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Housing and the Long-Term Real Effects of Changes in Trend Inflation

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1 Introduction

Whether the level of anticipated and stable inflation has real economic impacts remains highly debated. Indeed, a number of economists argue that an increase in a central bank's inflation targets would not impose economic costs since moderate levels of inflation have little economic impact (e.g., Ball 2013; Blanchard, Dell'Ariccia, and Mauro 2010). Central to this view is that the distortions of anticipated inflation arise from (modest) nominal rigidities related to changing prices. In contrast, others argue that moderate levels of inflation have real costs due to the incomplete indexation of taxes (e.g., Feldstein 1997; Altig et al. 2024). However, less attention has been devoted to asking whether the *structure* of standard fixed-amortization debt contracts results in anticipated inflation having real effects.

We show that an economy with fixed-amortization mortgages and borrowing-constrained consumers leads to anticipated and stable (which we term "trend") inflation having real impacts on consumers' housing, consumption, and borrowing decisions. We focus on mortgages for two reasons. First, mortgages are the most important liability of most households, accounting for over three-quarters of US consumer debt, while housing expenditures are a large share of total consumption. Second, mortgage contracts in the US (and most developed economies) see *nominal* payments set for a fixed amortization period (typically 30 years). Since the nominal monthly payment increases with the nominal interest rate, for a given real interest rate, higher trend inflation shifts up nominal mortgage payments via the Fisher equation. For borrowing-constrained households, a higher initial payment limits spending on non-housing consumption, which creates a trade-off between the timing of buying a house and non-housing consumption.

To quantify the impact of inflation on households' debt and housing demand, we extend an incomplete markets housing tenure choice model with fixed-amortization mortgages by embedding the standard relationship whereby trend inflation proportionately shifts nominal interest rates and income growth. We first show—analytically in a simplified two-period version of our model and quantitatively in our calibrated model—that the level of anticipated inflation has a real impact on life-cycle housing consumption and mortgage debt. We prove analytically that when households are borrowing-constrained, the tilt in the payment-to-income (PTI) profile caused by higher inflation leads to smaller homes and lower non-durable consumption for young homeowners. Using our calibrated model, we find that a 1 percentage point increase in inflation lowers the *steady-state* home ownership rate by more than 0.1 percentage points, reduces DTI by 0.7–1.2 percentage points and increases mortgage refinancing by 0.8 percentage points. Second, motivated by the sharp fall in trend inflation in the 1980s and proposals for central banks to increase their inflation targets (e.g., Ball

2013; Blanchard, Dell'Ariccia, and Mauro 2010), we examine the transitional dynamics between steady states following an unanticipated, permanent change in trend inflation. We find that a change in inflation—such as that following a change in the inflation target—results in prolonged transitions of over 20 years before home ownership and DTI reach their new steady-state values. The housing market dynamics of these transitions differ with the mortgage term—i.e., fixed-rate mortgages (FRMs) versus adjustable-rate mortgages (ARMs)—as well as refinancing costs. Finally, consistent with our analysis, we show that the fall in trend inflation in advanced economies in the 1980s, and in southern eurozone countries in the 1990s run-up to the euro, was followed by a rise in mortgage debt.

The impact of trend inflation on nominal rates, nominal income growth, and the path of PTI and debt over a borrower's life is supported by empirical evidence. The "tilt effect" results in higher inflation leading to a faster decline in the real mortgage balance and the PTI and DTI ratios over the amortization period. We show that these predictions hold in the US data by comparing the early 1980s (when inflation was over 8%) with 2000 (when inflation was near 2%): mortgage PTI ratios in the Census and the American Community Survey (ACS) decline faster with a borrower's age in 1980 than in 2000. Using the Survey of Consumer Finances (SCF), we document that, conditional on mortgage age, the fraction of debt outstanding was lower in 1983 than in 2001.

We extend a standard life-cycle housing tenure choice framework by denominating income and debt in nominal terms where the (exogenous) level of inflation proportionately shifts (via the Fisher equation) nominal interest rates and nominal wages while keeping the (real) price of housing relative to the consumption good constant.[1] Households face stochastic income and make choices about whether to rent or buy a home, consumption, and borrowing. All borrowing takes place using collateralized mortgages with 30-year amortization and fixed nominal payments.[2] Household borrowing is constrained by a maximum loan-to-value (LTV) constraint, although mortgagors can refinance to extract equity by incurring a refinancing cost.

We calibrate the model to match the US life-cycle profile of home ownership, loan-to-value ratios, debt-to-income ratios and payment-to-income ratios in the 2001 SCF. This choice is consistent with our finding that the effects on housing markets of the 1980s fall in inflation were largely complete by 2001.[3] In our baseline, we set inflation at its 2001 value of 2.8%

[1]To avoid tracking the change in prices and interest rates due to inflation, we map the household's nominal budget constraint into real terms so that real mortgage payments depend on inflation and mortgage age.

[2]FRMs and ARMs are the most common US mortgages. In our steady-state analysis, where inflation and mortgage interest rates are fixed, there is little difference between an ARM and an FRM so long as the mortgage spread is the same, which is natural since there is no interest rate risk in steady state.

[3]It also avoids the housing price swings around the 2007 financial crisis.

and the mortgage origination (refinance) cost at 1%. As in the data, in the calibrated model, PTI declines over the life cycle, and there are a number of younger, low-wealth homeowners with a significant PTI.

Trend inflation affects consumers' decisions: the higher anticipated inflation is, the lower home ownership (particularly for younger households) and (aggregate) DTI. In our calibrated model with a 1% refinancing cost, a 1 percentage point increase in inflation leads to 0.12 percentage point lower home ownership and a 0.7 percentage point decrease in steady-state DTI for annual inflation between 0% and 14%. These effects are driven by higher inflation increasing nominal interest rates and thus mortgage payments, which increases the PTI ratio of younger households. One way for borrowing-constrained households to mitigate a high PTI is to refinance their mortgage to extract home equity and extend the amortization (to lower their PTI) so as to afford more non-housing consumption. Our experiments show that higher refinancing costs lower home ownership and amplify the impact of inflation on DTI by making it more costly for borrowing-constrained households to relax a high PTI at origination by subsequently refinancing. With a cost of 2.5% (similar to the early 1980s in the US), home ownership is nearly 3 percentage points lower, and a 1 percentage point increase in inflation leads to a decline of roughly 1.2 percentage points in DTI. A corollary is that financial innovations that lower refinancing costs have a larger impact on debt when inflation is high than when it is lower.

Motivated by historical episodes such as the disinflation of the 1980s, when monetary policy changed trend inflation, we use the calibrated model to study housing market transitions between steady states following an unanticipated, permanent change (i.e., an MIT shock) in trend inflation. The costly adjustment of life-cycle housing decisions leads to prolonged transitions—up to 20 years—between steady states following an unanticipated change from high (8%) to low inflation (2%). The prolonged transitions result from the costs of adjusting housing and the negative wealth shock to mortgagors, which slows the adjustment of homeowners. Surprisingly, the option to refinance an FRM leads to similar transitional dynamics as with an ARM for mortgage interest payments, home ownership and DTI following a *one-period decline* in inflation. In contrast, following *a gradual (anticipated) fall* in inflation from 8% to 2% over 18 years, the transition with FRMs differs from that with ARMs. In an ARM economy, home ownership and DTI converge smoothly to the new steady state. However, following a gradual fall in inflation, with FRMs, home ownership initially declines because interest rates at origination (by assumption) are based on inflation next period, and thus the expectation of lower rates as inflation falls leads some renters to delay buying.

Motivated by proposals that central banks should increase their inflation targets (e.g., Ball 2013; Blanchard, Dell'Ariccia, and Mauro 2010), we examine an unanticipated *increase* in inflation from 2% to 5%. Our experiments show that a higher target would lower home ownership and that the transitions would be more prolonged with FRMs than with ARMs. After a fall in inflation, home ownership and debt converge more slowly with FRMs than ARMs. Central to this slower transition is the lock-in effect of mortgages originated in the 2% inflation steady state, which lowers refinancing activity. Combined with the wealth effect from lower real value of mortgage debt, the lock-in effect reduces transitions from home ownership to renting. As a result, the housing market transition and the extent of redistribution following an increase in a central bank's inflation target would differ between ARM and FRM economies.

We examine the implications of the 1980s fall in trend inflation in the US and other advanced economies. Using our calibrated model, we find that the fall in US inflation and refinancing costs during the 1980s and 1990s implies a 14 percentage point increase in steady-state DTI ratios, over half of the observed 26 percentage point increase from 1983 to 2001.[4] Our decomposition attributes nearly 70% of the rise in DTI to lower inflation back-loading debt payments (holding borrowing decisions fixed). Our experiment highlights a novel force that drives higher borrowing: lower nominal rates allow younger households to borrow more for the same initial PTI and thus buy a larger house. In our counterfactual, an increase in the average house size of young and middle-aged homeowners accounts for up to one-third of the increase in debt from 1983 to 2001. This increase in house size is qualitatively consistent with the increase in the average unit size among homeowners in the American Housing Survey (AHS).

We examine a transitional experiment that captures key features of the decline in US inflation and refinancing costs over the 1980s and early 1990s. Since most of the decline in inflation took place in the early 1980s, we find (consistent with our steady-state analysis) that the housing market transition is nearly complete by 2000. Although lower refinancing costs contributed to higher debt, financial innovations such as the rise in securitization are frequently cited as the main driver of the rise in US mortgage debt (e.g., Gerardi, Rosen, and Willen 2010; Iacoviello and Pavan 2013). We show that Canada (and other advanced economies) experienced a fall in inflation and rise in mortgage debt similar to those in the US from the early 1980s to 2000, but the timing and extent of securitization differed. We also document that the larger decline in inflation in Southern European countries in the run-up to the euro was followed by larger increases in mortgage DTI than Northern European countries experienced.

