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The Pricing-Out Phenomenon in the U.S. Housing Market

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The Pricing-Out Phenomenon in the U.S. Housing Market

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ABSTRACT: The COVID-19 pandemic further extended the multi-year housing boom in advanced economies and emerging markets alike against massive monetary easing during the pandemic. In this paper, we analyze the *pricing-out* phenomenon in the U.S. residential housing market due to higher house prices associated with monetary easing. We first set up a stylized general equilibrium model and show that although monetary easing decreases the mortgage payment burden, it would raise house prices, lower housing affordability for first-time homebuyers, and increase housing wealth inequality between first-time and repeat homebuyers. We then use the U.S. household-level data to quantify the effect of the house price change on housing affordability relative to that of the interest rate change. We find evidence of the pricing-out effect for all homebuyers; moreover, we find that the pricing-out effect is stronger for first-time homebuyers than for repeat homebuyers. The paper highlights the importance of accounting for general equilibrium effects and distributional implications of monetary policy while assessing housing affordability. It also calls for complementing monetary easing with well-targeted policy measures that can boost housing affordability, particularly for first-time and lower-income households. Such measures are also needed during aggressive monetary tightening, given that the fall in house prices may be insufficient or too slow to fully offset the immediate adverse impact of higher rates on housing affordability.

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I. INTRODUCTION

Conventional wisdom holds that monetary easing, via lowering the mortgage rate, would benefit first-time homebuyers and all homebuyers in general.[2] But the recent housing boom, which started before the COVID pandemic and gained pace after the massive monetary stimulus during the pandemic, casts doubt about the actual benefits for first-time homebuyers of monetary easing, as many such buyers have been priced out by soaring house prices.

In this paper, we analyze the extent of the *pricing-out* phenomenon in the U.S. residential housing market due to higher house prices, both theoretically and empirically. We find that higher house prices associated with monetary easing disproportionally decrease housing affordability for lower-income households, despite lower financing costs. We set up a stylized general equilibrium model and show that despite the lower mortgage payment burden, monetary easing would raise house prices, lower housing affordability for first-time homebuyers, and increase housing wealth inequality between first-time and repeat homebuyers. Empirically, using U.S. household-level data, we show that: (1) for a house of a given quality (including the house size, convenience of transportation, etc.), the buyer has a higher income in periods when house prices are higher, suggesting that lower-income buyers have been priced-out; (2) the pricing-out effect is stronger for first-time homebuyers than for repeat homebuyers, in line with our theoretical predictions; and (3) the higher home affordability for all homebuyers associated with a one-percentage-point decrease in mortgage rate would be fully offset if house prices increase by about *10 percent*.

Our first contribution is to provide a *general-equilibrium* perspective for thinking about the existing accounting-based framework of assessing the impact of monetary policy on housing affordability, particularly on home *ownership* affordability. The existing, widely-used framework measures the home ownership affordability as how much the median housing prices on the market are above or below levels consistent with spending a reasonable share (e.g., 30 percent) of median household income on costs of owning a house, such as mortgage payments, insurance costs, and taxes.[3] Despite the clear advantages of being simple, transparent, and feasible to many

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[2] Similarly, in the current context of global monetary tightening, numerous newspaper articles and opinion pieces hold the view that monetary tightening would (always) worsen housing affordability. Examples include: "The Fed's Interest Rate Hikes Just Made the Dream of Owning A Home Even More Out of Reach," *Fortune*, September 21, 2022; "Mortgage Rates at 15-Year High Bring Fresh Pain for Homebuyers," *Bloomberg*, September 29, 2022; and "Monetary Policy and Housing Markets: Interactions and Side Effects," June 25, 2021, Ernest Gnan, *OECD ECOSCOPE*.

[3] One example is the Home Ownership Affordability Monitor developed by the Federal Reserve Bank of Atlanta (link). Another example is the study by Biljanovska, Fu, and Igan (Forthcoming), which builds a new cross-country housing affordability database using the accounting-based framework.

countries and regions, this framework is intrinsically backward-looking and takes a partial equilibrium perspective. For example, immediately after massive monetary easing, this framework would typically suggest a substantial improvement in homeownership affordability due to the significant decrease in mortgage rates, without accounting for subsequent increases in housing prices. Our paper highlights the importance of accounting for such general equilibrium effects that could reverse the improvement in housing affordability following monetary easing.

Our second contribution is to highlight the unintended *distributional* effects of monetary policy and the importance of implementing complementary policy measures. We find that after accounting for general equilibrium effects, monetary easing is associated with a trade-off: On the one hand, monetary easing directly reduces mortgage payments and enhances housing affordability, as in the current framework; on the other hand, it raises the housing price, prices out potential homebuyers and lowers housing affordability. This pricing-out effect is stronger for first-time homebuyers than existing homeowners who can benefit from the higher housing price thanks to the appreciation of their previous property, thus increasing housing wealth inequality and, ultimately, inequality in overall wealth between first-time homebuyers and repeat homebuyers.

Our third contribution is to empirically estimate the *magnitude* of the effect of the house price change on housing affordability relative to that of the interest rate change, hence providing a benchmark for assessing the *net* effect on housing affordability. We find that the higher (lower) home affordability for all homebuyers associated with a one-percentage-point decrease (increase) in mortgage rate would be fully offset if house prices increase (decrease) by about 10 percent (due to the monetary policy shock or other factors). This result can shed light on not only the magnitude of the pricing-out effect during monetary easing, but also the net effect on housing affordability during monetary tightening, that is: If house prices decrease by less than 10 percent following a one-percentage-point increase in mortgage rate (in the context of the ongoing monetary tightening), then our result implies that housing affordability for all homebuyers will still deteriorate on a net basis.

Before laying out the policy implications, it is worth noting that the causal effect of monetary policy shocks on house prices has been well documented in the literature. For example, Jarocinski and Smets (2008) find evidence that exogenous monetary policy easing in 2002-04 has contributed to the U.S. housing boom in 2004 and 2005. In addition, using an extensive dataset during 1870-2013 in selected countries with fixed exchange rate regimes (where monetary policy actions are arguably exogenous to domestic economic conditions), Jorda, Schularick, and Taylor (2015) and Williams (2016) find that monetary policy has significant and

persistent effects on real house prices.[4] Hence, even if the recent round of monetary easing coincided with the emergence of a pandemic-induced preference shift from renting to owning houses, it has still contributed independently to raising house prices during the pandemic based on this literature. As such, it is crucial to complement monetary easing with well-targeted policy measures that can mitigate the impact on first-time homebuyers, as well as measures that can boost housing affordability, particularly for lower-income households. Such measures are also needed during a period of aggressive monetary *tightening* because substantial house price decreases (which may not happen based on the literature and due to other forces supporting house price increases) are needed to fully offset the adverse effect of aggressive monetary tightening on housing affordability.[5] Moreover, the monetary tightening poses an immediate threat to housing affordability despite possibly decreasing house prices over time. Indeed, literature and post-COVID experience seem to suggest that the impact of monetary policy shocks on house prices can be gradual and long-lasting, with the cumulative impact peaking after about two years. Hence, in the very short run, the pricing-out effect may be weaker than the interest payment effect, and thus monetary tightening can deteriorate housing affordability, calling for temporary and targeted measures that can help boost affordability in the short run.

To further motivate our study, we present two stylized facts in the U.S. housing market.

Stylized Fact #1: The median income of first-time homebuyers, relative to that of all homebuyers, has been significantly higher since 2020Q2.

As shown in Figure 1, the seasonally adjusted median income of the U.S. first-time homebuyers, normalized by that of all homebuyers,[6] increased sharply since 2020Q2, which is one quarter after the start of the COVID pandemic (the vertical line). This suggests that since the pandemic, either the income requirement for first-time homebuyers became higher, or only richer first-time homebuyers found it optimal to buy houses. Note that the normalized median income of first-time homebuyers also registered a sharp increase from 2006Q4 to 2009Q1. However, this increase appears to be mainly driven by the tightened lending standards in the aftermath of the

[4] More details are available in the literature review section.

[5] To put this into context, the average 30-year fixed mortgage rate in the U.S. increased by about 4.0 percentage points in the recent tightening cycle, from 3.1 percent in end-2021 to the 7.1 percent on November 10, 2022 (source: FRED). Accordingly, our estimates imply that house prices need to fall by 40 percent to offset the adverse impact of the higher rates on affordability. Such a big fall is unlikely, given the structural changes that have occurred during the pandemic, such as preference shifts due to working-from-home practices. Therefore, deteriorating housing affordability is still an issue in the current context.

[6] This is to eliminate the impact of changes in the nominal income in general. The pattern still holds without the normalization.

Global Financial Crisis (GFC) rather than the rising house prices (which started declining in 2006Q3). By contrast, the increase in the median income of first-time homebuyers since 2020Q2 appears to be mainly driven by soaring house prices, as the lending standards for first-time homebuyers remained broadly unchanged since then (Figure 2).

Stylized fact #2: After adjusting for secular trends, the fraction of mortgage loans to first-time homebuyers declined during the pandemic; moreover, it was positively correlated with mortgage rates both before and after the pandemic.

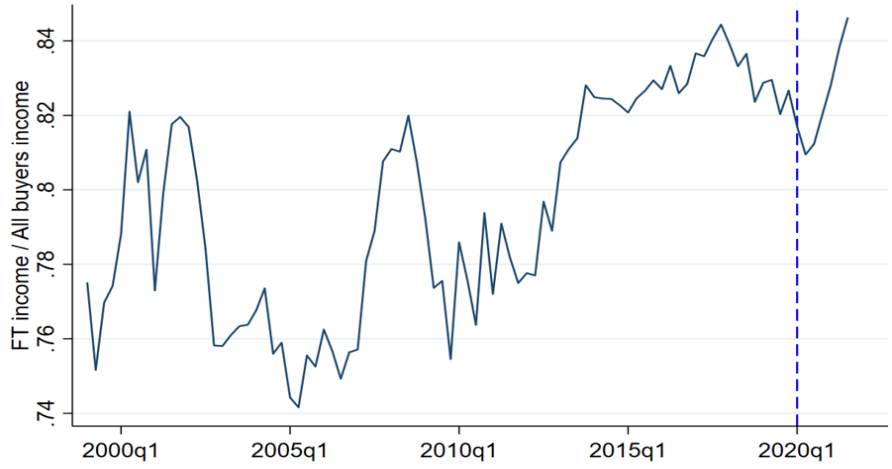
To understand the prevalence of first-time homebuyers in the U.S. housing market, we plot the fraction of first-time homebuyer mortgage loans among all types of home purchase loans (i.e., also including home purchase loans offered to repeat homebuyers), as well as the mortgage rates. To better understand the cyclical patterns and the response to shocks, we remove trends in both variables.[7] As shown in Figure 3, this fraction dropped significantly during the pandemic, which coincided with the massive COVID-era monetary easing. Furthermore, even before the pandemic, periods of high mortgage rates are associated with a high proportion of first-time homebuyers. This pattern appears counterintuitive at first glance, as the conventional wisdom suggests that lower mortgage rates would benefit first-time homebuyers and thus make mortgage loans to such buyers more prevalent. However, it is consistent with the existence of the general equilibrium effect highlighted earlier: The lower (higher) mortgage rates have also raised (lowered) house prices and thus may have lowered (raised) home affordability to first-time homebuyers. We will discuss this "pricing-out effect" in detail in subsequent sections.

The rest of the paper is structured as follows. Section II reviews related literature; Section III presents a stylized model to illustrate the main propositions; Section IV formally proposes the hypotheses and conducts empirical tests; Section V concludes and discusses potential policy implications. The appendices collect some technical details.

[7] Specifically, the fraction of mortgage loans to first-time homebuyers displays an increasing secular trend. This could be driven by some long-term structural changes, such as a possible decline in regional mobility of workers (as workers become less mobile, they tend to buy and stay in the same house rather than sell and buy a new house as repeat homebuyers). Even if we present Figure 3 as a stylized fact rather than a rigorous econometric analysis, we still want to rule out the impact of such factors to focus on the impact of monetary policy shocks. Relatedly, Freddie Mac (May 2022) finds that first-time homebuyers are the major driver of the increase in housing demand since the pandemic; however, this is in terms of the total number of first-time buyers rather than in proportion to repeat buyers.

