0.530***	0.405***	0.373***	0.047
	(5.34)	(5.55)	(4.95)	(3.95)	(0.86)
House Price $_{Dec/98}$	-0.051***	-0.060***	-0.049***	-0.052***	-0.010
	(-5.65)	(-5.72)	(-4.14)	(-4.18)	(-1.22)
HP Growth $_{Dec/96 \to Dec/98}$	0.006	-0.018	-0.026	-0.010	0.048*
	(0.23)	(-0.67)	(-1.08)	(-0.33)	(1.68)
Neigh. Inc. (Homeowners) $_{2000}$	0.001***	0.002***	0.001***	0.001***	0.001***
	(2.99)	(4.06)	(3.73)	(4.24)	(3.88)
Elasticity Saiz $_{2000}$	-0.010***	-0.006*	-0.008***	-0.010***	-0.007**
	(-3.39)	(-1.82)	(-2.93)	(-3.48)	(-2.35)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	3107	3070	3028	3109	3099
R-squared	0.407	0.452	0.470	0.467	0.493

Table A.9: Placebo Test between December 1998 and December 1999

The Table below reports the estimated coefficients for the following regression specification at the neighborhood level:

$$\begin{aligned}\text{House Price}_{\,Dec/98 \to Dec/99,i} &= \theta_0 + \theta_1 \times \text{Renters Latent Demand}_{\,Dec/98,i} \\ &+ \theta_2 \times \text{Renters Mortgaged-out}_{\,Dec/98,i} + \Delta \times X_i + \text{State-Fixed-Effects} + \varepsilon_i\end{aligned}$$

Notes: The regression model is estimated for each sub-sample of income quintiles. The income quintiles are computed within a metropolitan area. The average household income is $45,774 in the lowest quintile (Inc Q1), $57,721 in the second quintile (Inc Q2), $67,790 in the third quintile (Inc Q3), $80,169 in the fourth quintile (Inc Q4), and $102,347 in the highest quintile (Inc Q5). Renters latent demand and renters mortgaged-out in December 1998 is computed as described in the section 2.2. Intuitively, renter latent demand measures the potential demand shock in a neighborhood given the change in interest rates from July 2000 to December 2001, but in this case it is constructed assuming the price level in December 1998. Renters mortgaged-out measures the fraction of renter households whose income is too low to be able to afford mortgage payments in a given neighborhood. Neighborhood is defined by the house price terciles for a zip code, as defined by Zillow. House Price is the price index from Zillow at the neighborhood level. HP Growth measures the house price growth using the Zillow house price index. IRS Income Growth is computed using the IRS income at the zip code level. Neigh Inc (Homeowners) is the income at the neighborhood-level from the deciannial census 2000. Denial Rate change is the change in denial rates for mortgage applications for home purchase from 2000 to 2001 from HMDA. Standard errors are heteroskedastically robust, and are clustered at the metropolitan level. t-statistics are in parentheses. Statistic significance: ***=1%; **=5%; and *=10%.

	House Price Growth form Dec-1998 to Dec-1999				
	(1) Inc Q1	(2) Inc Q2	(3) Inc Q3	(4) Inc Q4	(5) Inc Q5
Renters Latent Demand $_{Dec/98}$	3.499***	1.796*	1.021	-0.094	-0.017
	(2.64)	(1.67)	(1.65)	(-0.22)	(-0.17)
Renters Mortgaged-out $_{Dec/98}$	0.203**	0.026	-0.116	-0.129	-0.139**
	(2.01)	(0.21)	(-1.23)	(-1.30)	(-2.45)
House Price $_{Dec/98}$	0.007	0.007	0.022*	0.017	0.015*
	(0.67)	(0.59)	(1.76)	(1.35)	(1.72)
HP Growth $_{Dec/96 \to Dec/98}$	0.015	-0.006	-0.013	0.003	0.055*
	(0.53)	(-0.23)	(-0.56)	(0.10)	(1.95)
Neigh. Inc. (Homeowners) $_{2000}$	0.001***	0.001***	0.001***	0.001***	0.000***
	(4.00)	(4.65)	(4.12)	(4.80)	(3.94)
Elasticity Saiz $_{2000}$	-0.009***	-0.006*	-0.008**	-0.011***	-0.008**
	(-2.87)	(-1.81)	(-2.49)	(-3.26)	(-2.54)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Zip Controls	Yes	Yes	Yes	Yes	Yes
MSA Controls	Yes	Yes	Yes	Yes	Yes
#Zip codes	3107	3070	3028	3109	3099
R-squared	0.384	0.426	0.453	0.448	0.497