Our paper quantifies a novel channel through which anticipated inflation has real effects

[4] In our counterfactuals, we hold the real price of housing fixed, which is consistent with the data since real housing prices did not rise until the early 2000s.

due to the structure of fixed-amortization debt. Although incomplete indexation of the tax code has been shown to result in anticipated inflation having real effects (Altig et al. 2024; Feldstein 1997), little attention has been paid to how inflation interacts with debt contracts. Building on the observations of Kearl (1979) and Schwab (1982) that higher inflation front-loads real mortgage payments, we show that inflation has real effects, via housing market choices, on life-cycle consumption and debt.[5] Our findings provide an economic rational for why the level of nominal interest rates has been found to impact consumer housing decisions (e.g., Green and Wachter 2010) even in the absence of changes in real rates. More generally, our analysis implies that the effects of nominal variables such as inflation and interest rates may not be fully accounted for by models that examine only real variables.

Our analysis offers new insights into the debate over the macroeconomic implications of the 1980s fall in inflation and the drivers of higher mortgage debt. Surprisingly, although that event has been called "the most widely discussed and visible macroeconomic event" in recent US history (Goodfriend and King 2005), little work has documented long-lasting impacts on the real economy.[6] Our finding that the 1980s disinflation was a significant quantitative driver of the rise in mortgage debt helps account for the seemingly puzzling rise in debt during a period of relatively high real mortgage rates (Barnes and Young 2003; Dynan and Kohn 2007; Foote, Loewenstein, and Willen 2021).[7] A number of papers study what drove the rise in mortgage debt in the run up to the 2007 housing bust (Favara and Imbs (2015) and Justiniano, Primiceri, and Tabbalotti (2019)). While our paper does not directly contribute to the debate over the drivers of the early 2000s boom-bust, we show that much of the pre-2000 rise in debt can be accounted for by the Volcker disinflation and lower refinancing costs.

Our paper is related to estimates of wealth redistribution following an *unexpected* change in inflation (see, e.g., Doepke and Schneider 2006; Doepke, Schneider, and Selezneva 2019; Meh and Terajima 2011; Hedlund et al. 2025; Pugsley and Rubinton 2023). Our analysis shows that even *in the absence of inflation shocks*, the level of inflation has real impacts on housing markets and consumers. As a result, a permanent change in inflation results in a transition to a new steady state with different levels of home ownership and debt. We also show that the option to refinance leads to larger redistribution of mortgage interest payments between borrowers and lenders with FRMs when trend inflation *rises* than when

[5] Since most debt contracts calculate payments using a fixed amortization schedule, the effect of anticipated inflation could be amplified by consumer debt, such as auto loans and unsecured debts, and corporate debt.

[6] Nakamura et al. (2018) find little change in US price dispersion between the 1970s and early 1980s and later periods, which challenges the view that higher inflation distorts economic outcomes via increased price dispersion. Pugsley and Rubinton (2023) examine the welfare implications of the Volcker disinflation in a model where the real steady state effects of inflation are due to distorting consumer's cash holdings.

[7] Debelle (2004) argues that the mechanism we quantify was an important factor in the 1980s rise in debt.

it *falls*. The asymmetry is important for permanent changes in inflation, since the (net) benefits of refinancing are larger than after a transitory change in inflation.

A growing literature examines how the transmission of cyclical monetary policy is impacted by the term of mortgages and the pass-through of policy rate changes into mortgage rates (e.g., Auclert 2019; Berger et al. 2021; Garriga, Kydland, and Šustek 2017; McKay and Wolf 2023).[8] Our analysis shows that the choice of inflation target also has real impacts on consumers' decisions and housing markets. Although our analysis of transitions following a permanent change in tend inflation shares many channels with this literature, we show that a permanent change in trend inflation results in permanent changes in home ownership, debt, and refinancing. Our analysis also shows that a (monetary policy induced) change in trend inflation results in extended transmission lags of over 20 years which should be accounted for in empirical analysis of the impact of monetary policy on consumers' decisions.

There is substantial evidence that financial frictions lead to many consumers being borrowing-constrained (e.g., Boar, Gorea, and Midrigan 2022) and that refinancing is used to relax these constraints (Chen, Michaux, and Roussanov 2020). Although we do not impose a binding cap on PTI as in Greenwald 2018 or Ma and Zubairy 2021, we show that inflation affects households' housing and non-housing consumption choices via its effect on PTI. While our paper builds on recent work examining how the structure of mortgage markets affects household borrowing and ownership decisions (Boutros, Clara, and Kartashova 2025; Chambers, Garriga, and Schlagenhauf 2009), we differ in explicitly working with nominal variables and in our focus on the impact of trend inflation on housing.

The remainder of this paper is organized as follows. Section 2 presents several empirical facts and an example illustrating how inflation affects mortgage payments. Section 3 uses a two-period model to show analytically that the interaction between how inflation tilts the profile of mortgage payments and borrowing-constrained consumers leads to the non-neutrality of money. Section 4 outlines the quantitative model and Section 5 the calibration. In Section 6, we quantify how inflation impacts steady-state consumer choices and transitions after an unanticipated change in inflation. Section 7 examines the fall in US inflation during the 1980s, and Section 8 concludes.

2 Empirics and an Illustrative Example

In this section, we document key empirical observations that motivate our model, as well as evidence consistent with how trend inflation affects the mortgage DTI and PTI ratios over the

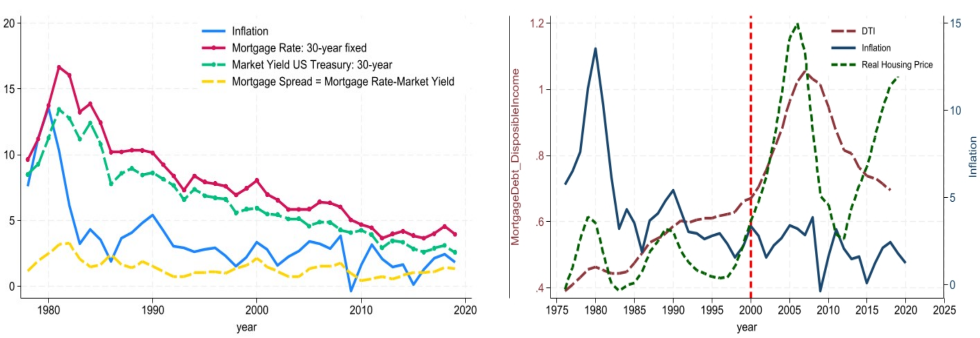
[8] MacGee and Yao (2024) show that the welfare costs of inflation vary with the elasticity of housing supply. This paper shows that the impact of a fall in trend inflation on housing is consistent with historical episodes.

amortization period. First, we show that sustained shifts in inflation translate into roughly proportional shifts in nominal interest rates. There has also been little systematic change in (the mortgage) spread between mortgage rates and Treasury yield. Second, the aggregate mortgage DTI ratio rose by more than 20% between the early 1980s and the late 1990s, despite there being little change in real house prices. We use a simple numerical example to illustrate how trend inflation shifts the profile of nominal income, mortgage payments to income, and outstanding debt over a 30-year amortization. We show that these patterns are qualitatively similar to changes observed in US data between the early 1980s when inflation was high and the end of the 1990s when inflation was near 2%.

2.1 Inflation, Interest Rates and Mortgage Debt

The Fisher equation implies that nominal interest rates vary with anticipated inflation. As is well known, this relationship holds empirically, as both the mortgage rate and the 30-year Treasury yield co-move with trends in inflation, with the early 1980s decline in inflation being followed by lower nominal interest rates (Figure 1.a). Although there has been little secular change in the spread between the mortgage rate and Treasuries (e.g., see Bartscher et al. 2025), real rates during the 1980s and 1990s were somewhat high (Barnes and Young 2003).

Figure 1: Inflation and Mortgage Rates, House prices and Households' Debt-to-Income Ratio



(a) Mortgage Rates and Inflation

(b) Inflation, DTI, and House Prices

Note: Panel (a) presents the average 30-year fixed-rate mortgagee, the market yield on US Treasury securities at 30-year constant maturity and inflation measured by the consumer price index (CPI). Panel (b) reports DTI measured by one to four family residential mortgage liability of households and non-profit organizations to disposable personal income. The US real house price index is the Federal Housing Finance Agency all-transactions house price index deflated by CPI. All series are annual and from FRED.

There was a striking rise in the DTI ratio of US residential mortgages of roughly 20 percentage points between 1980 and 2001 (see Figure 1.b). This rise does not appear to be driven by house prices, as real house prices did not see a sustained rise until after 2001. The rise in DTI before 2000 was not reversed by the fall in debt after the 2008 global financial crisis.

2.2 Inflation, Income, Mortgage Payments and Debt

We use a simple numerical example to illustrate how higher trend inflation tilts the PTI and DTI ratios of a borrower. For a given mortgage, the higher nominal interest rate associated with higher trend inflation results in higher nominal payments. Higher inflation also implies a faster growth rate of nominal income. These two forces imply that the higher trend inflation is, the higher the mortgage PTI ratio is at origination and the faster it declines over time. As a result, real mortgage payments and the PTI ratio are front-loaded when inflation is high and the average DTI ratio of a borrower over the amortization is decreasing in trend inflation. Using the SCF and Census, we show that these predictions are consistent with US data.

Standard economic intuition links average nominal wage growth to average inflation (Sanchez 2015). This relationship is important because higher nominal wage growth implies a faster decline in a borrower's PTI and DTI ratios over the amortization of a mortgage. In Figure 2.a, we plot the real wage profile from our calibrated economy (see Section 5) and nominal life-cycle earnings for 2% and 8% inflation. A 6 percentage point difference in inflation has a large impact on nominal income levels over a working life. We use the Current Population Survey (CPS) to illustrate this relationship by constructing nominal and real wage growth for two cohorts: the first cohort, born in 1955, experienced high inflation during the 1980s, with inflation averaging 5.6% when they were aged 25 to 35, and the second cohort, born in 1975, experienced inflation that averaged 2.6% (see Figure 2.b). Despite similar real wage growth, nominal growth was 50% higher for the 1955 cohort than the 1975 cohort by age 35.