Figure 1. Median First-time Homebuyer Income Relative to Median Income of All Buyers

(1999Q1-2022Q1; Seasonally Adjusted)

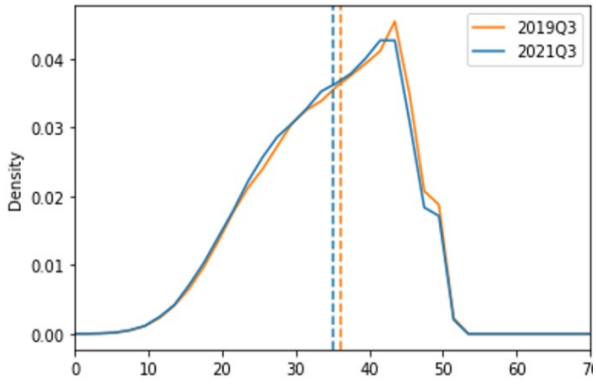


Note: In each quarter, we compute the ratio of the median income of all first-time homebuyers to the median income of all homebuyers. Data are seasonally adjusted using a Locally Estimated Scatterplot Smoothing method.

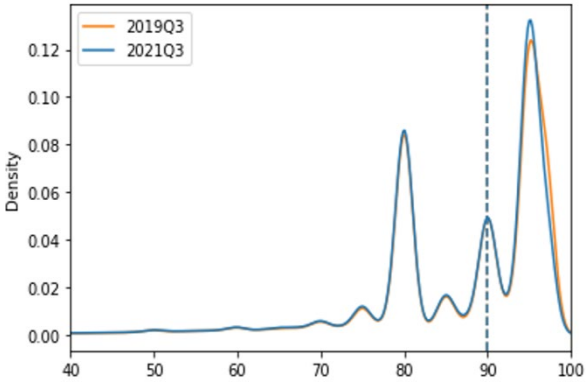
Sources: Freddie Mac; Authors' calculations.

Figure 2. Distributions of Lending Standards at Origination during the Pandemic

Debt-to-Income Ratio (DTI)



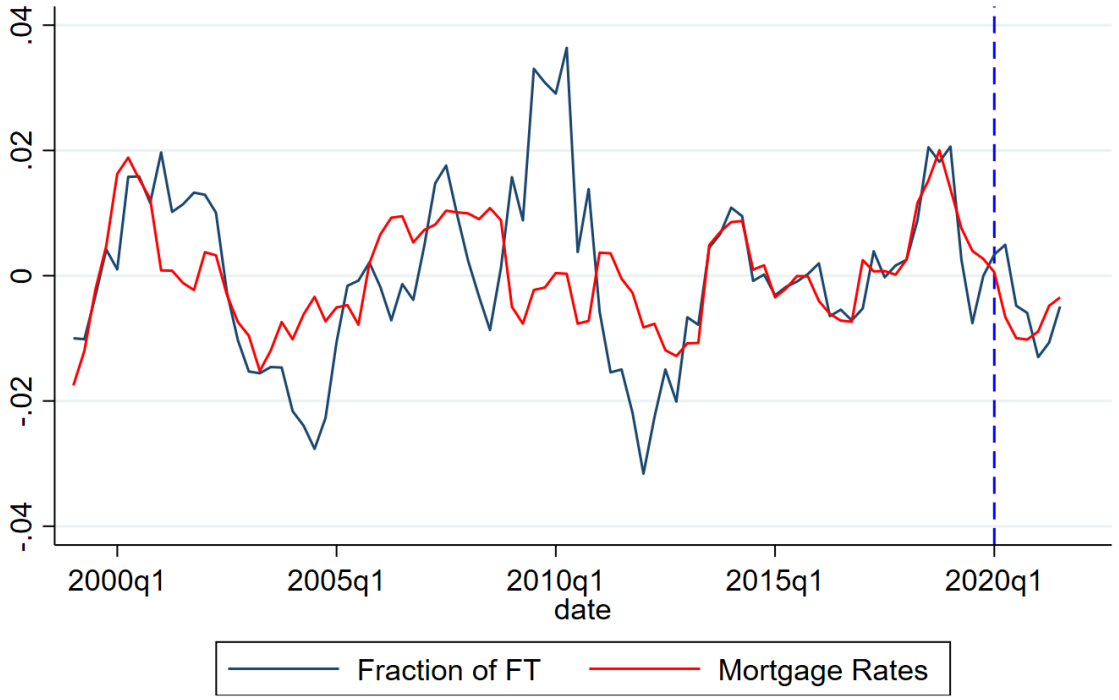
Loan-to-Value Ratio (LTV)



Sources: Freddie Mac; Authors' calculations.

Figure 3. Fraction of First-time Homebuyers and Mortgage Rate

(1999Q1-2022Q1; HP-filtered)



Note: Fraction of first-time homebuyers among all homebuyers (in blue) and median mortgage rate for all mortgages originated in each quarter (red). Both series are seasonally adjusted and HP-filtered; only the cyclical component is displayed.

Sources: Freddie Mac; Authors' calculations.

II. LITERATURE REVIEW

Our paper is related to three strands of literature. First, it is related to the literature on the effect of monetary policy on house prices. Applying an identified Bayesian VAR model to the U.S. data during 1987Q1-2007Q2, Jarocinski and Smets (2008) find evidence that exogenous monetary policy shocks have significant effects on house prices, and that easy monetary policy in 2002-04 has contributed to the U.S. housing boom in 2004 and 2005 (1 percentage point decrease in the short-term interest rate led to a 7.8 percentage point increase in the real house price after two years). Using an extensive dataset during 1870-2013[8] in 17 countries with fixed exchange rate regimes (where monetary policy actions are arguably exogenous to domestic economic conditions), Jorda, Schularick, and Taylor (2015) and Williams (2016) find that

[8] Except for the interwar period of 1914-45 and the oil crisis years of 1973-80.

monetary policy has significant and persistent effects on real house prices: Two years after a 1 percentage point increase in the short-term interest rate, real house prices would decline by over 6 percent. And after an extensive literature review, in his keynote speech at a BIS conference, Williams (2016) concludes that "monetary policy actions have sizeable and significant effects on house prices in advanced economies," a result that is robust after accounting for structural changes and stages of the housing cycle (i.e., booms and busts).[9] Using quarterly data from 1998 to 2022, Cevik and Naik (2022) find that short-term and long-term interest rates are negatively correlated with real house price growth in Emerging Europe, although the authors do not focus on establishing causal relationships.

Accounting for responses on the housing supply side, Aastveit and Anundsen (2022) find that in MSAs with an elastic housing supply, contractionary monetary policy shocks have a more significant impact on house prices than expansionary shocks: Following monetary easing and thus a higher housing demand, real estate developers can build more houses, which would mitigate the increase in house prices; however, following monetary tightening and hence a lower housing demand, the housing supply does not decrease much (because real estate developers do not usually destroy existing houses), which would amplify the decrease in house prices. This result highlights the importance of accounting for the impact of monetary policy on house prices while assessing housing affordability (particularly during monetary tightening), and thus it reinforces the main proposition of our paper.

Focusing on the U.S. housing market in the COVID era, Zhao (2020) finds suggestive evidence for the hypothesis that the *nationwide* monetary easing played a crucial role in driving up the *nationwide* housing price (possibly more so than the structural shift in households' housing preferences), as the paper finds that the housing price increases in the U.S. during the COVID era were remarkably similar across metropolitan, micropolitan, small-town, and rural areas.[10] Using a panel data set of five advanced economies (including the U.S.) from 2017Q1 to 2021Q1, Yiu (2021) finds that a 1 percent fall in the real interest rate "caused" a 1.5 percent increase in

[9] The literature cited by Williams (2016) also covers studies on the U.S., including: Fratantoni and Schuh (2003), Otrok and Terrones (2005), Del Negro and Otrok (2007), and Ungerer (2015). Besides these, some other studies on this topic include Iacoviello and Neri (2010), Gelain, Lansing, and Natvik (2018), etc. For example, using quarterly data over 1965Q1–2006Q4 in the U.S., Iacoviello and Neri (2010) find that housing demand and housing technology shocks each explain 25 percent of the volatility of housing investment and housing prices; monetary factors explain less than 20 percent but have played a *bigger* role in the housing cycle at the turn of the 21st century.

[10] If the housing price increase were mainly driven by urban households buying houses in suburban areas (due to aversion to the pandemic or the need for more housing space associated with the more common working-from-home practice), then we would observe a lower increase in urban areas' housing prices than in suburban areas.

house prices in this period after controlling for economic growth factors, unemployment factors, and cross-country fixed effects. And applying a structural VAR model to some Asia-Pacific advanced economies (with data covering the post-pandemic period), Deb et al. (2022) find that low mortgage rates associated with accommodative conventional and unconventional monetary policy measures played an important role in boosting housing prices during the pandemic.

The second strand of literature related to our paper is that on housing affordability. In both developing and developed countries, housing unaffordability is found to be directly linked to inequality in homeownership, potentially leading to socioeconomic inequality (see, e.g., Aizawa et al., 2020).[11] At the aggregate level, housing unaffordability could lead to significant and long-term macroeconomic costs, including downward pressure on fertility and metropolitan-wide congestion (Galster and Lee, 2021). Housing unaffordability could also dampen the competitive structure and growth of a metropolitan area by deterring the mobility of households and firms, and this labor misallocation can lower national-level economic growth (Hsieh and Moretti, 2019; Bryan and Morten, 2019; and Seitz, 2021). Note that the definition of housing affordability involves not only the cost of owning a house, but also that of renting a house. Indeed, as Liu, Yang, and Zhao (2022) show, higher rents tend to follow higher house sales prices in the U.S. and some other major economies.

Regarding the effect of monetary policy on housing affordability, academic literature has been sparse. Deb et al. (2022) use an accounting-based approach (similar to that by the Federal Reserve Bank at Atlanta) and find that rising interest rates would deteriorate housing affordability in the Asia Pacific region. Specifically, Deb et al. (2022) estimate that following the interest rate increase, housing prices in 2022 "may be as much as 70 and 50 percent above what a median household can afford in New Zealand and Australia, respectively." However, this estimate uses the median housing price in June 2022 and may not capture the declining trends of housing prices recently or trends in the coming years.[12] Our paper builds on Deb et al. (2022) and analyzes the effect of monetary policy on housing affordability theoretically and empirically, incorporating both the partial equilibrium effect on mortgage payments and the general equilibrium effect on housing prices. Our paper also extends Andrle and Plasil (2019)'s accounting-based borrowing-capacity and the net-present-value approaches by considering the

[11] An extensive literature suggests that children of households with housing affordability problems are more likely to suffer from adverse outcomes on health, education and employment. Examples include Newman and Holupka (2014, 2015), and Andersson et al. (2016).

[12] According to data from TradingEconomics.com (link), New Zealand's housing price index started declining in July 2022. And according to CoreLogic (link), in August 2022, Australia's housing price index recorded the largest month-on-month decline since 1983. However, the magnitudes of cumulative house price declines experienced so far may still be insufficient to fully offset the effect of higher mortgage rates on housing affordability.

housing market clearing condition (making it an explicit equilibrium set-up), as well as both first-time and repeat homebuyers (allowing for examining distributional implications).

The third strand of literature related to our paper is the literature on the distributional effects of monetary policy, particularly its effects on wealth inequality. Conceptually, monetary easing can push up prices of equities, bonds, and houses, likely benefiting wealthy households the most and thus increasing wealth inequality. However, after accounting for the role of agent heterogeneity in shaping macroeconomic dynamics highlighted in recent theoretical work (such as the Heterogeneous Agent New Keynesian framework by Kaplan, Moll, and Violante, 2018), Bonifacio et al. (2021) set up a conceptual framework and find that the heterogeneity of the composition of assets and liabilities in households' balance sheets play a crucial role in the direction and magnitude of the distributional effect of monetary policy. As a result, the effect of monetary policy on wealth inequality is ambiguous, and the determination of this effect remains an open empirical question.

Relatedly, empirical/simulation results in the literature appear mixed. On the one hand, using Danish household-level data, Andersen et al. (2020) find that the benefit to wealthy households from the monetary easing-induced asset price increases is much higher than the benefit to poorer households from wage income gains, thus raising inequality. And using simulations based on *general equilibrium macroeconomic* models, Doepke and Schneider (2006) (on the U.S.), Meh, Rios-Rull, and Terajima (2010) (on Canada), and Casiraghi et al. (2018) (on Italy) find that wealth inequality *increases* in the *short* term, although this effect disappears in the medium term. On the other hand, using simulations based on *partial equilibrium* models with *micro*-level household exposure data, Lenza and Slacalek (2018 and 2022) (on four European countries) find a negligible effect of expansionary monetary policy on wealth inequality; Adam and Tzamourani (2016) (on the Euro Area) find a negligible impact of asset purchases on wealth inequality; Adam and Zhu (2016) find that an expansionary policy reduces wealth inequality in most of the Euro Area but increases it in Austria, Germany, and Malta; and Bonifacio et al. (2021) find that higher house prices induced by monetary easing favor mostly the bottom 20 percent of the wealth distribution in the U.S., although the authors note that this result does not account for the adverse impact of higher house prices on young and middle-aged potential homebuyers and thus "should be taken with caution."

III. MODEL

In this section, we propose a model of the housing market with competition between first-time and repeat buyers. The model is purposedly stylized, as it does not aim to capture the entire complexity of the housing market dynamics, but only the fundamental forces shaping housing affordability under different market conditions and how these affect first-time and repeat buyers differently. The model features a central bank setting exogenously the interest rate, which

determines how costly mortgage payments are. After observing the mortgage rate, the two groups of households, first-time and repeat homebuyers, compete in the housing market to purchase a fixed stock of houses. House prices are determined endogenously to balance the total demand for housing (by the two groups) with the fixed supply of housing. Since mortgage rates affect the demand for housing, house prices will ultimately depend on the interest rate set by the central bank. For simplicity, we assume the mortgage rate equals the policy rate set by the central bank, effectively assuming that the risk premium of mortgages is constant at zero. Assuming a non-zero risk premium does not qualitatively change our results. The aggregate stock of housing (more precisely, stock of "housing quality" under our definition) is fixed; that is, we abstract from housing construction and deprecation so that the aggregate stock remains constant over time.

We can characterize three propositions by studying the partial equilibrium responses of households to market conditions. They will show that, when the other variable is kept fixed, housing affordability is hampered both by rising interest rates and by higher house prices, especially for first-time homebuyers.

By solving the model, we can find the equilibria under a high-interest-rate scenario and a low-interest-rate scenario. This comparative static exercise shows that lower rates lead to increased housing demand by both first-time and repeat buyers; thus, house prices must rise to clear the market. As house prices rise, first-time buyers are particularly affected and end up with deteriorated housing affordability (defined as a higher borrower income associated with the purchase of houses of a given quality in the model). In contrast, housing affordability improves for repeat buyers (i.e., their incomes associated with the purchase of houses of a given quality decrease), thanks to the lower rates and the capital gain from selling their previous houses.

A. Setup and Partial Equilibrium

The model is static and captures a snapshot of the housing market in one period. A continuum of first-time homebuyers of measure α is endowed with income $y \sim U\left(y_M - \frac{1}{2}, y_M + \frac{1}{2}\right)$, where y_M is the average income across first-time homebuyers. These households plan to use their income, plus any amount borrowed, to consume nondurable goods and to purchase a house of a quality h^{FT}. There is a continuum of repeat homebuyers of measure $1 - \alpha$, whose distribution of income endowment is identical to that of first-time homebuyers. However, each of the repeat homebuyers already owns a quantity of housing h_0, which for simplicity is assumed to be constant for all repeat homebuyers. Repeat homebuyers are simultaneously selling their current house and purchasing a new one.

Note that the problem of a household with an idiosyncratic income y can be written without specifying whether that household is a first-time or a repeat homebuyer, as the problem of a first-

time buyer is a special case with $h_0 = 0$. Thus, we can write the problem of a generic household as follows:

$$log\ (c) + \psi log\ (h)$$

$$s.t.\ c + (ph - b) + g(r)b = y + ph_0,$$
$$b = LTVph$$

In the objective function, c is non-durable consumption; h is the amount of housing consumption, which can be interpreted as representing a composite "house quality bundle" consisting of the size of the house, quality of amenities, convenience of the location, quality of schools in the neighborhood, etc.; and ψ governs the relative taste for housing.

The first constraint is the household's budget constraint, which equates the household's total expenditures, equal to the sum of consumption $c,$ down payment $ph - b$, and mortgage payments $g(r)b$, to its total resources, equal to the sum of its income y and the proceeds obtained from selling the previous house ph_0, if any. To reflect a common feature in the U.S. mortgage market, we assume that the mortgage is a 30-year fixed-rate mortgage with an annual interest rate of r. And the function $g(r)$ is the payment per dollar of the mortgage loan; it can be shown[13] that $g(r) = \frac{r}{1-(1+r)^{-30}}$, which is strictly increasing in r.

The second constraint is a loan-to-value (LTV) constraint, which equates the borrowed amount b to a fraction LTV of the value of the purchased house ph. To maintain analytical tractability, we assume a binding LTV constraint for both first-time and repeat homebuyers. This assumption is not an irrelevant detail because for our proposed theory to work well, both first-time and repeat buyers have to benefit from lower rates in terms of reduced mortgage payments. If repeat buyers were to buy houses with cash only, then they would not expand their demand in response to lower rates, likely affecting our main results. In the Freddie Mac data we use, over the period of 1999Q1-2022Q1, we observe an average LTV of 84 percent for first-time buyers and 76 percent for repeat buyers, making our simplifying assumption of equal leverage (set to 80 percent in the quantitative exercise) a reasonable approximation of the data.

In addition, although we abstract the debt-to-income (DTI) constraint from the model, considering this constraint does not change the existence of the trade-off highlighted in the model. That is, a lower interest rate will relax the DTI constraint, but it will also increase the

[13] Specifically, the total present value of all future mortgage payments must be equal to the loan size, which is \$1 due to the definition of $g(r)$. That is, $\frac{g(r)}{1+r} + \frac{g(r)}{(1+r)^2} + \cdots + \frac{g(r)}{(1+r)^{30}} = 1$. Therefore, we have $\frac{g(r)}{1+r}\left[\frac{1-\frac{1}{(1+r)^{30}}}{1-\frac{1}{1+r}}\right] = 1$, from which we can solve for $g(r)$.

housing price and thus tighten this constraint.

Given the market prices (r, p), we can solve for the housing demand by first-time and repeat homebuyers. Note that their housing demand also depends on their idiosyncratic income y.

Specifically, the housing demand of a first-time homebuyer is given by:

$$h^{FT}(y; r, p) = \frac{\tilde{\psi}}{g(r)LTV + (1 - LTV)} \frac{1}{p} y \equiv \frac{\tilde{\psi}}{f(r)} \frac{1}{p} y \qquad (1)$$

And the housing demand of a repeat buyer is given by:

$$h^{R}(y; r, p) = \frac{\tilde{\psi}}{g(r)LTV + (1 - LTV)} \frac{1}{p} (y + ph_0) \equiv \frac{\tilde{\psi}}{f(r)} \frac{1}{p} (y + ph_0) \qquad (2)$$

Where $\tilde{\psi} = \frac{\psi}{1+\psi}$ captures the taste for housing relative to non-housing consumption; and $f(r)p \equiv [g(r)LTV + (1 - LTV)]p$ is the household's actual payment for each unit of the house that is purchased: one unit of the house costs $\$p$; a $(1 - LTV)$ fraction of this is paid out of pocket as a down payment, and an *LTV* fraction of this is paid by taking a mortgage loan of size $LTVp$ and making a payment of $g(r)LTVp$ during the current year. Note that although our static model accounts for the mortgage *payment* during the current year only, the household's objective function also accounts for the *utility* derived from the purchased house during the current year only, making our static model internally consistent. Extending the model to a fully dynamic setting is an interesting exercise that we leave for future research.

It is clear from equations (1) and (2) that housing demand depends on the market conditions (r, p) and on the taste for housing ψ relative to non-housing: the housing demand of each type of the homebuyers strictly decreases in the housing price p and the interest rate r, and strictly increases in the taste for housing ψ. Propositions 1 and 2 formally establish how changes in interest rates r and house prices p affect the demand for housing of both types, in a partial equilibrium sense.

To derive more intuition about the difference between first-time homebuyers and repeat homebuyers, we can rewrite equations (1) and (2) as:

$$\frac{h^{FT}(y; r, p)pf(r)}{y} = \tilde{\psi}$$

$$\frac{h^{R}(y; r, p)pf(r)}{y + ph_0} = \tilde{\psi}$$

Hence, in equilibrium, both types of households choose to spend a constant fraction $\tilde{\psi}$ of their resources on housing. Recall that the key difference between the two types of homebuyers is the amount of total resources available to them: first-time buyers rely only on their incomes (plus any borrowed resources) to purchase their first house. But repeat buyers can also use the

proceeds of the sale of their previous houses ph_0. As house prices increase, although repeat buyers find new houses less affordable to buy, they also see their resources increasing from sales of their existing houses, in part protecting their purchasing power. Since the housing expenditure by each type of homebuyers is proportional to its total resources, the higher resources available to repeat homebuyers will enable them to purchase a larger amount of the house after a house price increase, hence mitigating the elasticity of repeat homebuyers' housing demand to house price. We will formalize this intuition in Proposition 3.

To establish a more direct link with the subsequent empirical section, we now present an alternative way to express the equilibrium conditions. To this end, we invert the housing demand function $h(y; r, p)$ for a given income *y* and obtain instead the income function $y(h; r, p)$ for a given house quality *h*. This new function, which we will refer to as "housing affordability function," is the income of the household who chooses to buy a house of a given quality h under the market conditions (r, p).

It can be shown that:

$$y^{FT}(h; r, p) = p\frac{1}{\bar{\psi}}f(r)h,$$

And

$$y^{R}(h; r, p) = p\left[\frac{1}{\bar{\psi}}f(r)h - h_0\right]$$

We now analyze three propositions that will highlight how housing affordability is affected by market conditions.

Proposition 1(Partial Equilibrium Effects of Monetary Policy): *For a fixed level of house price* p *, if the interest rate* r *decreases, the income of households associated with the purchase of houses of a given quality* h *decreases for both first-time and repeat buyers. That is:*

$$\frac{\partial y(h; r, p)}{\partial r} > 0$$

Proposition 1 immediately follows by differentiating the $y(h; r, p)$ function and is intuitive. A lower monetary policy rate and mortgage rate imply a lower mortgage payment, all else being equal. However, it only highlights the direct, partial equilibrium effect of the interest rate on housing demand, keeping the house price fixed. To understand the full impact on housing affordability resulting from a monetary policy shock, which is likely to also affect house prices, we need to study how housing price affects housing demand. Proposition 2 below describes how housing affordability is affected by changes in house prices while keeping the monetary policy stance (and the mortgage rate) unchanged.

Proposition 2: *For a fixed level of interest rate* r*, if the house price* p *increases, the income of households associated with the purchase of houses of a given quality* h *increases for both first-*

time and repeat buyers. That is:

$$\frac{\partial \mathrm{y}(h;r,p)}{\partial p} > 0$$

And Proposition 3 below describes the relative effect of house prices on the housing affordability of the two groups, under a given monetary policy stance.

Proposition 3: *For a fixed level of the interest rate r, an increase in house prices raises the income associated with the purchase of houses of a given quality h more strongly for first-time homebuyers than for repeat homebuyers. That is:*

$$\frac{\partial y^{FT}(h;r,p)}{\partial p} > \frac{\partial y^{R}(h;r,p)}{\partial p}$$

We can get more intuition by examining the expressions for the two derivatives in the proposition. The increase in the income for first-time buyers is: $\frac{\partial y^{FT}(h;r,p)}{\partial p} = \frac{1}{\tilde{\psi}} f(r)h$, while that for repeat buyers is $\frac{\partial y^{R}(h;r,p)}{\partial p} = \frac{1}{\tilde{\psi}} f(r)h - \mathrm{h}_0$. Intuitively, when house prices soar, the income of repeat buyers does not have to rise as much to be able to afford the same house because they can partly count on the appreciation of their previous house.