Inflation has a large effect on the profile of PTI and DTI ratios over a mortgage's amortization. Our example examines a $D = \$200,000$ mortgage with a 30-year amortization in a 2% inflation versus 8% inflation environment.[9] Consistent with the Fisher equation, the nominal mortgage interest (r_m) depends on the real rate (fixed at $r = 2\%$) and inflation π, i.e., $1 + \bar{r}_m = (1 + \pi)(1 + r)$. According to the annuity formula (Equation 1), higher mortgage rates shift up the scheduled nominal payment m for fixed-amortization contracts—from

[9] Our example focuses on a fixed mortgage and housing choice so as to isolate the direct effect of inflation on payments and debt with fixed-amortization mortgages.

\$11,428 at 2% to \$21,385 (nearly double) for 8% inflation.

$$m = \frac{\bar{r}_m D}{(1 - (1 + \bar{r}_m)^{-N})} \tag{1}$$

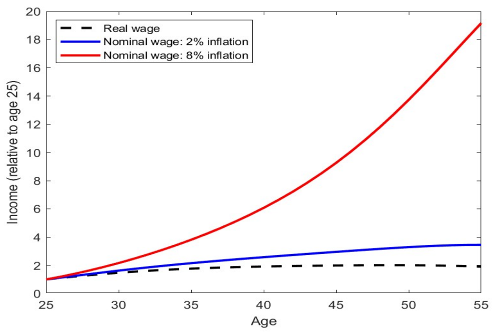
Since higher trend inflation means faster nominal income growth (see Figure 2.a, b) and higher nominal interest rates, for a fixed house purchase price and down payment, higher inflation increases the *initial* PTI ratio and *quickens* the decline over the amortization (see Figure 2.c). Inflation also affects the evolution of (real) mortgage debt: debt (in real terms or measured by the DTI ratio) is paid down faster when inflation is higher. After 10 years, at 8%, roughly 42% of the (real) debt remains, while at 2%, roughly 67% remains (Figure 2.e). Thus, the DTI ratio 10 years after origination is 60% (67/42) higher when inflation is 2% compared to 8%.

To evaluate whether these patterns are consistent with the data, we first compare PTI ratios by age and debt outstanding by mortgage age in the early 1980s (when inflation was high) and the 2000s (when inflation was near 2%). Figure 2.d plots the PTI using the 1980 Census and the 2016 ACS.[10] Consistent with the front-loading of payments under higher inflation, the cross-section of PTI declines faster in 1980 than in 2016. Next, we compare the real balance over the amortization in 1983 and 2016 using the SCF since it reports the year of origination and the outstanding balance. We deflate nominal outstanding debt by the consumer price index (CPI) to compute the real value and the fraction outstanding by mortgage age. Consistent with the evolution of real debt in our illustrative example (see Figure 2.e), households pay down their debt faster during the initial years of a mortgage under higher inflation (see Figure 2.f). The share of debt outstanding after 10 years is 40% in 1983 and 65% in 2016.

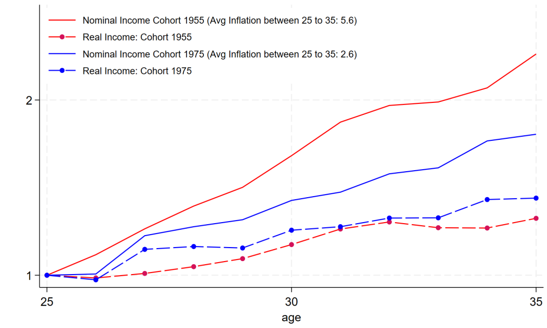
The implications of inflation for PTI and DTI ratios result from the structure of *fixed-amortization* mortgages rather than the term for which interest rates are fixed. For constant inflation, the PTI and DTI ratios for a borrower with an FRM or an ARM with the same amortization (and mortgage spread) would be identical. Although an interest-only mortgage would see a lower (higher) path of PTI compared to a standard 30-year amortization, the impact of inflation on the nominal mortgage payment is similar: higher anticipated inflation leads to a more front-loaded payment path and debt-to-income ratio (see Appendix A). This implies that although there are substantial differences across developed countries in the term of a mortgage (e.g., see Albertazzi, Fringuellotti, and Ongena 2024), the mechanism through which higher trend inflation results in a higher initial but faster decline of mortgage PTI

[10] We use household age to approximate mortgage age because the Census and the ACS do not report the origination.

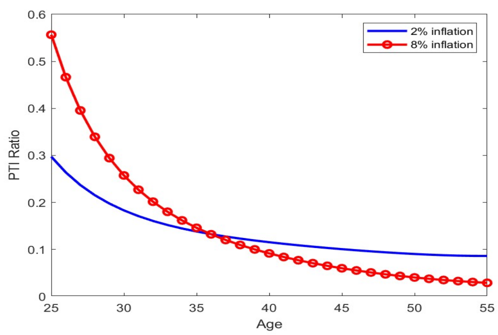
Figure 2: Inflation, Path of Payment-to-Income Ratio and Fraction of Outstanding Debt



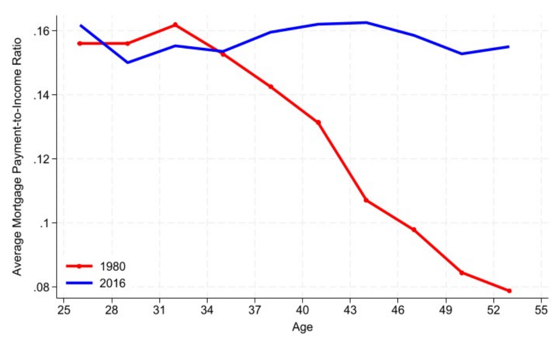
(a) Nominal Income: Theory



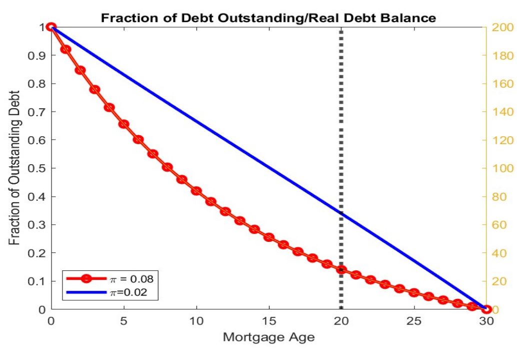
(b) Nominal and Real Wage Income: Data



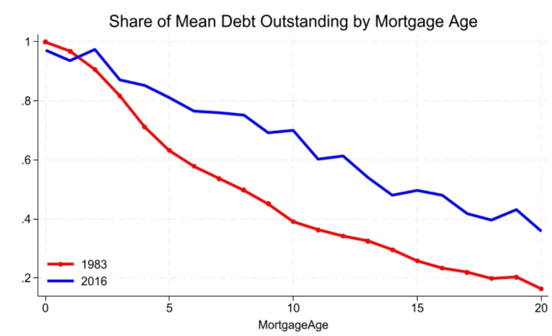
(c) Path of Payment-to-Income Ratio: Theory



(d) Payment-to-Income Ratio: Census and ACS



(e) Share of Outstanding Debt: Theory



(f) Share of Outstanding Debt: SCF

Note: Panels (a), (c), and (e) are calculations, and panels (b), (d), and (f) are the data counterparts. Panel (a) plots the average (real) labour income profile from the American Community Survey 2001 and nominal labour income profile for 2% and 8% trend inflation. Panel (b) plots average nominal and real income of full-time workers by age for the 1955 and 1975 cohorts using the CPS. Panel (c) shows the PTI ratio over a 30-year amortization for a $200,000 mortgage. Panel (d) computes the average annual mortgage payment divided by household labour income by age using the Census (wave 1980) and the 2016 ACS for homeowners with at least $5,000 annual income. Panel (e) plots the share of the mortgage paid out over the amortization under different trend inflation. Panel (f) computes the fraction of principal paid out by mortgage age using the 1983 and 2016 SCF (the ratio of the real value of the mortgage at origination to the real value of outstanding balances). Mortgage age is calculated using the interview and origination year.

ratios applies broadly.

Although the implications of trend inflation for the mortgage PTI ratio were documented in the 1970s, the implications for the real effects of anticipated inflation have (surprisingly) been largely ignored.[11] As we show, the structure of standard mortgages leads to the non-neutrality of money because the level of anticipated inflation has real effects on housing markets. Our illustrative example foreshadows how inflation could tilt the profile of life-cycle (non-housing) consumption. This effect is easiest to see for a hand-to-mouth borrower because non-housing consumption is simply $1 - PTI$. However, for any borrowing-constrained household, if we hold housing consumption fixed, then higher inflation tilts their non-housing consumption profile. This implies that changes in trend inflation may lead some borrowing-constrained households to vary either the timing or the size of the house they purchase as well as their mortgage borrowing. We formalize this intuition in the stylized two-period household choice problem in Section 3, and we use our quantitative model to estimate the quantitative impact of these forces in Section 6.

3 Two-Period Example

We use a simple two-period consumer problem to illustrate the key mechanism behind the real effects of trend inflation in our quantitative model. We show analytically that the combination of inflation tilting the profile of real payments with fixed-amortization mortgages and borrowing constraints distorts intra- and inter-temporal consumption decisions.[12] In the absence of borrowing constraints, the tilting of the profile of real mortgage payments caused by inflation does not distort consumption or housing as borrowing adjusts.

A two-period-lived household receives an endowment of 1 when young and $g > 1$ units when old of a composite good. Household preferences are represented by a separable utility function defined on consumption (c_1 when young and c_2 when old) and housing services, h:

$$\ln(c_1) + \eta \ln(h) + \beta \ln(c_2) \tag{2}$$

The relative price of housing to the composite good is fixed at P for both periods. The nominal price of housing and nominal income move proportionately with inflation π. Households

[11] The implications of inflation for mortgage payments and debt (and housing affordability) were prominent during the high inflation of the 1970s (e.g., Kearl (1979) and Lessard and Modigliani (1975)).

[12] Schwab (1982) shows similar results in a two-period model for the interaction between inflation and mortgage payments, but abstracts from how life-cycle forces amplify this mechanism. MacGee and Yao (2024) show how varying supply elasticities can amplify or dampen this mechanism in a similar two-period model.

can save (but not borrow) in a risk-free asset a with real return $1+r$ and nominal return $(1+\pi)(1+r)$. The only borrowing instrument is a fixed-amortization mortgage secured against the housing good with a nominal mortgage interest $\bar{r}_m = (1+r)(1+\pi) - 1$.