Now that we have clarified the partial equilibrium responses of housing affordability to market conditions, we move to endogenize the house price in a general equilibrium framework.

B. General Equilibrium

So far, we have only discussed the partial equilibrium relationships between market conditions and housing affordability. In this section, we solve for the general equilibrium house price. We keep the assumption that the interest rate is set exogenously by the central bank and solve for the house price $p(r)$ that equates the housing demand to supply.

Notice that the market demand for housing can be obtained by integrating household-specific housing demands. Because households are only heterogeneous in their incomes y and housing demands of both groups are linear in y, we can obtain the market/aggregate housing demand as follows:

$$H^D(r,p) = \alpha \int_{\underline{y}-\frac{1}{2}}^{\underline{y}+\frac{1}{2}} \frac{\tilde{\psi}}{f(r)} \frac{1}{p} y \, dy + (1-\alpha) \int_{\underline{y}-\frac{1}{2}}^{\underline{y}+\frac{1}{2}} \frac{\tilde{\psi}}{f(r)} \frac{1}{p} (y + ph_0) \, dy = \frac{\tilde{\psi}}{f(r)} \frac{1}{p} (y + \alpha p h_0)$$

By equating the housing demand $H^D(r,p)$ to the fixed housing supply H^S, we can solve for the equilibrium housing price $p(r)$ for any level of the interest rate set by the central bank as:

$$p(r) = \frac{\tilde{\psi}}{f(r)H^s - \alpha\tilde{\psi}h_0}.$$

As the central bank moves the interest rate, it will therefore affect house prices, which further

affect housing affordability (in addition to the direct effect of the interest rate on housing affordability). The next section is devoted to studying a monetary easing experiment to understand how these forces interact, and what is the ultimate effect of interest rates on housing affordability in the model.

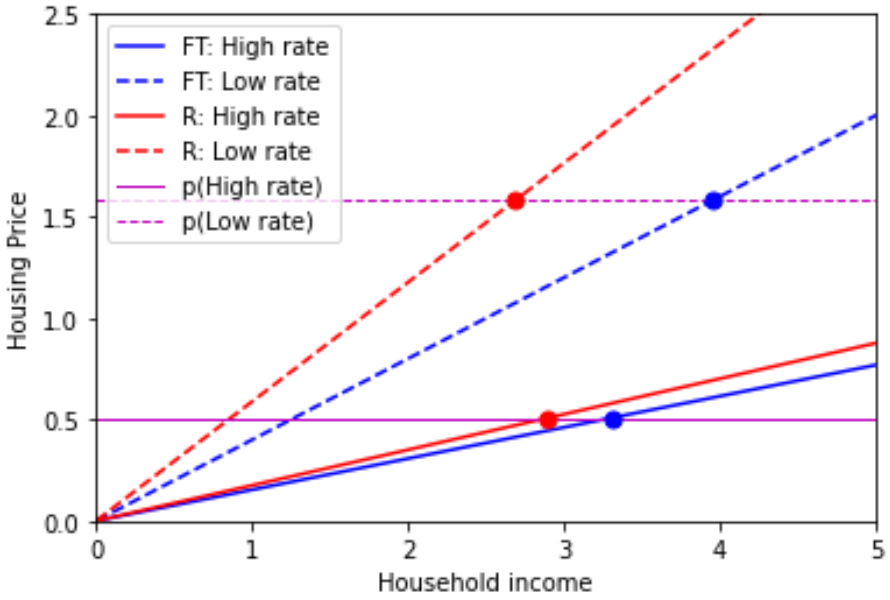
C. Responses to Monetary Policy Shocks

In this section, we study the general equilibrium responses to monetary policy shocks. The formal results on the effect of interest rate policy on housing are presented in Proposition IV. To clarify the mechanisms of the model, we first describe an episode of monetary easing and illustrate how it affects the housing demand by first-time and repeat buyers.

First of all, we solve for the equilibrium corresponding to a high interest rate. In Figure 4, we display multiple "housing affordability curves," $y(h; r^H, p)$, that relate the house price p to the income y of homebuyers who choose to purchase houses of a given house quality h, for first-time and repeat homebuyers, respectively. That is, we fix the house quality and show, for each level of the house price, what is the income of homebuyers that find it optimal to purchase that house. Appendix Figure 1 presents an equivalent housing affordability curve, which relates the house price p to the quality h of house that homebuyers can afford under a given interest rate r and a given income y.

First, let us focus on the two solid lines, which are the housing affordability curves for first-time and repeat homebuyers under the initially high interest rate. As expected, the housing affordability curves are positively sloped for both groups of buyers. This follows directly from Proposition 2 that $\frac{\partial y(h;r,p)}{\partial p} > 0$. As the house price increases, higher-income households will purchase houses of a certain quality. Furthermore, we can notice that the curve for repeat buyers is steeper. Since we have the house price on the y axis, this is a manifestation of Proposition 2: $\frac{\partial y^{FT}(h;r,p)}{\partial p} > \frac{\partial y^{R}(h;r,p)}{\partial p}$. As the house price increases, it is first-time buyers whose incomes have to raise by more to purchase the same type of houses. The purple line is the equilibrium house price under a high interest rate, $p(r^H)$.

Figure 4. Housing Affordability Curves Following Monetary Policy Shocks



Note: Solid lines are the housing affordability curves when the interest rate is high. Dashed lines are the housing affordability curves when the interest rate is low. The blue and red colors denote first-time and repeat homebuyers, respectively. p is the equilibrium housing price.

Source: Authors.

Next, we look at how the $y(h; r^H, p)$ curve shifts when the central bank cuts the interest rates. Now both groups find it cheaper to buy houses. Therefore, both of the two housing affordability curves shift to the left. Lower-income households are able to purchase the "typical house" that has the median quality. This coincides with an increase in the aggregate demand for housing, which can be best seen in the diagram in Figure 4. Under r^L the original house price is no longer an equilibrium because the lower rate has raised the aggregate housing demand, i.e., $H^D\left(r^L, p(r^H)\right) > H^D\left(r^H, p(r^H)\right) = H^S$. Hence, the house price has to increase to clear the market. As the house price increases, we move along the two dashed lines.

By comparing the two blue dots in the figure, we can see that first-time homebuyers will have to increase their incomes to afford the same type of houses under the lower interest rate. And by comparing the two red dots in the figure, we can see that repeat homebuyers will decrease their incomes to afford the same type of houses. That is, housing affordability is increased for repeat buyers but decreased for first-time buyers following the monetary easing, despite the lower mortgage payments for both types of homebuyers. Another clear pattern from the figure is that following the monetary easing, the two affordability curves (for first-time and repeat homebuyers) are diverging, suggesting a higher housing wealth inequality among the two types of homebuyers. The opposite effects would occur following a monetary tightening. The insights

from the above policy experiment (with two levels of interest rates) also apply more generally when interest rates change continuously, as formally established in the following proposition:

Proposition 4 (General Equilibrium Effects of Monetary Policy): *Following a decrease in the interest rate* r*:*

(i) The income of households associated with the purchase of houses of a given quality increases for first-time homebuyers, while it decreases for repeat buyers.

(ii) *The inequality of housing wealth between first-time homebuyers and repeat homebuyers rises.*

(iii) *The opposite effects hold following an increase in the interest rate r. That is, the effects of monetary easing and monetary tightening are symmetric.*

Proof:

(i) Recall that the housing demand functions for first-time and repeat homebuyers are given by: $y^{FT}(h;r,p(r)) = p\frac{1}{\tilde{\psi}}\mathrm{f(r)h} = \frac{1}{f(r)H^s-\alpha\tilde{\psi}h_0}\mathrm{f(r)h}$

Taking the total derivatives for first-time homebuyers' housing demand function, we have:

$$\frac{dy^{FT}(h;r,p(r))}{dr} = \frac{f'(r)h[f(r)H^s-\alpha\tilde{\psi}h_0]-f(r)hf'(h)H^s}{[f(r)H^s-\alpha\tilde{\psi}h_0]^2} = \frac{-\alpha\tilde{\psi}h_0f'(r)\mathrm{h}}{[f(r)H^s-\alpha\tilde{\psi}h_0]^2} < 0$$

For repeat buyers:

$$y^R(h;r,p(r)) = p[\frac{1}{\tilde{\psi}}\mathrm{f(r)h}-h_0] = \frac{\tilde{\psi}}{f(r)H^s-\alpha\tilde{\psi}h_0}[\frac{1}{\tilde{\psi}}\mathrm{f(r)h}-h_0]$$

Therefore:

$$\frac{dy^R(h;r,p(r))}{dr} = \tilde{\psi}\frac{\frac{1}{\tilde{\psi}}f'(r)h[f(r)H^s-\alpha\tilde{\psi}h_0]-[\frac{1}{\tilde{\psi}}\mathrm{f(r)h}-h_0]f'(h)H^s}{[f(r)H^s-\alpha\tilde{\psi}h_0]^2}$$
$$= \psi\frac{h_0f'(r)}{[f(r)H^s-\alpha\tilde{\psi}h_0]^2}[H^s-\alpha\mathrm{h}] > 0, if\ h < \frac{1}{\alpha}H^s$$

Notice that $h < \frac{1}{\alpha}H^s$ is a mild requirement, given that H^s represents the average house quality and that $\frac{1}{\alpha} > 1$. The intuition is that if the target house of the household has a very high value, high value (e.g., with a large size or excellent school quality), then the initial housing appreciation becomes negligible because we are assuming a constant initial housing quality across households. Thus, the behavior of the required income starts to behave more closely to that of a first-time homebuyer.

(ii) The percentage difference in housing wealth between two repeat and first-time buyers of the same income level is:

$$\frac{p(r)h^R(y;r,p(r)) - p(r)h^{FT}(y;r,p(r))}{p(r)h^{FT}(y;r,p(r))} = \frac{h^R(y;r,p(r)) - h^{FT}(y;r,p(r))}{h^{FT}(y;r,p(r))} = p(r)\frac{h_0}{y}$$

which is increasing in house prices and therefore raises with lower rates. Notice that the wedge between the two groups is driven by the initial housing wealth of repeat buyers. Ultimately, housing inequality increases because existing homeowners benefit from the capital gains on their houses.

(iii) All the above derivations work symmetrically, regardless of the directions of the interest rate changes. Q.E.D.

We would like to offer some remarks related to a few factors not emphasized so far:

- Housing supply responses and asymmetric effects of monetary policy. For simplicity, our model assumes a fixed housing supply. As noted in the literature review section, Aastveit and Anundsen (2022) find that following monetary tightening and thus a lower housing demand, the house supply does not decrease much (because real estate developers do not usually destroy existing houses); this would amplify the decrease in house prices and thus mitigate the deterioration in housing affordability by more than what we highlight in Proposition 4 with symmetric responses between monetary easing and tightening.
- Preference shift. A preference shift from renting to owning houses (induced by, for example, the pandemic) would generate similar effects with monetary easing, causing higher housing demand and higher housing prices that would hurt first-time homebuyers and benefit repeat homebuyers.
- Relaxation of the credit constraint. So far, our model considers the change in the "price" of money (i.e., interest rate); a change in the "quantity" of money (i.e., availability of mortgage credit) would also lead to similar effects. For example, a relaxation of the LTV constraint in the model would also lead to higher housing prices, hurting first-time homebuyers and benefiting repeat homebuyers. Although such considerations make it challenging to empirically identify the causal effect of monetary easing (specifically, a change in interest rate) on housing affordability, they do not pose additional challenges to our empirical strategy presented below. This is because our empirical strategy focuses on the *pricing-out* effect on first-time homebuyers due to a *general* house price change, which can be driven by either a monetary policy shock or any other shock (e.g., a preference shift). Our empirical results show that a house price increase will disproportionally hurt first-time homebuyers, and our theoretical model shows that one of the possible driving forces for the higher house price itself is monetary easing (a decrease in interest rate).

IV. EMPIRICAL ANALYSES

A. Hypotheses

Motivated by the stylized facts presented in the Introduction, we now formally present the hypotheses that we will test empirically.

Hypothesis 1: Given the quality of the house, higher housing price is associated with a higher income among the cohort of approved first-time homebuyers.

This hypothesis states that after an increase in house prices, either the income requirement for first-time homebuyers to purchase a house of a given quality has become more stringent, or only richer potential first-time homebuyers found it optimal to buy houses (i.e., lower-income potential first-time homebuyers may find that they could only afford a house that is too small, at the high housing price). In either case, lower-income potential first-time homebuyers are priced out by the rising housing prices.

Hypothesis 1 implies that a higher housing price tends to increase housing wealth *inequality between existing homeowners and potential homebuyers*: The higher housing price increases the housing wealth of existing homeowners (if they do not sell their existing house and buy another house), while making it harder for first-time homebuyers to acquire housing assets.

Hypothesis 2: Given the quality of the house, a higher housing price is associated with a larger income increase for first-time homebuyers than for repeat homebuyers.

This hypothesis makes a distinction between first-time homebuyers and repeat buyers because our theoretical model shows that first-time homebuyers would suffer more from house price increases than repeat buyers. Intuitively, repeat buyers are not necessarily worse off after a price increase because although they have to spend more to purchase a new house (as the house price increases), they also sell their existing house at a higher price. The house sale proceeds can either be used as down payments for purchasing the new house or simply increase the value of the repeat homebuyers' liquid assets (which could, in turn, reduce the minimum income required to qualify for the new mortgage).

Hypothesis 2 also implies that an increase in house prices can lead to a higher housing wealth inequality even when existing homeowners sell their houses and buy new ones (i.e., become repeat homebuyers). This is because, as argued above, higher housing prices will "hurt" first-time homebuyers more than repeat homebuyers since the former do not have existing (and more expensive) houses to sell. Importantly, the higher inequality in *housing* wealth might worsen the inequality in the *overall* wealth over time because housing is the primary source of wealth accumulation for the middle class. See, for example, Kaplan, Violante, and Weidner (2014), who uncover that the median U.S. household has 63 percent of its wealth in housing equity.

B. Data

Our main data source is Freddie Mac's publicly available Single-Family Loan-Level Dataset. The data are organized into quarterly files from 1999Q1 to 2022Q1. In each quarter, we observe loan-level information for all the mortgages that were originated during the quarter and purchased by Freddie Mac. Given the large size of the dataset, even if we restrict to mortgages originated for house purchases (thus excluding home-equity and refinancing loans), we still observe over 8 million mortgage originations. In addition to household-level regressions, such richness allows us to also compute statistics of our interest at the Metropolitan Statistical Area (MSA) level and build a panel dataset of 287 MSAs for over 80 quarters.

To complement the statistics that we compute by aggregating the Freddie Mac mortgage data at the MSA level, we collect some other data from Zillow and the Quarterly Census of Employment and Wages (QCEW) compiled by the BLS. From Zillow, we obtain a measure of house prices at the quarter-MSA-level. From the QCEW, we obtain the average wage also at the quarter-MSA level, which is useful as a benchmark for the average income level in a specific area. In addition, we obtain the employment and number of establishments active in the MSA, which are useful controls for the level of economic activity in the area.

C. Empirical Strategy

Empirical Strategy for Hypothesis 1

To empirically test Hypothesis 1, we conduct the following household-level regressions using data for first-time homebuyers from Freddie Mac and other data sources described above:

$$\begin{aligned} Log\_Income_{i,t} = \beta_0 &+ \beta_1 Log\_House\_Price\_MSA_{MSA,t} + \beta_2 Orig\_Rate\_MSA_{MSA,t} \\ &+ \beta_3 Log\_House\_Quality_{i,t} + \beta_4 Post\_GFC\_Dummy_t \\ &+ \beta_5 Log\_Avg\_Wage\_MSA_{MSA,t} + \epsilon_{i,t} \end{aligned}$$

Where:

- $Log\_Income_{i,t}$: Log of the income of Household i during Quarter t. Freddie Mac's dataset does not provide income data, so we impute this variable using the information on mortgage characteristics. Specifically, income is obtained as the monthly mortgage payment (computed using the outstanding balance, mortgage rate, and other mortgage terms), divided by the debt-to-income ratio (DTI).[14] We take logs to generate coefficients

[14] Note that the DTI ratio in the Freddie Mac dataset covers not only mortgage debt but also other types of debt, such as credit card debt. Hence, this DTI ratio is larger than the ratio of mortgage payment over income. Accordingly, the income imputed as the mortgage payment divided by this (larger) DTI ratio tends to underestimate the true income. Fortunately, correcting this bias could *reinforce* our results. That is, following monetary easing, the true income of first-time homebuyers is even higher than that

with more interpretable magnitudes.

- *Log_House_Price_MSA$_{MSA,t}$:* Log of the house price index in the MSA during Quarter t. Specifically, we take the widely-used Zillow Home Value Index (ZHVI) for single-family houses. We choose the index for single-family houses to be consistent with the Freddie Mac data, which covers this type of houses only. This is the regressor we are most interested in, as it captures the effect of changes in house prices on the income of households that have succeeded in buying houses. Note that we use the MSA-level house price index instead of the household-level house value because our research goal is to examine the impact of the *market-wide* housing price (which applies to all households in the same market) on *individual* households in the same market. We also do not use the median (or mean) of Freddie Mac's household-level house values because such a median is more volatile than the ZHVI, probably because the Freddie Mac data set does not always have many observations in a given MSA in every quarter. Mathematically, Hypothesis 1 corresponds to $\beta_1 > 0$.
- *Orig_Rate_MSA$_{MSA,t}$:* The median mortgage origination rate among all house purchasers observed in Freddie Mac in each MSA during each quarter. This captures the impact of the *market-wide* mortgage rate on individual households and reflects the impact of the monetary policy stance. Note that since we have controlled for house prices, this variable only captures the direct or partial-equilibrium effect of interest rates on mortgage (and housing) affordability, and not its indirect or general-equilibrium effect through house prices. We would also like to note that the coefficient of *Log_House_Price_MSA$_{MSA,t}$* (i.e., β_1) reflects not only this general equilibrium effect of a monetary policy shock via house prices, but also other forces that affect house prices (such as shifts in housing preferences). Nonetheless, estimating β_1 and β_2 is still useful in understanding the *magnitude* of the effect of the house price change (for whatever reason) on housing affordability relative to that of the interest rate change, hence providing a benchmark for assessing the *net* effect on housing affordability.
- *Log_House_Quality$_{i,t}$:* Log of the "relative house quality" of the newly purchased house by Household i during Quarter t. It is calculated as the value of the house at the household level, divided by the house price index in the MSA from Zillow. The value of the house, in turn, is computed as the initial mortgage loan amount divided by the loan-to-value (LTV) ratio at origination. This variable captures the quality of the house

suggested by our estimates, indicating even lower housing affordability and an even stronger pricing-out effect. Similarly, following monetary tightening, the true income of first-time homebuyers is also higher than that suggested by our estimates, also indicating even lower affordability. In both cases, our case for adopting policies to enhance housing affordability would be *stronger*.

relative to the "typical" house in the same MSA.[15] Controlling for this variable is important because it accounts for the variation in the homebuyer's income that is simply explained by the purchase of a house of a higher quality, such as having better schools nearby. Just like in the model, our notion of affordability is related to the level of income of households who purchase a given type of house. Therefore, our empirical strategy is to keep the housing characteristics fixed and examine how changes in mortgage rates and house prices affect the income of buyers who will manage to purchase that "typical" or "average" house.

- *Post_GFC_Dummy:* A dummy variable equal to one in every quarter starting in 2008Q1. This is to account for the potential regime shift associated with tougher lending standards after the GFC.
- *Log_Avg_Wage_MSA:* Log of the average wage in each MSA during each quarter. The data is from the QCEW by the BLS. This variable and the next one (used in robustness checks) control for the overall economic development in each MSA during each quarter. Controlling for such variables is important because doing so allows us to rule out the possibility that an increase in the average wage (or the local labor market) in the MSA can mechanically and simultaneously raise the income of homebuyers and house prices.
- *Log_Employment_MSA:* Log of the total employment in each MSA during each quarter, also from the QCEW. This variable is used in robustness checks.
- In some specifications, we also control for MSA fixed effects so that the identification stems from the time variation within the same MSA rather than from the cross-sectional variation.

Note that because the Freddie Mac data at the time of loan origination does not track the individual household, it is infeasible to run panel regressions. Instead, we conduct pooled cross-sectional analyses over multiple periods. For the same reason, we cannot use changes of variables and will instead conduct the analysis based on the levels. We also normalize both the income and house price by the CPI index to mitigate the risk that the relationship we identify is simply caused by spurious correlations.

Empirical Strategy for Hypothesis 2

To empirically test Hypothesis 2, we apply two complementary approaches. The first approach is to conduct similar regressions in each sub-sample, i.e., first-time homebuyers and repeat

[15] To see this, note that we can rewrite our variable as: $\frac{\text{House Price of House i}}{\text{House Price Index of MSA j}} = \frac{\text{MSA Price per Unit of House Quality} \times \text{Quality of House i}}{\text{MSA Price per Unit of House Quality} \times \text{Quality of A Typical House in MSA j}} = \frac{\text{Quality of House i}}{\text{Quality of A Typical House in MSA j}}$.

homebuyers. Mathematically, Hypothesis 2 corresponds to the statement that the (positive) β_1 for first-time homebuyers is larger than that for repeat buyers.

The second approach for testing Hypothesis 2 is to pool the data for first-time and repeat buyers, introduce an interaction term, and conduct the following household-level regressions:

$$\begin{aligned} Log\_Income_{i,t} = {} & \beta_0 + \beta_1 Log\_House\_Price\_MSA_{MSA,t} + \beta_2 FT\_Dummy_{i,t} \\ & + \beta_3 Log\_House\_Price\_MSA_{MSA,t} \times FT\_Dummy_{i,t} \\ & + \beta_4 Orig\_Rate\_MSA_{MSA,t} + \beta_5 Log\_House\_Quality_{i,t} \\ & + \beta_6 Post\_GFC\_Dummy_t + \beta_7 Log\_Avg\_Wage\_MSA_{MSA,t} + \epsilon_{i,t} \end{aligned}$$

Where $FT\_Dummy_{i,t}$ equals 1 for first-time homebuyers and 0 otherwise; and $Log\_House\_Price\_MSA_{MSA,t}$ x $FT\_Dummy_{i,t}$ is the interaction term. Other variables remain the same as before. Mathematically, Hypothesis 2 corresponds to $\beta_3 > 0$.

These two approaches for Hypothesis 2 are complementary: The first approach has the advantage of allowing for heterogenous effects of all variables between the two groups of homebuyers, with the disadvantage of being unable to rigorously test whether the two β_1's are statistically different. The second approach fills in this gap.

D. Regression Results

Testing Results for Hypothesis 1

Table 1 reports the testing results for Hypothesis 1, which is about the pricing-out effect on first-time homebuyers. The dependent variable is the log income of first-time homebuyers. The sample consists of quarterly data from 1999Q1 to 2022Q1. Different columns show the results under different model specifications: The baseline specification; the specification after controlling for the MSA fixed effects; and the specification after controlling for both the MSA fixed effects and more variables such as the household-level FICO score and additional controls at the MSA level.

As shown in Column (1) of Table 1, all else being equal, a one percent increase in the MSA-level house prices is associated with an increase in the income of first-time homebuyers by about 0.752 percent (since both variables are in logs, this coefficient represents the elasticity; see Appendix 1). Since we have controlled for the quality of the house purchased by the household relative to the quality of a typical house in the MSA, this coefficient can be interpreted as the increase in the income of first-time homebuyers purchasing a *typical* type of house following an increase in house prices.