At the beginning of the first period, households choose the size of house h to buy. In our timing, inflation occurs during the period. We set the base period for all real values to the end of the first period (beginning of the second period), and thus the nominal house price at purchase is $\frac{P}{1+\pi}$. To simplify the algebra, we assume that there is no down payment (i.e., the LTV = 1) and thus the mortgage $D = \frac{Ph}{1+\pi}$. The mortgage amortizes over two periods with fixed nominal payments, $m = \frac{D(1+\bar{r}_m)^2}{2+\bar{r}_m}$, according to the annuity formula (Equation 1). At the end of the first period, households receive income 1, pay the first of two mortgage payments, save and consume. The budget constraint for the young is:

$$c_1 + \frac{D(1+\bar{r}_m)^2}{2+\bar{r}_m} + a = 1, \qquad a \geq 0 \tag{3}$$

Households enter the second period with housing h, saving a and debt $\frac{D(1+\bar{r}_m)}{2+\bar{r}_m}$. At the end of the second period, households receive income $g(1+\pi)$ and return on saving, pay their mortgage, sell the house, and consume their wealth. The budget constraint for the old is:

$$(1+\pi)c_2 + \frac{D(1+\bar{r}_m)^2}{2+\bar{r}_m} = (1+\pi)Ph + (1+\pi)g + (1+r)(1+\pi)a \tag{4}$$

Lemma 3.1. *For a given h, higher inflation increases the real mortgage payment and PTI ratio in the first period and lowers the real mortgage payment and PTI ratio in the second period.*

Proof. To finance h, the first-period PTI ratio is $\frac{D(1+\bar{r}_m)^2}{2+\bar{r}_m} = \frac{Ph(1+\bar{r}_m)(1+r)}{2+\bar{r}_m}$, which increases in inflation π though $\bar{r}_m$. The second-period PTI ratio is $\frac{D(1+\bar{r}_m)^2}{(2+\bar{r}_m)(1+\pi)g} = \frac{Ph(1+r)^2}{(2+\bar{r}_m)g}$, which decreases in π. The young DTI ratio $\frac{Ph(1+r)}{2+\bar{r}_m}$ (after the first installment) also decreases with π. □

To illustrate how inflation interacts with borrowing constraints, we allow households to borrow up to their intertemporal budget constraint at the same interest rate as for saving by dropping the constraint ($a > 0$). The lifetime budget constraint can be expressed as:

$$c_1 + \frac{c_2}{1+r} + \frac{(r^2+2r)Ph}{1+r} = 1 + \frac{g}{1+r} \tag{5}$$

where $\frac{(r^2+2r)Ph}{1+r}$ represents the forgone interest on the house. Noticeably, the lifetime budget constraint is independent of inflation. As a result, households' optimal consumption and housing are independent of inflation. However, saving a decreases with inflation because households respond to the shift in real mortgage payments from the second to the first period by reducing saving (borrowing more).[13]

Theorem 3.2. *When households are borrowing-constrained,* $(\frac{1+\frac{g}{1+r}}{1+\beta+\eta})[1+\frac{(1+r_m)(1+r)}{2+r_m}\frac{\eta}{\frac{r^2+2r}{1+r}}] > 1$, *an increase in inflation tightens the constraint and reduces house size, DTI ratio, and first-period consumption and increases consumption in the second period.*

Proof. See Appendix. □

The two-period model shows that the interaction between how inflation tilts the profile of payments for a fixed-amortization mortgage and borrowing constraints leads to anticipated inflation having real effects on life-cycle housing and consumption. As a result, calibrating a life-cycle housing model by deflating nominal interest rates and nominal income growth by inflation will not capture the real effects of inflation on consumer decisions since it does not account for how inflation tilts the PTI profile. Our numerical experiments show that these effects are large enough to help account for medium-run macrotrends in housing markets following permanent changes in inflation, such as the 1980s Volcker disinflation.

The mechanism we examine is missing from common specifications of how mortgages enter budget constraints in dynamic stochastic general equilibrium (DSGE) models. For example, consider an infinitely lived household environment in the spirit of Iacoviello (2005), where mortgagors face a maximum LTV constraint and a flow constraint of the form $P_t c_t + (1+\bar{r}_m)D_t = P_t w_t + D_{t+1}$. In steady state, the level of inflation cancels out the flow budget constraint, and thus trend inflation does not impact household choices.[14] This result follows since this budget constraint abstracts from how fixed-amortization mortgages tilt the real profile of mortgage payments.

The two-period model illustrates that anticipated inflation can impact decisions about consumption and home ownership. Over a consumer's life, other costs—such as mortgage refinancing costs and the costs of buying and selling homes—as well as the life-cycle earnings profile are likely to influence the quantitative impact of inflation on consumers. We use our quantitative life-cycle housing tenure choice model—which incorporates these features—to quantify the impact of inflation on life-cycle consumption and housing.

[13]If mortgage lending is costly (i.e., there is a spread between borrowing and saving rates), Equation 5 no longer holds and inflation affects consumption.

[14]This is consistent with a constant PTI (and DTI) ratio for different steady-state inflation levels given by $(1+\bar{r}_m)D\bar{T}I\frac{P_{t-1}w_{t-1}}{P_t w_t} - D\bar{T}I = \frac{(1+\bar{r}_m)}{1+\pi}D\bar{T}I - D\bar{T}I = rD\bar{T}I$.

4 Model

To quantify the impact of trend inflation on household debt, housing, and consumption, we develop a small open economy, life-cycle, housing tenure choice model.[15] Each period, households choose consumption of a non-durable good and housing services, which can be obtained by owning or renting. Compared to renting, owning is attractive since it provides a higher service (utility) flow. Although renters can adjust their housing services each period without cost, buying or selling a house incurs transaction costs. In addition, each new mortgage incurs a closing (refinancing) cost.

We model trend (steady-state) inflation via how it affects real mortgage payments and real debt outstanding in the budget constraint, based on mortgage age. Our specification is equivalent to writing the budget constraint in nominal terms where the numeraire good price, house prices, rents, nominal wage, and nominal interest rates grow at the same rate as inflation, while nominal mortgage payments are fixed over amortization. The real rate of return on savings, r, is exogenous and does not change with inflation.

4.1 Households

The economy is populated by J-period-lived overlapping generations of ex ante identical households who face mortality risks and uncertain labour income over their life. Households draw initial wealth from a distribution Γ at birth. Households' preferences about the non-durable good C and housing services h are represented by

$$u(C,h) = \frac{((1-\eta)C^{1-\xi}) + \eta(\theta h)^{1-\xi})^{\frac{(1-\sigma)}{1-\xi}}}{1-\sigma} \tag{6}$$

where the ownership premium θ captures the additional value of owning compared to renting housing services h.[16] The share η captures the relative importance of housing compared to non-durable consumption, while $\frac{1}{\xi}$ measures the substitutability between housing and non-housing consumption, and σ is the elasticity of intertemporal substitution.

For each period j, the objective function of the household is defined by

$$V_j = \frac{((1-\eta)C_j^{1-\xi}) + \eta(\theta h_j)^{1-\xi})^{\frac{(1-\sigma)}{1-\xi}}}{1-\sigma} + \beta_j s_j V_{j+1} + \beta_j(1-s_j)B(W_{j+1}) \tag{7}$$

[15] Our model is largely standard, with features similar to those of models such as Gervais (2002).

[16] As discussed in Yao 2019, most owners live in detached homes and most renters in apartments. Therefore, the price and rent observed in the data are for housing units that are not directly comparable. θ is calibrated to home ownership rates and captures the utility difference between a detached house and an apartment.

where β_j is the age-specific discount factor that captures the deterministic changes in household size and composition (i.e., McClements scale), s_j is the probability of surviving from age j to age $j+1$, C_j is consumption at j, and h_j is housing services at j. With probability $1-s_j$, the household dies and receives bequest motive $B(W_{T+1})$, where W_{j+1} is the wealth left by a household (savings plus net home equity for owners). Following the literature (e.g., Guren et al. 2021), we assume the following bequest motive functional form:

$$B(W_{T+1}) = \frac{B_0(B_1 + W_{T+1})^{1-\sigma}}{1-\sigma} \tag{8}$$

There are three assets in this economy: housing, risk-free bonds, and mortgages. Households can save through a risk-free bond that pays real interest r. Homeowners pay a maintenance cost, δ, and property tax τ_h, both proportional to the house value Ph. A homebuyer incurs a proportional (to the house value Ph) transaction cost of k_b, and a seller incurs a proportional transaction cost of k_s. The minimum size of an owner-occupied house is $\underline{h}$.

At the beginning of each period, households receive real wage income that depends on the average income $\bar{w_j}$ of age j and an idiosyncratic shock ϵ where $y(j,\epsilon) = \bar{w_j}\epsilon_i$. The idiosyncratic shock ϵ_i follows an AR(1) process, $\epsilon_{i,j+1} = \rho\epsilon_{i,j} + \upsilon$, where $\rho \in [0,1]$ and υ follows a normal probability distribution with mean 0 and standard deviation of σ_υ. Following Kaplan, Mitman, and Violante (2020), tax rate $\tau(y)$ increases with income y according to $\tau(y) = \tau_0 + \tau_1(log(y) - log(\bar{y}))$, where $\tau(y)$ is $\bar{y}$ is the average income of all households and τ_0 and τ_1 are positive.

4.2 Mortgages

Households can borrow only via collateralized credit.[17] Mortgages are N-period fixed-amortization contracts that incur a financing cost of τ_m at origination (i.e., τ_m applies to new borrowers and refinancing owners). A mortgage is defined by interest, nominal mortgage payments, and nominal debt outstanding from the period after origination t_0+1 to t_0+N.[18] Although we consider fixed- and adjustable-rate mortgages, we abstract from the choice of mortgage type since an FRM and an ARM are identical in the steady state.

At the beginning of each period t, inflation π_t is realized and interest $r_{m,t}(n)$ accrues to the previous period's nominal debt $D_{t-1}(n-1)$. At the end of t, households receive income, make mortgage payments, adjust their housing and mortgage debt, save, and consume. The FRM rate is fixed over the amortization $n = 1, ...N$. As payments on an FRM at time

[17] This is a common assumption in the literature; see for example Yang (2009) and Sommer, Sullivan, and Verbrugge (2013).