Table 1. Pricing-Out Effect for First-Time Homebuyers

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.752***	0.693***	0.686***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.075***	0.072***	0.070***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.912***	0.913***	0.911***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.049***	0.039***	0.031***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.130***	0.133***	0.144***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.149***
			(0.000)
Log_Employment_MSA			0.134***
			(0.000)
Log_Establishments_MSA			-0.085***
			(0.000)
Constant	-1.219***	-0.900***	-2.654***
	(0.000)	(0.000)	(0.000)
Observations	2,571,323	2,571,323	2,571,323
R-squared	0.555	0.559	0.560

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Such an increase in the income of first-time homebuyers could be due to an *"involuntary" pricing-out* effect: for a given house quality, a higher MSA-wide average house price raises the required mortgage balance and thus the debt servicing cost, which might push some households (who qualified for the mortgage loan before the house price increase) into violation of the DTI constraint, thus making them ineligible for the mortgage loan needed to purchase the house of the same quality. Alternatively, the higher income of the first-time homebuyers could capture a *"voluntary" pricing-out* effect: After the house price surge, some households may find it optimal to either continue renting or buy a smaller house; for such households, buying a house that has the same size would be suboptimal since it would force them to substantially cut their non-housing consumption. We do not take a stance on the nature of the pricing-out in these regressions. However, our results highlight the existence of such an involuntary or voluntary pricing-out effect because as shown in Table 1, following surges in house prices, the same type of houses is purchased by first-time homebuyers with higher incomes.

All the control variables in Table 1 have intuitive signs. In particular, the MSA-level mortgage rate at loan origination is positively associated with the income of first-time homebuyers: A one-percentage-point decrease in the MSA-level mortgage rate (say, from 3 percent to 4 percent) is associated with a 7.5 percent decrease in the income of the first-time homebuyers (since the dependent variable is in log, but the independent variable is in levels, the regression coefficient represents the *semi-elasticity*; see Appendix 1). As discussed above, the coefficient of the mortgage rate variable only captures the direct or partial-equilibrium effect of the monetary policy change, via the mortgage interest payment channel only. It does not capture the general equilibrium effect due to changes in house prices that typically follow interest rate changes.

It is also informative to compare the magnitudes between the interest payment effect and the pricing-out effect. Column (1) of Table 1 suggests that following a one-percentage-point decrease in the mortgage rate, the income "requirement" for first-time homebuyers would decrease by 7.5 percent. However, because one percent increase in house prices is associated with a 0.752 percent increase in the income of first-time homebuyers, this higher home affordability (following the one-percentage-point decrease in the mortgage rate) would be fully offset if house prices increase by *10.0 percent* (i.e., 7.5/0.752).[16]

To put this comparison in historical context, consider the period from November 2018 to December 2021. During this period, mortgage rates declined by 1.77 percentage points, from their pre-COVID peak of 4.87 percent in November 2018 to 3.10 percent in December 2021, which marks the end of the post-COVID monetary easing. During the same period, the U.S. Zillow house price index increased by 34.8 percent. Given these, our regression results in Table 1 (Column (1)) imply that first-time homebuyers' income would decrease by roughly 13.3 percent (7.5×1.77 percent) via the interest payment channel (i.e., via the direct savings from the lower mortgage interest payments), but it would increase by roughly 26.2 percent (0.752×34.8 percent) via the pricing-out effect.

This simple comparison suggests that, at least during the recent monetary easing cycle featured soaring house prices, the general-equilibrium pricing-out effect[17] is much more significant than (twice as large as) the partial-equilibrium interest payment effect, highlighting the importance of

[16] Our result of 10.0 percent is close to Andrle (Forthcoming)'s finding for Canada (10.9 percent) when the mortgage rate increases from 1.5 percent to 2.5 percent for a loan duration of 25 years, although the two studies are based on significantly different approaches.

[17] As noted earlier, this reflects not only the general equilibrium effect of a monetary policy shock via house prices, but also other forces that affect house prices (such as shifts in housing preferences). Nonetheless, the comparison being made here is still useful in understanding the *magnitude* of the effect of the house price change (for whatever reason) on housing affordability relative to that of the interest rate change, hence providing a benchmark for assessing the *net* effect on housing affordability.

accounting for the general-equilibrium effect. But even during other periods of monetary easing, our results suggest that this general-equilibrium effect is still sizable, given that a 10-percent increase in housing prices could fully offset a one-percentage-point reduction in the mortgage rate in terms of their effects on home affordability.

The effects of housing price on first-time homebuyers' income are quantitatively similar after controlling for MSA fixed effects (Column (2)) and for more factors (Column (3)), including the household-level FICO score and the number of establishments in the MSA. The household-level FICO score could account for more idiosyncratic forces in the dependent variable, the household-level income, whereas the number of establishments in the MSA serves as an additional variable capturing the growth dynamics of the MSA.

As for the effects of other control variables, the income of a typical first-time homebuyer is found to be positively associated with a higher house size purchased by the household, as well as a higher average wage in the MSA, both of which are intuitive.[18] It also tends to be higher after the GFC, consistent with the potential post-GFC regime shift associated with tougher lending standards. And finally, the income of a typical first-time homebuyer is positively associated with his/her FICO score, as expected. The results are also quantitatively similar after controlling for MSA fixed effects and for more factors. In particular, Column (3) of Table 1 also implies that the higher home affordability following a one-percentage-point decrease in the mortgage rate would be fully offset if house prices increase by about *10 percent* (i.e., 7.0/0.686).

Results for Hypothesis 2

As explained above, we take two complementary approaches to test Hypothesis 2. For the first approach, we conduct similar regressions for repeat homebuyers (Table 2) and compare them with the results for first-time homebuyers (Table 1). We find that the pricing-out effect of house prices for repeat homebuyers, captured by the coefficient in the first row of Table 2, also exists and is statistically significant. In particular, Column (1) of Table 2 implies that for repeat buyers, the higher home affordability following a one-percentage-point decrease in the mortgage rate would be fully offset if house prices increase by 10.6 percent (i.e., 7.4/0.700). However, the pricing-out effect is weaker than that for first-time homebuyers. That is, first-time homebuyers tend to be affected more by the pricing-out effect associated with higher house prices. This pattern is robust across all specifications between Table 1 and Table 2, i.e., the pricing-out effect

[18] The coefficient of the number of establishments in the MSA is counterintuitive, although the other two similar variables (average wage and employment in the MSA) have intuitive signs. This could be due to either measurement issues in these three indicators or the multicollinearity among them, as they are very similar in nature.

in each column of Table 1 (for first-time homebuyers) is stronger than that in the corresponding column of Table 2 (for repeat homebuyers).

To have a sense of the magnitude of the difference between the effects on first-time and repeat homebuyers, we first consider a scenario where the interest rate decreases by 1 percentage point, and the housing price increases by 18 percent, which is the actual year-on-year percent change of the U.S. housing price in May 2022. Based on the coefficients in the first column of Table 2, the median income of repeat homebuyers will increase by $7.4\times(-1)+0.700\times18=5.20$ percent. Similarly, based on the coefficients in the first column of Table 1, the median income of first-time homebuyers will increase by $7.5\times(-1)+0.752\times18=6.04$ percent, which is higher than that of repeat homebuyers by 0.84 percentage points, or 16 percent ($\frac{0.84}{5.20}$) of the percent change in the median income of repeat homebuyers. This difference seems economically large and plausible.

We then consider another scenario where the interest rate decreases by 1 percentage point, and the housing price increases by 10 percent. Similar calculations imply that the median income of repeat homebuyers will increase by $7.4\times(-1)+0.700\times10=-0.40$ percent, i.e., *decrease* by 0.40 percent, suggesting a (slight) improvement of housing affordability for this group of homebuyers. Meanwhile, the median income of first-time homebuyers will *increase* by $7.5\times(-1)+0.752\times10=0.02$ percent, suggesting a (slight) deterioration of housing affordability for this other group. This simple simulation indicates that, under some scenarios, the median incomes of first-time and repeat homebuyers can move in opposite directions, with housing affordability improving for repeat homebuyers and deteriorating for first-time homebuyers.

As for the alternative approach for testing Hypothesis 2, rather than estimating the pricing-out effect separately for the two groups of buyers, we introduce an interaction term between the log MSA-level house price and a dummy variable indicating first-time homebuyers. The third row of Table 3 reports the coefficient of this interaction term. The interaction term is positive and statistically significant across all specifications, meaning that the pricing-out effect of higher house prices is stronger for first-time homebuyers.

Both approaches thus suggest a stronger pricing-out for first-time buyers. These results are consistent with those of our theoretical section. Intuitively, although repeat buyers lose from higher house prices when purchasing, they also benefit from selling their previous houses at higher prices. Therefore, the net effect for these households is less trivial.

Table 2. Pricing-Out Effect for Repeat Homebuyers

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log House Price MSA	0.700***	0.600***	0.626***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.074***	0.065***	0.062***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.860***	0.859***	0.858***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.057***	0.037***	0.044***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.120***	0.022***	0.057***
	(0.000)	(0.001)	(0.000)
Log_FICO			0.070***
			(0.000)
Log_Employment_MSA			0.047***
			(0.000)
Log_Establishments_MSA			-0.118***
			(0.000)
Constant	-0.896***	0.239***	-0.103**
	(0.000)	(0.000)	(0.021)
Observations	5,746,938	5,746,938	5,746,938
R-squared	0.418	0.422	0.422

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Table 3. Pricing-Out Effect for Both Types of Homebuyers with the Interaction Term

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.704***	0.614***	0.633***
	(0.000)	(0.000)	(0.000)
FT_Dummy	-0.186***	-0.195***	-0.200***
	(0.000)	(0.000)	(0.000)
FT_Dummy × Log_House_Price_MSA	0.040***	0.041***	0.043***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.074***	0.067***	0.064***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.874***	0.873***	0.872***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.055***	0.038***	0.041***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.123***	0.060***	0.086***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.097***
			(0.000)
Log_Employment_MSA			0.069***
			(0.000)
Log_Establishments_MSA			-0.110***
			(0.000)
Constant	-0.938***	-0.060**	-0.785***
	(0.000)	(0.013)	(0.000)
Observations	8,318,261	8,318,261	8,318,261
R-squared	0.453	0.457	0.457

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The third row reports the additional pricing-out effect from a one percent increase in house prices on first-time homebuyers, compared with the result for repeat buyers.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

E. Robustness Checks

In this section, we conduct some robustness checks. Firstly, we use the household-level rather than MSA-level mortgage rate at origination. Doing so has the potential advantage of capturing more household-specific idiosyncratic factors that are correlated with the household-level income (our dependent variable), although the link between such a variable and the market-wide monetary policy stance is less clear exactly because it reflects too many household-level

idiosyncratic factors. The robustness check results for first-time homebuyers (i.e., Hypothesis 1) are presented in Table 4 (results for other cases are presented in Appendix Tables 1-2). A comparison between Table 4 and Table 1 suggests that using the household-level mortgage rate leads to a similar pricing-out effect as before but a smaller interest-payment effect: A one percent increase in the house price is still associated with about 0.7 percent increase in the income of first-time homebuyers; but a percentage point decrease in the mortgage rate is associated with only associated with a 4-5 percent decrease in income.

The second set of robustness checks we conduct is to cluster standard errors at the MSA level. This is to account for the potential correlation among observations from the same MSA, which might lead to artificially low standard errors when such a correlation is not considered. Table 5 reports the results of this robustness check for the testing of Hypothesis 2 using regressions with the interaction term, i.e., the robustness check for Table 3 (robustness check results for other cases are presented in Appendix Tables 3-4). A comparison between Table 5 and Table 3 suggests that clustering standard errors at the MSA level does not change the significance levels of any of our regressors, confirming that Hypothesis 2 still holds.