[18] In the simulation, we convert mortgage payments and debt into real terms evaluated at origination.

t_0 start from the following period, t_0+1, the rate depends on expected inflation in t_0+1, $E_{t_0}(\pi_{t_0+1})$. For an ARM, the rate at $t \in \{t_0+1, t_0+2, ...t_0+N\}$ depends on realized inflation π_t. Equation 9 summarizes the mortgage rates:

$$1 + r^i_{m,t}(n) = \begin{cases} (1 + E_{t_0}(\pi_{t_0+1}))(1+r)(1+\zeta_m), & \text{if } i \text{ is FRM} \\ (1+\pi_t)(1+r)(1+\zeta_m), & \text{if } i \text{ is ARM} \end{cases} \tag{9}$$

where $t_0 = t - n$ denotes when the mortgage is originated, r is the real risk-free rate, ζ_m is the spread, and $E_{t_0}(\pi_{t_0}) = \pi_t = \bar{\pi}$ in steady state.

4.2.1 The Evolution of Debt and Mortgage Payments

Nominal: The nominal outstanding balance on a mortgage of amount D originated at t_0 over the amortization periods $n \in \{1, 2, .., N\}$ is

$$D^i(n) = (1 + r^i_{m,t}(n))D^i(n-1) - m^i_t(D(n-1)) \tag{10}$$

where $D^i(n-1)$ is the previous debt balance and $m^i_t(D(n-1))$ is the mortgage payment:

$$m^i_t(D(n-1)) = \frac{r^i_{m,t}(n)D^i(n-1)}{1 - (1 + r^i_{m,t}(n))^{-(N+1-n)}} \tag{11}$$

For a fixed-rate mortgage, $r^i_{m,t}(n) = r_{m,t_0}$, $m^i_t(n) = \frac{r_{m,t_0}D(0)}{1-(1+r_{m,t_0})^{-N}}$ is constant.

Real: Real mortgage payments $\tilde{m}^i$ and real outstanding debt after the mortgage payment $\tilde{D}^i(n)$ at period t using period t_0 as the reference period is given by

$$\begin{aligned} \tilde{D}^i(0) = D; \quad \tilde{D}^i(n) &= \frac{D^i(n)}{\prod_{k=0}^{n-1}(1+\pi_{t-k})} \\ \tilde{m}^i_t(D(n-1)) &= \frac{m^i_t(D(n-1))}{\prod_{k=0}^{n-1}(1+\pi_{t-k})} \end{aligned} \tag{12}$$

where $\prod_{k=0}^{n-1}(1+\pi_{t-k})$ is the product of realized inflation since origination.

4.3 Households' Recursive Problem

The state variables of a household, $\Lambda = (a, h, D, n, \epsilon, j)$, are their age j, house size h, savings a, the previous period mortgage balance D, mortgage age n, and the income shock ϵ.

At the beginning of each period t, a household i receives their after-tax wage income $y(j, \epsilon)$, chooses housing services, mortgage, saving, and consumption of the non-durable good. We group households into one of three situations with respect to housing and mortgage choices.

Households choose to rent: A household who decides to rent chooses the size of rental unit x, consumption c, and saving a' to maximize:

$$\begin{aligned} V^1(a,h,D,n,\epsilon,j) &= \max_{c,x,a'} u(c,x) + \beta_j s_j E_{\epsilon'|\epsilon}(V(a',0,0,0,\epsilon',j+1)) + \beta_j(1-s_j)B(a') \\ s.t.\;\; c + a' + Rx &= y(j,\epsilon) + (1+r)a + (1-k_s)Ph - \frac{(1+r^i_{m,t})D}{\prod_{k=0}^{n-1}(1+\pi_{t-k})} \end{aligned} \tag{13}$$

where R is the real rental rate and $y(j,\epsilon)$ is real after-tax labour income. If the household is an owner, choosing to rent requires selling their house (they cannot simultaneously own and rent), and $(1-k_s)Ph$ is the income net of the selling cost. $\frac{(1+r^i_{m,t})D}{\prod_{k=0}^{n-1}(1+\pi_{t-k})}$ is the real value of the mortgage balance. $E(.)$ denotes the expected value given current housing and mortgage decisions over future income shocks ϵ'. Renters enter the next period with $h'=0$ and $D'=0$. $\beta_j(1-s_j)B(a')$ is the value of bequest a'.

Owners continue with their current mortgage contract: An owner with a house $h>0$ and outstanding mortgage loan D originated n years previously consumes housing services and chooses consumption c and savings a' to maximize her utility:

$$\begin{aligned} &V^2(a,h,D,n,\epsilon,j) = \max_{c,a'} u(c,\theta h) + \beta_j s_j E_{\epsilon'|\epsilon}(V(a',h,D',n+1,\epsilon',j+1)\mathbb{1}_{n<N} \\ &+ V(a',h,0,0,\epsilon',j+1)\mathbb{1}_{n=N}) + \beta_j(1-s_j)B(a') \\ &s.t.\;\; c + a' = y(j,\epsilon) + (1+r)a - (\delta+\tau_h)Ph - \tilde{m}(D(n)) \\ &D' = (1+r^i_{m,t}(n))D - m(D(n)) \end{aligned} \tag{14}$$

where $\tilde{m}(D)$ is the real mortgage payment (see Equation 12), and $(\delta+\tau_h)Ph$ is the maintenance cost and property tax. $n=N$ denotes the last period of the amortization, and the household would be debt-free from the next period, i.e., $D'=0$ and $n'=0$.

Households choose a new mortgage: This includes when a renter becomes an owner, an owner changes their house size, or an owner refinances without changing house size. A household chooses house h', mortgage contract D', savings a', and consumption c to maximize:

$$
\begin{aligned}
&V^3(a,h,D,n,\epsilon,j) = \max_{c,h',D',a'} u(c,\theta h') + \beta_j s_j E_{\epsilon'|\epsilon}(V(a',h',D',1,\epsilon,j+1)) + \beta_j(1-s_j)B(a') \\
&s.t.\;\; c + a' + Ph' = y(j,\epsilon) + (1+r)a - (\delta+\tau_h)Ph' - (k_sPh + k_bPh')\mathbb{1}_{h\neq h'} \\
&+ Ph - \frac{(1+r^i_{m,t})D}{\prod_{k=0}^{n-1}(1+\pi_{t-k})} + (1-\tau_m)D' \\
&D' \leq (1-\chi)Ph' \qquad \frac{r^i_{m,t}(n)D'}{(1-(1+r^i_{m,t})^{-N})(w_j\epsilon)} \leq \varphi.
\end{aligned} \tag{15}
$$

In the budget constraint, $(k_sPh + k_bPh')\mathbb{1}_{h\neq h'}$ is the transaction costs of buying and selling a house when households adjust house size, $h \neq h'$. There is no transaction cost for a household refinancing their mortgage ($h = h'$), but they are subject to a refinancing cost τ_m. $Ph - \frac{(1+r^i_{m,t})D}{\prod_{k=0}^{n-1}(1+\pi_{t-k})}$ is real home equity for a previous owner. Similar to Greenwald (2018), we include a maximum LTV and a PTI restriction on new mortgages in the last line.

Households with state variable $\Lambda = (a,h,D,n,\epsilon,j)$ choose between renting, continuing with their mortgage, or refinancing.

5 Parameterization

We calibrate the model using generalized method of moments to match the 2001 US age profile of home ownership rates and loan-to-value, debt-to-income, and payment-to-income ratios.[19]

5.1 Externally Calibrated Parameters

Households are born at age 23, retire at 64, and live up to 81. Each period corresponds to two years. The survival probabilities are from the National Center for Health Statistics, United States Life Tables, 2016. The age-specific discount factor is calibrated to the life-cycle evolution of household size.[20] Following the literature (e.g., Guren et al. 2021; Kaplan, Mitman, and Violante 2020), the intertemporal elasticity of substitution σ is set to 2.

The annual risk-free interest rate is $r = 2\%$. In the baseline, we set inflation to $\pi = 2.8\%$, the average annual inflation between 1999 and 2001, and the mortgage spread to $\zeta_m = 1.5\%$

[19] As is common in the literature, we choose 2001 to avoid the boom and bust in the following years.

[20] This is equivalent to assuming the discount factor does not vary with age, but allowing for an age-specific ownership premium so as to capture how changes in life-cycle household size impact housing demand.

based on the difference between the mortgage rate in 2001 and the market yield on a 30-year Treasury bond. We set the annual property tax and depreciation cost at 1% and 1.5%, respectively, based on the average property taxes and owner costs reported in the ACS. Transaction costs for buyers and sellers are $k_b = 6\%$ and $k_s = 2\%$, respectively, based on estimates in the literature (Sommer, Sullivan, and Verbrugge 2013). The mortgage refinancing cost, $\tau_m = 1\%$, is the average of initial fees reported by the Federal Housing and Finance Agency (FHFA) between 1999 and 2001.

For the baseline calibration (which targets 2001), we set the minimum downpayment χ to 20% and set the cap on PTI φ to 1.[21] The initial wealth distribution is based on the 2001 SCF where initial wealth is correlated with the initial income realization.[22] We use the 2000 Census to compute the median house value of owners and the median gross rent.

We follow Kaplan, Mitman, and Violante (2020) and approximate the life-cycle income profile with a fourth-order polynomial and set the persistence of the annual income process ρ to 0.97 (biannual 0.941) and the annual standard deviation of earning shocks σ_v to 0.2. The standard deviation of two years (per period) is $(1 + \rho)\sigma_v$. The standard deviation of initial earnings is 0.42, such that the income variation grows with age (see, e.g., Heathcote, Perri, and Violante 2010). The income process is approximated by a seven-state Markov chain (Tauchen 1986). We set the income tax parameters τ_0 at 0.135 and τ_1 to 0.062, based on Guner, Kaygusuz, and Ventura (2014).

Table 1 summarizes the externally calibrated parameters.

5.2 Internally Calibrated Parameters

We use simulated method of moments to calibrate seven parameters: the discount factor β, housing share η, substitutability between housing and non-housing consumption ξ, ownership premium θ, minimum house size $\underline{h}$, and the bequest motive parameters B_0 and B_1. We target the age profile(s) of home ownership, LTV, mortgage DTI, and mortgage PTI ratios of owners. This gives 120 moments.

Although the parameters are estimated jointly, several are closely related to specific moments. The ownership premium θ targets mainly home ownership rates, since higher θ makes owning more attractive relative to renting. The minimum house size, $\underline{h}$, has the largest impact on the home ownership rates of young and old households with relatively less wealth

[21] The Dodd-Frank legislation, which mandates a lower φ, was introduced in 2010.

[22] We compute the value of assets for households aged 20 to 22 in the SCF. To construct the initial wealth distribution, we divide households into three groups based on mean income: those with income below 46% of mean income, income between 46% and 147% of mean income and income above 147% of mean income. For each group, the initial wealth is drawn from an exponential distribution with the mean wealth depending on the income group, with values of $3,048, $9,294 and $26,826.

Table 1: Externally Calibrated Parameters

Parameter	Value	Source
Annual risk-free interest rate	2%	Standard in the literature
Annual inflation rate π	2.8%	Inflation rate in 2001
Mortgage spread ζ_m	1.8%	FHFA
Annual property tax	1%	American Community Survey
Annual depreciation cost	2%	American Community Survey
Transaction cost for buyers, sellers	6%, 2%	Sommer, Sullivan, and Verbrugge (2013)
Mortgage closing cost	1%	Federal Housing Finance Agency 2001
Annual auto correlation of earnings ρ	0.97	Kaplan, Mitman, and Violante (2020)
Standard deviation of earning σ_ϵ	0.2	Kaplan, Mitman, and Violante (2020)
Down payment required χ	20%	LTV distribution
Cap on PTI φ	1	
Tax schedule τ_0, τ_1	0.135, 0.064	Kaplan, Mitman, and Violante (2020)

because they are more likely to be constrained by $\underline{h}$ when purchasing a home. The housing share in the utility function, η, and the substitutability between housing, the discount factor β, and the weight on non-housing consumption ξ are most closely related to the DTI ratio and thus the mortgage PTI ratios of owners. The bequest motive parameters, B_0 and B_1, influence the ownership rates and mortgage debts of older households.

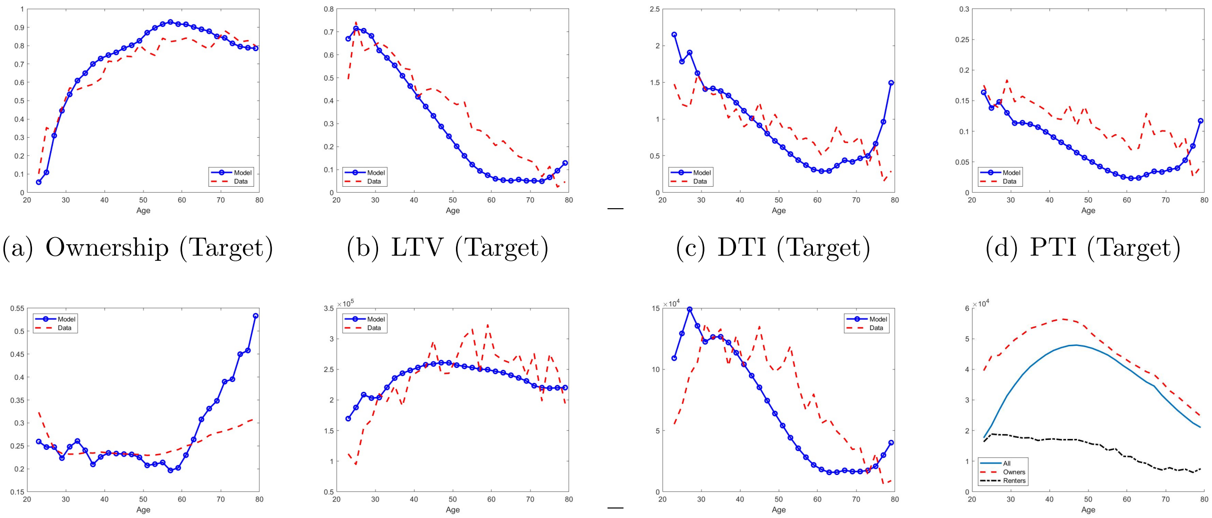
The internally calibrated parameter values are similar to those of related work (see Table 2). The calibrated model matches the targeted age profile of home ownership rates and LTV, DTI, and PTI ratios reasonably well (see Figure 3).

Table 2: Calibration Results

Parameter		Value	Target
β	Discount factor	0.9	Life-cycle LTV and DTI
η	Housing share	0.27	DTI
ξ	Substitutability	1.2	DTI and LTV
θ	Ownership premium	1.8	Home ownership rate
$\underline{h}$	Minimum house size	0.9	Home ownership rate
B_0	Bequest motive	13	Home ownership rate & mortgage loan
B_1	Bequest motive	0.1	of senior households

Our model replicates key US housing statistics, including several non-targeted moments: the rent-to-income ratio, average mortgage debt, and average house value (see Figure 3). The fraction of owners who do not move and refinance (increasing their balance) is 14.3% per period (7.15% annually), close to the estimates of Boar, Gorea, and Midrigan (2022). Although we do not directly target non-housing consumption, consistent with Foster (2015), non-housing consumption peaks between ages 45 and 50 at about twice the level of those aged 20 to 25 and those over 75 (see Figure 3.h). Behind this are different profiles for the

Figure 3: Benchmark Calibration



(a) Ownership (Target) (b) LTV (Target) (c) DTI (Target) (d) PTI (Target)

(e) Rent-to-Income (f) House Value: Owners (g) Debt: Owners (h) Consumption

Note: Targets are constructed using data from the 2001 SCF. LTV is the ratio of total mortgage debt to total house value of owners. DTI is the ratio of total mortgage debt divided by total household labour income of owners. PTI is the ratio of total mortgage payments divided by total household labour income of owners. Consumption is annualized non-housing consumption in 2001 dollars.

cross-section of homeowners and renters. As in the data, on average, homeowners have higher income than renters, and the non-housing consumption of owners is roughly three times that of renters (see Figure 3.h).

6 Counterfactual Experiments

We use our parameterized model to quantify the effect of the level of trend inflation on housing markets and the mortgage debt-to-income ratio. In our experiments, we vary steady-state annual inflation between 0% and 14%. We show that the level of trend inflation affects consumers' housing and non-housing consumption over the life cycle and that the steady-state mortgage DTI ratio is decreasing in trend inflation. We also find that higher mortgage refinancing costs lead to a larger impact of inflation on housing markets. This result is intuitive since refinancing allows borrowers with a high PTI ratio to lower their payments and increase non-housing consumption. A higher refinancing cost makes this option less attractive, which reduces the home ownership rate of younger households. We use the model to analyze the transitional dynamics after a permanent change in trend inflation. We find that it takes more than 20 years for ownership and DTI ratios to reach their new steady states and that transitional dynamics can differ between economies with FRMs or ARMs as well as refinancing costs.

6.1 Inflation and Housing in Steady State

We use our calibrated model to examine the steady state implications of trend inflation for life-cycle home ownership, consumption, and borrowing. In the top panels of Figure 4, we plot the difference between the life-cycle profiles for 8% inflation (close to US inflation in the early 1980s) and 2% (the current US inflation target). Higher inflation reduces ownership and average house size and steepens the life-cycle profile of consumption. Relative to the 2% steady state, at 8% inflation, home ownership is more than 1% lower, while non-housing consumption is lower for the young (those under 40) and higher for the 40- to 60-year-olds.

The real effects of anticipated inflation on consumers' decisions arise from higher inflation front-loading mortgage payments and PTI ratios (see Section 3). Young households who are not borrowing-constrained respond to inflation front-loading real mortgage payments by reducing their savings in the risk-free asset (see Figure 4.f). For borrowing-constrained households, a higher PTI ratio leaves less income for non-housing consumption.[23] Households respond to the tighter constraints imposed by higher inflation by postponing when they purchase, buying a smaller home, refinancing more often to extract equity for consumption or to extend the maturity of their mortgage, or postponing consumption to later in life.

All of these responses are at work in our experiments. As trend inflation increases, home ownership declines due to the complementarity between housing and non-housing consumption (see Figure 4.a, g). This effect is amplified by some young and middle-aged households purchasing a smaller home as the average house size falls with inflation (see Figure 4.d). The fraction of (especially younger) homeowners who refinance each period increases from 17% at 2% inflation to 26% at 8% inflation (see Figure 4.c). Despite these adaptations, the non-housing consumption of younger households is lower at 8% inflation than at 2% inflation (see Figure 4.b).

The change in steady-state debt is driven by two key forces. On the real side, the fall in average house size pushes down the DTI ratio of borrowers. The second force is that front-loaded mortgage payments (see Section 2.2) imply faster accumulation of home equity (see Figure 2.f). Combined with the fall in home ownership, these forces imply that the DTI ratio—total debt divided by total household income—is decreasing in trend inflation. As we

[23] Our experiments impose a maximum PTI ratio of 1, so the entire income can be spent on mortgage payments. Households internalize the implications of a high PTI ratio for non-housing consumption, and thus most mortgagors do not choose a high PTI ratio at origination. Imposing a (binding) PTI ratio cap as in Greenwald (2018) or Kaplan, Mitman, and Violante (2020) would imply even greater impacts of inflation on consumers.

vary inflation from 0% to 14% (with a refinancing cost of 1%), a percentage point increase in inflation results in a roughly 0.7 percentage point drop in the DTI ratio (see the top line in Figure 4.g).