Table 4. Pricing-Out Effect for First-Time Homebuyers with *Household-level* Rates

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE with controls
Log_House_Price_MSA	0.753***	0.702***	0.704***
	(0.000)	(0.000)	(0.000)
Orig_Rate	0.052***	0.040***	0.037***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.919***	0.918***	0.916***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	-0.006***	-0.017***	-0.019***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.111***	-0.154***	-0.090***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.163***
			(0.000)
Log_Employment_MSA			0.245***
			(0.000)
Log_Establishments_MSA			-0.202***
			(0.000)
Constant	-0.978***	0.696***	-1.745***
	(0.000)	(0.000)	(0.000)
Observations	2,571,323	2,571,323	2,571,323
R-squared	0.552	0.556	0.557

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Table 5. Pricing-Out Effect for Both Types of Homebuyers with the Interaction Term and *Clustered Standard Errors*

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.704***	0.614***	0.633***
	(0.000)	(0.000)	(0.000)
FT_Dummy	-0.186***	-0.195***	-0.200***
	(0.000)	(0.000)	(0.000)
FT_Dummy × Log_House_Price_MSA	0.040***	0.041***	0.043***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.074***	0.067***	0.064***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.874***	0.873***	0.872***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.055***	0.038***	0.041***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.123***	0.060*	0.086**
	(0.000)	(0.097)	(0.014)
Log_FICO			0.097***
			(0.000)
Log_Employment_MSA			0.069***
			(0.003)
Log_Establishments_MSA			-0.110***
			(0.000)
Constant	-0.938***	-0.060	-0.785***
	(0.000)	(0.716)	(0.001)
Observations	8,318,261	8,318,261	8,318,261
R-squared	0.453	0.457	0.457

Note: P-values are in parentheses, corresponding to standard errors that are clustered at the MSA level. *** p<0.01, ** p<0.05, * p<0.1. The third row reports the additional pricing-out effect from a one percent increase in house prices on first-time homebuyers, compared with the result for repeat buyers.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

V. CONCLUSION AND POLICY IMPLICATIONS

In this paper, we challenge the conventional wisdom that lower mortgage rates always favor first-time homebuyers, or higher mortgage rates always harm first-time homebuyers. We do this both theoretically with a stylized general equilibrium model and empirically, focusing on the U.S. market with Freddie Mac's household-level data. We find that, after accounting for general-

equilibrium effects, monetary easing is associated with a *trade-off*: on the one hand, monetary easing directly reduces mortgage payments and enhances housing affordability; on the other hand, it raises the housing price, prices out potential homebuyers, and lowers housing affordability. This pricing-out effect is stronger for first-time homebuyers than existing homeowners, thus increasing housing wealth inequality. We also quantify the magnitude of the effect of the house price change on housing affordability relative to that of the interest rate change, and find that the higher home affordability following a one-percentage-point decrease in the mortgage rate would be fully offset if house prices increase (for whatever reason) by about *10 percent*.

As such, our paper points to the following policy implications. While implementing *expansionary* monetary policy to stimulate the economy, it is crucial to complement it with well-targeted policy measures that can mitigate the deterioration of housing affordability for first-time and lower-income homebuyers. Similarly, while implementing *contractionary* monetary policy, although the higher mortgage rates pose an immediate threat to housing affordability, it is useful to account for the potential mitigation effect on affordability due to lower house prices over time. Thus, it may not be advisable to slow down the pace of monetary tightening simply because of concerns about the deteriorating housing affordability, although measures are still warranted to address the deteriorating housing affordability caused by monetary tightening in the short run.

The ultimate net effect on affordability depends on the relative strength of the mortgage payment channel and the house price channel, the latter of which also depends on the housing demand elasticity and housing supply elasticity with respect to a change in the house price (associated with a change in the mortgage rate). For example, if housing supply is highly inelastic in one area, then the house price will increase (decrease) more following monetary easing (tightening), and the deterioration (mitigation) in housing affordability in this area will be stronger. Since such elasticities could differ substantially across different areas in the same country (and between monetary easing and tightening stages), no one size fits all. Instead, it is important for policymakers to take a *region-specific approach* by carefully estimating the subsequent changes in house prices for different areas following monetary easing and tightening, respectively. The same argument applies when generalizing our findings to countries other than the U.S.. But even in the monetary *tightening* case, because the fall in house prices may be insufficient (compared with our empirical estimates) and it takes time for the high house prices to come down, aggressive monetary tightening will deteriorate housing affordability further in the short term. Therefore, targeted and temporary policy measures to boost housing affordability for first-time and lower-income homebuyers are still needed, as in the monetary easing case.[19]

[19] In case the monetary tightening is motivated to tackle high inflationary pressure, these targeted measures should ideally be budget-neutral to avoid intensifying the inflationary pressure.

Such policy measures could include demand-side and supply-side measures, both targeted to first-time or lower-income homebuyers. In the context of the U.S., one example of the demand-side measures is the first-time homebuyer tax credit (FHTC). As one of the largest policy responses to the 2008 housing bust, the FHTC was aimed at boosting the housing demand and was temporarily offered between April 2008 and September 2010. A recent study by Hembre (2018) shows that the FHTC program increased first-time homebuyer purchases by 16.0 percent between April 2008 and September 2010, with a much larger effect in areas with lower home values and without a measurable effect on mortgage delinquencies. A bill to create a new FHTC program was introduced in April 2021 (increasing the maximum tax credit from $8,000 to $15,000), and is under consideration by Congress as of October 1, 2022.[20] The FHTC seems more effective in raising homeownership than other more general homeownership-promotion measures, such as the mortgage interest deduction (as analyzed in Hanson, 2012), deduction of state and local property taxes (Glaeser and Shapiro, 2003), and the implicit mortgage default insurance subsidy via the mortgage purchases by Fannie Mae and Freddie Mac (Zhao, 2019; and Zhao, 2021).

Supply-side measures could include continued implementation of the Low-Income Housing Tax Credit (LIHTC) program. According to the U.S. Department of Housing and Urban Development (HUD), the LIHTC program is currently "the most important resource for creating affordable housing" in the U.S., issuing tax credits for the acquisition, rehabilitation, or new construction of rental housing targeted to lower-income households (with incomes below or at 60 percent of the MSA's median income). The latest report by the HUD[21] suggests that the program has been well-targeted, with 44.4 percent of LIHTC households having annual incomes of less than 30 percent of the MSA's median income and the median household income for a LIHTC household being $17,943 (well below the federal poverty level for a family of four in 2019, $25,750). And based on some recent studies (e.g., Diamond and McQuade, 2019), the welfare impact of the program can be further enhanced by moving LIHTC properties from higher-income to lower-income neighborhoods, where the net spillovers of the LIHTC on surrounding properties are found to be the most positive.[22]

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[20] "H.R.2863 - First-Time Homebuyer Act of 2021," U.S. Congress. And "What Is the First-Time Homebuyer Credit? Does It Still Exist?" SmartAsset.com, October 1, 2022.

[21] "Understanding Whom the LIHTC Serves: Data on Tenants in LIHTC Units as of December 31, 2017," HUD, published in March 2020. The findings are similar to those in the HUD's report published in April 2017, as analyzed in "The Effects of the Low-Income Housing Tax Credit (LIHTC)", published by NYU Furman Center in May 2017.

[22] Note that these neighborhood benefits must be weighed against the costs and benefits to the tenants residing in the affordable housing. Chetty, Hendren, and Katz (2016) find that moving young children from high-poverty public housing to low-poverty areas increases these children's future earnings by

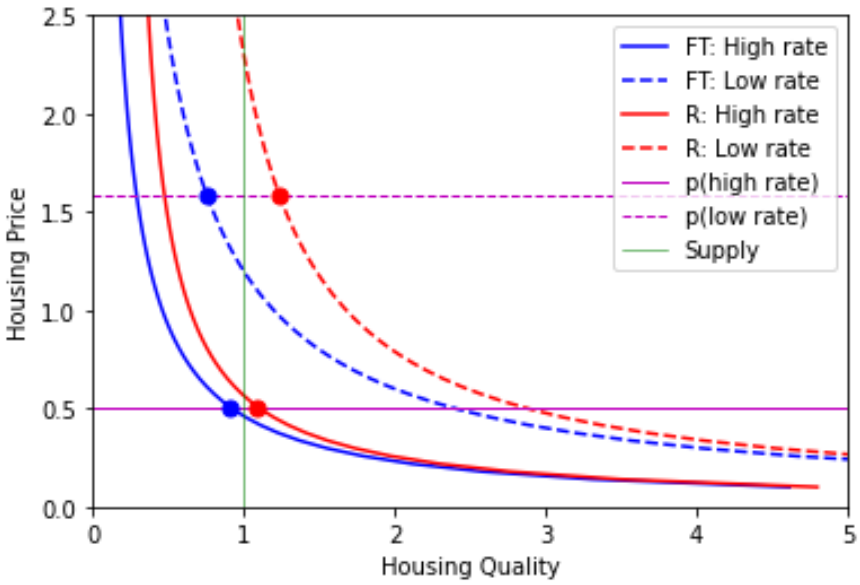
Some policy recommendations by Deb et al. (2022) in the context of Asia-Pacific countries are also informative to policymakers in the U.S. and other countries. Demand-side measures discussed in Deb et al. (2022) include: (1) targeted housing vouchers or housing subsidies to low-income households, and grants, tax relief, or accommodative financing terms to first-time homeowners; (2) targeted housing financing, insurance, and guarantee mechanisms, given that low- and middle-income households have disproportionately lower access to formal housing finance. Supply-side measures could include: (1) freeing up land supply, and improving planning/zoning; (2) increasing the stock of social housing, although the merit of this measure (which is fiscally costly and less flexible) relative to housing allowance requires a careful cost-benefit analysis (ElFayoumi et al., 2021). And as noted by Andrle (2019), the demand-side measures that simply increase households' capacity to borrow may not boost housing affordability because they may raise the housing price and more than offset the intended effect of these measures on affordability.

Our paper focuses on the affordability of owning a house rather than that of renting a house, and on the distributional implications between first-time homebuyers and existing homeowners. Future studies could examine in greater detail the trade-offs between renting and buying for first-time homebuyers, as well as policies that can narrow the gap between homeowners and renters. In addition, the model in our theoretical section is stylized, and the literature would benefit from analyzing the insights presented in this paper in a richer and more dynamic framework, such as the framework in Berger et al. (2018). Finally, our empirical approach focuses on quantifying the magnitude of the house price effect on housing affordability relative to that of the interest rate effect; it does not aim to quantify the causal effect of monetary policy changes on house prices and housing inequality, which would be a promising avenue for future research.

$100,000 in terms of the present discounted value. This effect is not sufficient to offset the benefits to low-income neighborhoods (estimated by Diamond and McQuade, 2019) because, as pointed out by Diamond and McQuade (2019), there are many more low-income households living in a low-income area than in the affordable housing units themselves.

VI. APPENDICES: FIGURES, TABLES, AND PROOFS

Appendix Figure 1. Housing Affordability in Terms of Housing Quality



Note: This figure is an equivalent presentation of Figure 4 in the main text, which plots the homebuyers' income instead of the housing quality. Solid lines are the housing demand curves when the interest rate is high. Dashed lines are the housing demand curves when the interest rate is low. FT = First-time Homebuyers; R = Repeat Homebuyers; p = Housing Price. The vertical line is the housing supply.

Source: Authors.

Appendix 1. Interpretations of Two Key Regression Coefficients

Interpretation of the Coefficient of the (log) MSA-level House Price

Since both income on the left-hand-side and house prices on the right-hand-side are in logs, the coefficient β_1 has to be interpreted as an elasticity. Indeed, from the regression equation:

$$log(Income) = \beta_1 log(House\_Price\_MSA) + \text{other terms}$$

We have:

$$\frac{\partial Income}{Income} = \beta_1 \frac{\partial House\_Price\_MSA}{House\_Price\_MSA}$$

Hence, a one percent increase in house prices is associated with an increase in the income of first-time buyers of β_1 percent; in our case, that is of around 0.7 percent, according to Table 1.

Interpretation of the Coefficient of the MSA-Level Mortgage Origination Rate

Since income on the left-hand side is in logs, while the mortgage rate on the right-hand side is in levels (specifically, in percentage points), the coefficient β_3 has to be interpreted as a semi-elasticity. Indeed, from the regression equation:

$$log(Income) = \beta_3 Orig\_Rate\_MSA + \text{other terms}$$

We have:

$$\frac{\partial Income}{Income} = \beta_3 \partial Orig\_Rate\_MSA$$

Hence, a one percentage point increase in the mortgage rate (e.g., from 2 percent to 3 percent) is associated with an increase in the income of first-time buyers by β_3, or equivalently, by $100*\beta_3$ percent; in our case, that is of around 7 percent.