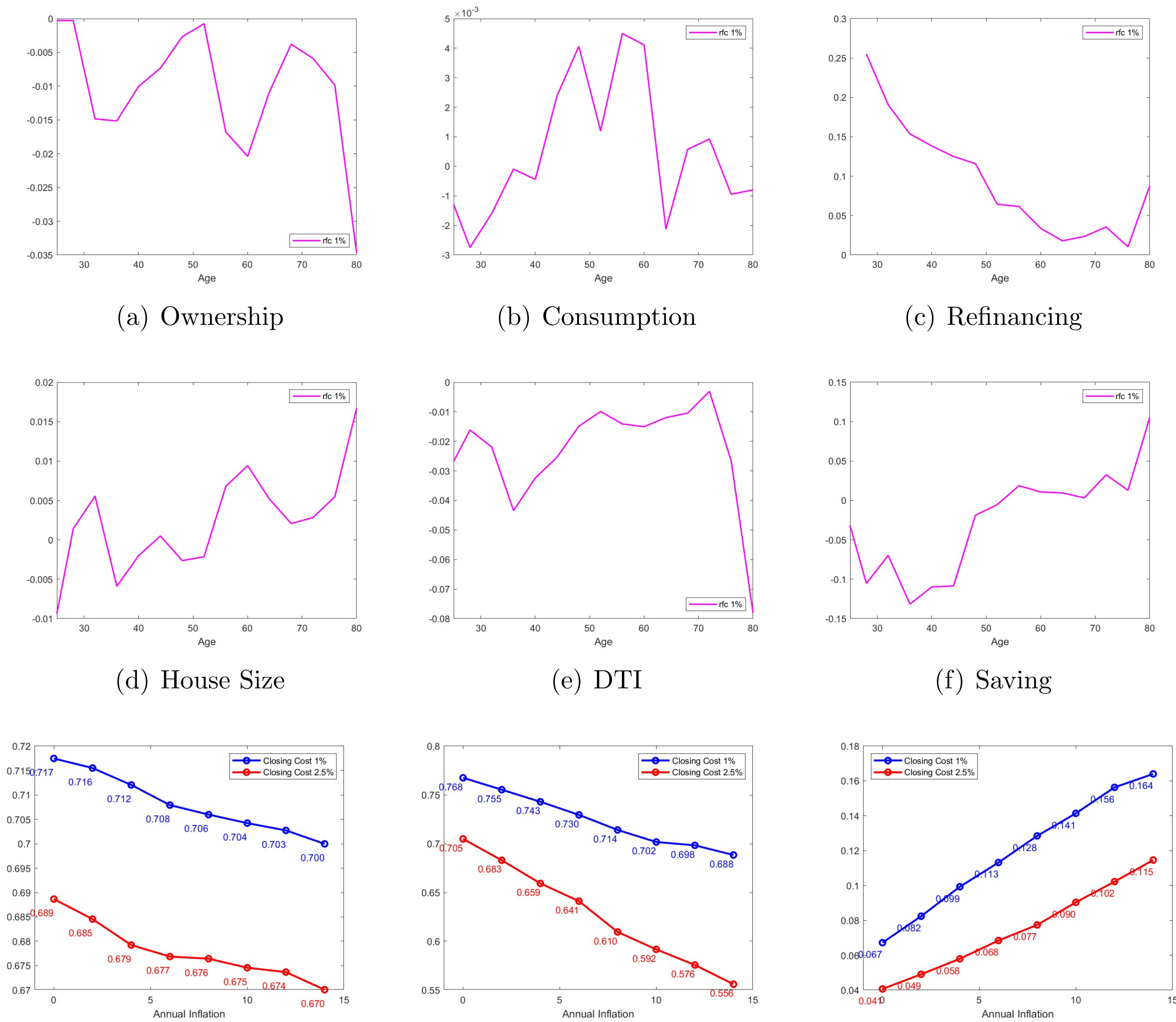
The level of refinancing costs affects the magnitude of the impact of trend inflation on housing. Refinancing helps consumers mitigate the distortionary impact of higher inflation: by refinancing a mortgage within a few years of origination, a mortgagor can lower their PTI ratio and thus increase expenditure on non-housing consumption (which flattens the life-cycle consumption profile). The refinancing costs in our baseline calibration are conservative for two reasons. First, they include only financial costs and abstract from a mortgagor's time costs (see, e.g., Boar, Gorea, and Midrigan 2022; Zhang 2022). Second, refinancing costs have varied over time and have frequently been well above 1%.

To quantify how higher refinancing costs amplify the effect of trend inflation on housing markets, we repeat our experiments for a refinancing cost of 2.5%, the level of closing costs in the early 1980s (FHFA). The difference between a refinancing cost of 1% and 2.5% is substantial. Home ownership is roughly 3 percentage points lower when refinancing costs are 2.5% (see Figure 4.g). In addition, higher trend inflation has a larger impact when refinancing costs are higher, with a larger fall in home ownership and house size and more "tilt" in life-cycle consumption. These effects are accompanied by a smaller difference in refinancing activity when comparing 2% and 8% inflation: the fraction of owners who increase their mortgage balance each period increases from 11% to 16% for a refinancing cost of 2.5% but from 17% to 26% for a refinancing cost of 1%. As a result, the fall in the DTI ratio for younger mortgagors is greater when refinancing costs are higher, and the aggregate DTI ratio is also more responsive to the level of trend inflation.[24] At 2.5%, the DTI ratio falls by 1.2 percentage points for each percentage point increase in inflation—nearly twice as much as at 1% refinancing costs (see Figure 4.g).

The steady-state experiments offer novel insights for the debate over the long-run non-neutrality of money. Our results show that the structure of standard fixed-amortization debt contracts and household borrowing constraints result in the long-run *non-neutrality* of money since the level of anticipated inflation distorts the composition and timing of life-cycle consumption. This is a novel perspective on the recent debate over how inflation impacts the real economy that has focused on how (and whether) the costly (or slow) adjustment of prices can lead to the long-run non-neutrality of money. In an important contribution, Golosov and Lucas Jr (2007) argue that state-dependent price setting leads to the near long-run neutrality of money. In related work, Nakamura et al. (2018) find little change in price dispersion during the high inflation of the 1970s, which challenges the view that higher

[24] See the online appendix for the plots with 2.5% refinancing cost.

Figure 4: Steady State Comparison



(a) Ownership (b) Consumption (c) Refinancing

(d) House Size (e) DTI (f) Saving

(g) Ownership (h) DTI (i) Refinancers

Note: Panels (a) through (f) plot the steady-state ownership rate, consumption, refinancing, house size among owners, DTI ratio, and saving by age under 8% inflation relative to 2% inflation with a refinancing cost of 1%. The share of owners refinancing is defined as the annualized fraction of owners who obtain a new mortgage with a higher balance without changing house size. Panel (g) plots the aggregate home ownership rate by inflation and mortgage refinancing cost. Panel (h) plots the aggregate DTI ratio by inflation and mortgage refinancing costs. Panel (i) shows the fraction of owners who refinance by increasing their debt balance.

inflation distorts economic outcomes through increased price dispersion. In our model—even without changes in relative prices—the interaction between the profile of payments on standard mortgage contracts and borrowing constraints results in anticipated inflation distorting the composition and timing of life-cycle consumption. In Section 7.1, we argue that the implications of our model for housing markets are consistent with the US experience (and that of other developed countries) following the sharp fall in trend inflation in the 1980s as well as the southern eurozone countries that experienced larger declines in inflation (and nominal interest rates) when they joined the euro (see Section 7.3).

One critique of our analysis is that we take the structure of mortgage contracts as exogenous. In practice, standard fixed-amortization mortgages have dominated mortgage markets in advanced economies for over 100 years.[25] Consistent with some households being borrowing-constrained, Cocco (2013) argues that alternative mortgage products (AMPs) that lowered payments in the initial years of the amortization were taken up by UK borrowers who were borrowing-constrained. Much of the UK AMP market described by Cocco (2013) consisted of interest-only (IO) mortgages. Importantly, higher inflation also front-loads (real) IO mortgage payments.[26] Overall, this suggests that AMPs are unlikely to offer an easy path to eliminating the non-neutrality of money that arises from standard mortgage contracts.

Our results also have implications for recent work using life-cycle housing models—for example, Iacoviello and Pavan (2013) and Sommer, Sullivan, and Verbrugge (2013)—which abstract from the level of inflation and calibrate to a real interest rate and life-cycle income profile. Our experiments (see Figure 4.g, h, i) show that abstracting from inflation when the level of inflation and refinancing costs are low does not have a large impact because the difference between 2% and 0% inflation for home ownership, DTI ratios and refinancing is modest.[27] However, when refinancing costs or inflation is higher, abstracting from inflation can be misleading. Our experiments show the quantitative impact of trend inflation at the levels of the early 1980s are significant and that a fall in refinancing costs has a larger impact on housing markets and debt when inflation is high than when it is lower. These results suggest that abstracting from the changes in trend inflation may misattribute the

[25] Green and Wachter 2005 report that while the ARM share of US mortgages rose during the 1980s, they continued to be primarily 30-year fixed amortization. Similarly, much of the subprime mortgage lending of the early 2000s involved interest rate resets but with fixed amortization periods.

[26] Switching from a 30-year amortization to an interest-only product would lower the PTI ratio. However, higher inflation (and nominal interest rates) front-load payments for an IO mortgage, and at higher inflation the difference in the PTI ratio between an IO mortgage and a 30-year mortgage early in the amortization is smaller than it is at low inflation. AMPs are also generally more complicated contracts, which means that a higher degree of financial literacy is required for borrowers to make informed choices.

[27] One can interpret the difference between our experiment with 0% inflation and other experiments as what the model would miss if one simply deflated nominal interest rates and income growth by inflation.

drivers of long-run changes in housing markets and debt. In Section 7.1 we turn to this question and find a significant role for the fall in inflation and mortgage refinancing costs in the increase in US mortgage debt in the 1980s.

6.2 Transitions: Unanticipated Permanent Change in Inflation

Following the monetary policy–induced disinflation of the early 1980s, most advanced economy central banks adopted an inflation target near 2%. This has prompted debate over whether central banks should raise their inflation targets (e.g., Blanchard, Dell'Ariccia, and Mauro 2010) or lower them.[28] In this section, we examine the implications for housing markets along the transitions between steady states following an unanticipated permanent change in trend inflation. We also examine whether the transitional dynamics vary with the speed of inflation adjustment and the type of mortgage—fixed versus variable rate.