Appendix Table 1. Pricing-Out Effect for Repeat Homebuyers with *Household-level* Mortgage Rate

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.702***	0.611***	0.645***
	(0.000)	(0.000)	(0.000)
Orig_Rate	0.053***	0.039***	0.036***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.873***	0.868***	0.867***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.008***	-0.006***	0.006***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.102***	-0.221***	-0.146***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.083***
			(0.000)
Log_Employment_MSA			0.125***
			(0.000)
Log_Establishments_MSA			-0.207***
			(0.000)
Constant	-0.677***	1.558***	0.751***
	(0.000)	(0.000)	(0.000)
Observations	5,746,938	5,746,938	5,746,938
R-squared	0.416	0.420	0.421

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Appendix Table 2. Pricing-Out Effect for Both Types of Homebuyers with the Interaction Term and with *Household-level* Mortgage Rate

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.705***	0.624***	0.650***
	(0.000)	(0.000)	(0.000)
FT_Dummy	-0.191***	-0.204***	-0.214***
	(0.000)	(0.000)	(0.000)
FT_Dummy × Log_House_Price_MSA	0.041***	0.043***	0.045***
	(0.000)	(0.000)	(0.000)
Orig_Rate	0.053***	0.039***	0.037***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.885***	0.881***	0.879***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.005***	-0.009***	0.000
	(0.000)	(0.000)	(0.584)
Log_Avg_Wage_MSA	0.104***	-0.191***	-0.123***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.110***
			(0.000)
Log_Employment_MSA			0.154***
			(0.000)
Log_Establishments_MSA			-0.204***
			(0.000)
Constant	-0.714***	1.314***	0.076**
	(0.000)	(0.000)	(0.029)
Observations	8,318,261	8,318,261	8,318,261
R-squared	0.451	0.455	0.456

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The third row reports the additional pricing-out effect from a one percent increase in house prices on first-time homebuyers, compared with the result for repeat buyers.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Appendix Table 3. Pricing-Out Effect for First-Time Homebuyers with *Clustered Standard Errors*

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.752***	0.693***	0.686***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.075***	0.072***	0.070***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.912***	0.913***	0.911***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.049***	0.039***	0.031***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.130***	0.133***	0.144***
	(0.000)	(0.000)	(0.000)
Log_FICO			0.149***
			(0.000)
Log_Employment_MSA			0.134***
			(0.000)
Log_Establishments_MSA			-0.085***
			(0.000)
Constant	-1.219***	-0.900***	-2.654***
	(0.000)	(0.000)	(0.000)
Observations	2,571,323	2,571,323	2,571,323
R-squared	0.555	0.559	0.560

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

Appendix Table 4. Pricing-Out Effect for Repeat of Homebuyers with *Clustered Standard Errors*

Dep: Log_Income	(1) Baseline	(2) MSA FE	(3) MSA FE more controls
Log_House_Price_MSA	0.700***	0.600***	0.626***
	(0.000)	(0.000)	(0.000)
Orig_Rate_MSA	0.074***	0.065***	0.062***
	(0.000)	(0.000)	(0.000)
Log_House_Quality	0.860***	0.859***	0.858***
	(0.000)	(0.000)	(0.000)
Post_GFC_Dummy	0.057***	0.037***	0.044***
	(0.000)	(0.000)	(0.000)
Log_Avg_Wage_MSA	0.120***	0.022***	0.057***
	(0.000)	(0.001)	(0.000)
Log_FICO			0.070***
			(0.000)
Log_Employment_MSA			0.047***
			(0.000)
Log_Establishments_MSA			-0.118***
			(0.000)
Constant	-0.896***	0.239***	-0.103**
	(0.000)	(0.000)	(0.021)
Observations	5,746,938	5,746,938	5,746,938
R-squared	0.418	0.422	0.422

Note: P-values are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sources: Freddie Mac; Zillow; BLS; Authors' calculations.

VII. REFERENCES

Aastveit, K.A., and A.K. Anundsen, 2022. Asymmetric Effects of Monetary Policy in Regional Housing Markets, *American Economic Journal: Macroeconomics*, 14 (4): 499-529.

Adam, K., and Tzamourani, P., 2016. Distributional Consequences of Asset Price Inflation in the Euro Area, *European Economic Review*, 89: 172-192.

Adam, K., and Zhu, J., 2016. Price-Level Changes and the Redistribution of Nominal Wealth across the Euro Area, *Journal of European Economic Association*, 14 (4): 871-906.

Aizawa, T., Helble, M., and Lee, K.O., 2020. Housing Inequality in Developing Asia and the United States: Will Common Problems Mean Common Solutions? *Journal of Policy Development and Research*, 22 (2).

Andersson, F., Haltiwanger, J.C., Kutzbach, M.J., Palloni, G.E., Pollakowski, H.O., and Weinberg, D.H., 2016. Childhood Housing and Adult Earnings: A between-Siblings Analysis of Housing Vouchers and Public Housing. *NBER Working Paper #22721.*

Andersen, A. L., Johannesen, N., Jørgensen, M., and Peydró, J-L., 2020. Monetary Policy and Inequality, *CEPR Discussion Paper No. 15599*.

Andrle, M., 2019. Assessing House Prices in Canada, *Selected Issues Paper for Canada, IMF*.

Andrle, M., Forthcoming. House Prices in Canada: An Update. *IMF Working Paper*.

Andrle, M., and Plasil, 2019. M. Assessing House Prices in Canada, *IMF Working Paper 19/248*.

Berger, D., Guerrieri, V., Lorenzoni, G., and Vavra, J., 2018. House Prices and Consumer Spending, *Review of Economic Studies*, 85 (3): 1502-1542.

Biljanovska, N., Fu, C., and Igan, D., Forthcoming. Housing Affordability: A New Dataset. *IMF Working Paper.*

Bonifacio, V., Brandao-Marques, L., Budina, N., Csonto, B., Fratto, C., Engler, P., Furceri, D., Igan, D., Mano, R., Narita, M., Omoev, M., Pasricha, G.K., and Poirson, H., 2021. Distributional Effects of Monetary Policy, *IMF Working Paper 21/201.*

Bryan, G., and Morten, M., 2019. The Aggregate Productivity Effects of Internal Migration: Evidence from Indonesia, *Journal of Political Economy*, 127 (5): 2229-2268.

Casiraghi, M., Gaiotti, E., Rodano, M.L., and Secchi, A., 2018. A "Reverse Robin Hood"? The Distributional Implications of Non-Standard Monetary Policy for Italian Households, *Journal of International Money and Finance*, 85: 215-235.

Cevik, S., and Naik, S., 2022. Don't Look Up: House Prices in Emerging Europe, *IMF Working Paper 22/236*.

Chetty, R., Hendren, N., and Katz, L.F., 2016. The Effects of Exposure to Better Neighborhoods on Children: New Evidence from the Moving to Opportunity Experiment, *American Economic Review*, 106 (4): 855-902.

Deb, P., Finger, H., Kashiwase, K., Kido, Y., Kothari, S., and Papageorgiou, E., 2022. Housing Market Stability and Affordability in Asia-Pacific, *Departmental Paper, Asia and Pacific Department, IMF*.

Del Negro, M., and Otrok, C., 2007. 99 Luftballons: Monetary Policy and the House Price Boom across U.S. States, *Journal of Monetary Economics*, 54 (7): 1962-85.

Diamond, R., and McQuade, T., 2019. Who Wants Affordable Housing in Their Backyard? An Equilibrium Analysis of Low-Income Property Development. *Journal of Political Economy*, 127 (3): 1063-1117.

Doepke, M., and Schneider, M., 2006. Inflation and the Redistribution of Nominal Wealth, *Journal of Political Economy*, 114 (6): 1069-1097.

ElFayoumi, K., Karpowicz, I., Lee, J., Marinkov, M., Mineshima, A., Salas, J., Tudyka A.,, and A. Schaechter, 2021. Affordable Rental Housing: Making It Part of Europe's Recovery, *Departmental Paper No. 21/13, European Department, IMF*.

Fratantoni, M, and Schuh, S., 2003. Monetary Policy, Housing, and Heterogeneous Regional Markets, *Journal of Money, Credit, and Banking*, 35 (4): 557-89.

Galster, G., and K.O. Lee, 2021. Introduction to the Special Issue of the Global Crisis in Housing Affordability, *International Journal of Urban Sciences*, 25: sup1, 1-6.

Gelain, P., Lansing, K.J., and Natvik, G.J., 2018. Explaining the Boom–Bust Cycle in the U.S. Housing Market: A Reverse-Engineering Approach. *Journal of Money, Credit and Banking*, 50 (8): 1751-1783.

Glaeser, E.L., and Shapiro, J.M., 2003. The Benefits of the Home Mortgage Interest Deduction. *Tax Policy and the Economy*, 17: 37-82.

Hanson, A., 2012. Size of Home, Homeownership, and the Mortgage Interest Deduction. *Journal of Housing Economics*, 21 (3): 195-210.

Hembre, E., 2018. An Examination of the First-time Homebuyer Tax Credit. *Regional Science and Urban Economics,* 73: 196-216.

Hsieh, C., and Moretti, E., 2019. Housing Constraints and Spatial Misallocation. *American Economic Journal: Macroeconomics*, 11 (2): 1-39.

Iacoviello, M., and Neri, S., 2010. Housing Market Spillovers: Evidence from an Estimated DSGE Model. *American Economic Journal: Macroeconomics*, 2 (April): 125-164.

Jarocinski, M, and Smets, F., 2008. House Prices and the Stance of Monetary Policy. *Federal Reserve Bank of St. Louis Review*, 90 (4): 339–65.

Jordà, O., Schularick, M., and Taylor, A., 2015. Betting the House. *Journal of International Economics*, 96 (1): 2-18.

Kaplan, G., Violante, G.L., and Weidner, J., 2014. The Wealthy Hand-to-Mouth, *Brookings Papers on Economic Activity*: 77-153.

Lenza, M., and Slacalek, J., 2018. How Does Monetary Policy Affect Income and Wealth Inequality? Evidence from the Euro Area, *ECB Working Paper No. 2190*.

Lenza, M., and Slacalek, J., 2022, How Does Monetary Policy Affect Income and Wealth Inequality? Evidence from Quantitative Easing in the Euro Area, Mimeo, European Central Bank.

Liu, Y., Yang, D., and Zhao, Y., 2022. Housing Boom and Headline Inflation: Insights from Machine Learning, *IMF Working Paper 2022/151*.

Kaplan, G., Moll, B., and Violante, G.L., 2018. Monetary Policy according to HANK, *American Economic Review*, 108 (3): 697-743.

Meh, C., Rios-Rull, J., and Terajima, Y., 2010. Aggregate and Welfare Effects of Redistribution of Wealth under Inflation and Price-Level Targeting. *Journal of Monetary Economics*, 57 (6): 637-652.

Newman, S.J., and Holupka, C.S., 2014. Housing Affordability and Investments in Children. *Journal of Housing Economics*, 24: 89-100.

Newman, S.J., and Holupka, C.S., 2015. Housing Affordability and Child Well-being. *Housing Policy Debate*, 25 (1): 116-151.

Otrok, C., and Terrones, M., 2005. House Prices, Interest Rates, and Macroeconomic Fluctuations:

International Evidence. *Conference paper, Federal Reserve Bank of Atlanta*.

Seitz, W., 2021. Urbanization in Kazakhstan: Desirable Cities, Unaffordable Housing, and the Missing Rental Market. *International Journal of Urban Sciences*, 25, Sup. 1.

Ungerer, C., 2015. Monetary Policy, Hot Housing Markets, and Leverage. *Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series, No. 2015-048*.

Williams, J.C., 2016. Measuring the Effects of Monetary Policy on House Prices and the Economy. *BIS Paper No. 88*.

Yiu, C.Y., 2021. Why House Prices Increase in the COVID-19 Recession: A Five-Country Empirical Study on the Real Interest Rate Hypothesis. *Urban Science*, 5 (4), 77: 1-14.

Zhao, Y., 2019. Evidence of Government Subsidy on Mortgage Rate and Default: Revisited. *Journal of Housing Research*, 28 (1): 23-49.

Zhao, Y., 2020. U.S. Housing Market during COVID-19: Aggregate and Distributional Evidence. *COVID Economics*, 50: 113-154.

Zhao, Y., 2021. Got Hurt for What You Paid? Revisiting Government Subsidy in the U.S. Mortgage Market. *Journal of Real Estate Literature*, 29 (2): 115-148.