Unlike in our steady-state analysis, unanticipated changes in inflation can result in mortgagors experiencing gains (losses). The magnitude of these changes depends on whether the mortgage has a fixed or adjustable rate that varies with inflation (see, e.g., Doepke and Schneider 2006). An unanticipated rise in inflation benefits mortgagors with fixed rates by reducing the real rate, which creates an incentive to *not* refinance (i.e., "lock in"). However, when inflation falls, mortgagors with fixed rates see the real value of their debt and mortgage rate rise. We show that this leads to asymmetric effects along the transition after an unanticipated increase versus decrease in inflation.

Our analysis yields several insights. First, we find that the transition following a permanent change in trend inflation can take up to 20 years. This prolonged transition reflects the life-cycle nature of housing decisions. Since adjusting housing is costly, after a permanent change in trend inflation, many mortgagors are slow to adjust. Second, the transitional dynamics can differ between an economy with FRMs and one with ARMs. Interestingly, the option to refinance narrows the difference in transitional dynamics after a fall in inflation between an economy with FRMs and one with ARMs. However, the transition following an increase in inflation generally takes longer with FRMs than with ARMs due to the asymmetric mortgage lock-in effect: when inflation and mortgage rates fall, mortgagors refinance at lower rates, but when inflation rises, mortgagors hold onto their low-interest loans. Our experiments thus imply that an increase in a central bank's target inflation rate—which, advocates argue, would have little effect on the real economy—would have significant impacts on housing markets. Finally, expectations around the path of inflation and mortgage rates along the transition can slow the transition if some prospective homebuyers delay purchasing

[28] We abstract from the practical question these proposals raise around the credibility of inflation targeting.

in anticipation of lower rates. As a result, alternative inflation transition paths (i.e., fast or gradual) can significantly impact housing markets and consumption along the transition.

6.2.1 An Unanticipated Permanent Fall in Inflation

We examine the housing market dynamics of a (permanent) transition from the 8% to the 2% trend inflation steady state, which is similar in magnitude to the 1980s experience in the US. We find that both the speed with which inflation reaches the new steady state and the mortgage structure affect the speed and dynamics of home ownership and mortgage debt.

The transitions begin in the 8% inflation steady state (with refinancing costs of 2.5%) when an unexpected and permanent fall in inflation is announced. We compare two paths: a *sudden* transition where inflation falls to 2% in the first period and a *gradual* one where inflation declines linearly from 8% to 2% in nine periods. We compare these transitions in an economy where mortgages have fixed rates and an economy with adjustable rates. For fixed-rate mortgages originated at t (payments begin in $t+1$), the rate is based on (expected) inflation in $t+1$ at period t ($E_t(\pi_{t+1})$), while the ARM rate varies with inflation each period.[29]

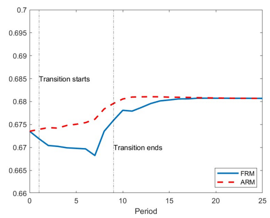
Transitions take a long time: for the sudden inflation path, it takes 10 periods (20 years) for ownership and the mortgage DTI ratio to fully converge to the new steady state (Figure 5.e, f). The gradual transition in inflation is even more prolonged as it takes another 5 periods (10 years) following the 9-period transition in inflation (see Figure 5.a, b). This reflects the slow adjustment of debt levels for existing homeowners after the change in inflation.

A key force along the transition is the mortgagor wealth effect of the unanticipated change in inflation. For mortgagors, an unexpected fall in inflation leads to slower-than-expected nominal income growth and an increase in real mortgage payments and real debt (nominal debt divided by the price index). The negative wealth effects with FRMs are shaped by the option to refinance and the speed of the inflation transition. In the gradual transition, the fixed cost of mortgage refinancing means that existing mortgagors face a trade-off in when to refinance. On the one hand, the longer mortgagors delay refinancing, the more interest they pay. On the other hand, since inflation and mortgage rates will fall in the future, mortgagors have an incentive to wait because refinancing is costly. These forces drive the differences in refinancing between the gradual and sudden transitions (Figure 5.c, g).

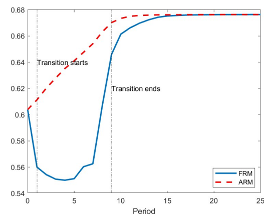
The refinance option also shapes the differences between transitions in an ARM economy and FRM economy. In an ARM economy, the mortgage rate and interest payments fall with inflation (see Figure 5.d, h). What is surprising is that the (debt-weighted) average mortgage

[29] Along the transition, we hold fixed the relative (real) price of housing in terms of the non-housing good for analytical tractability. This also corresponds to US data during the 1980s and 1990s.

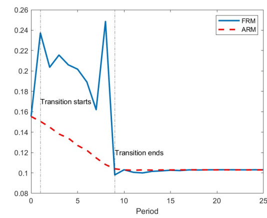
Figure 5: Permanent Decline in Inflation from 8% to 2%



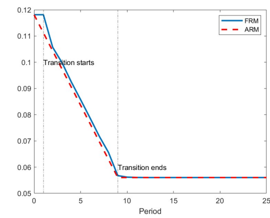
(a) Gradual: Ownership



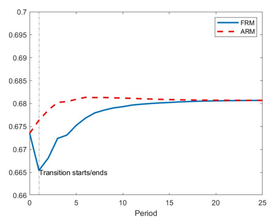
(b) Gradual: DTI



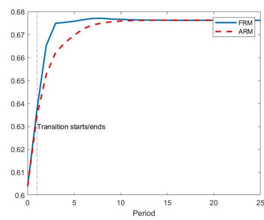
(c) Gradual: Refinance



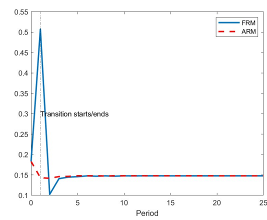
(d) Gradual: Avg Int.



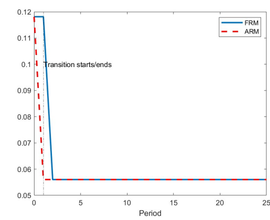
(e) Sudden: Ownership



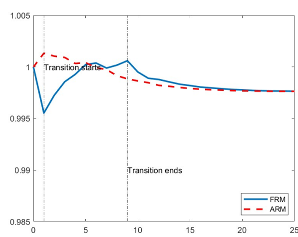
(f) Sudden: DTI



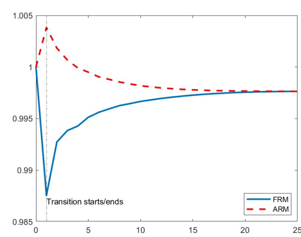
(g) Sudden: Refinance



(h) Sudden: Avg Int.



(i) Gradual: Consumption



(j) Sudden: Consumption

Note: This figure presents the housing market dynamics after a permanent shock in inflation. Each period is two years. Inflation falls from 8% to 2% linearly in 9 periods in the gradual-transition scenario and from 8% to 2% in period 1 in the sudden-transition scenario. The refinancing cost is 2.5%. DTI is the ratio of total debt to total labour income of all households. Refinance is the fraction of owners who increase their balance. Average interest is debt-weighted.

rate in the FRM environment closely tracks the ARM payments. This is due to refinancing: In the sudden transition, high-balance FRMs (which generally have longer remaining amortization) are refinanced. In the gradual transition, while the spike in refinancing is less pronounced, it remains high throughout the transition in inflation. However, since refinancing is costly, in the FRM economy some homeowners switch to renting. This effect is quantitatively modest in the sudden inflation transition, which as a result features similar paths for home ownership, debt, and interest payments in the FRM and ARM economies.

To illustrate why refinancing is important, we compare the payments for an FRM that is *not* refinanced with an ARM originated before inflation transitions from 8% to 2% over 18 years. If the FRM is not refinanced, by the end of the transition (year 18), the FRM payment is 55% higher than the ARM payment, and despite the higher (interest) payments, the outstanding FRM balance is higher. This difference between FRMs and ARMs does not appear in our experiments since FRM mortgagors *choose to refinance*, and thus interest payments in the FRM and ARM economies closely track one another.[30]

In the gradual transition, significant differences arise between the FRM and ARM economies for home ownership and the DTI ratio. The main driver of these differences is renters who delay buying. Since the mortgage rate in our FRM economy is based on next-period inflation, households anticipate that rates will decline along the transition. Costly refinancing leads some renters to wait until inflation falls closer to 2% before buying, and some homeowners wait to transition to renting until rates have fallen. The combination of the negative wealth effect and postponed homebuying results in a larger initial drop in home ownership and DTI ratios in the gradual transition with FRM. In contrast, in the ARM economy, the dynamics of home ownership and DTI ratios are only slightly slower than those of the sudden transition.

The steady-state difference in non-housing consumption is modest (less than 0.2%). However, deviations along the transitions can be larger, particularly with FRMs. Along the transition, non-housing consumption initially falls (see Figure 5.i, j) as the negative wealth shock for mortgagors drives a small decline in non-housing consumption. The initial decline is deeper but less protracted in the one-period transition where mortgagors see a 6% increase in real mortgage debt, whereas the gradual transition sees a slower recovery in consumption. Behind the aggregate lie larger shifts in consumption across age cohorts, with the young and middle-aged seeing larger declines, particularly in the gradual transition with FRMs.[31] The complementarity between housing and non-housing consumption contributes to the drop in consumption among young households who postpone buying a home (anticipating rates

[30]See Appendix D.1 for more details.

[31]See the supplementary appendix.

will decline) and lower their non-housing consumption. This contributes to initially higher savings, which supports higher consumption following the transition to lower inflation.

The transition following an unanticipated and permanent change in inflation is surprisingly prolonged and dependent upon the structure of mortgage markets. Our experiment offers two other novel insights. First, the option to refinance FRMs reduces borrowers' negative wealth shock following a fall in inflation. Second, the speed of the inflation transition can be important. Compared to the sudden transition in the FRM environment, the gradual decline in inflation results in lower home ownership along the transition, but a smaller fall in non-housing consumption. Understanding these trade-offs can help inform policy-makers who are considering a permanent downward change in inflation targets.

6.2.2 A Permanent Rise in Inflation

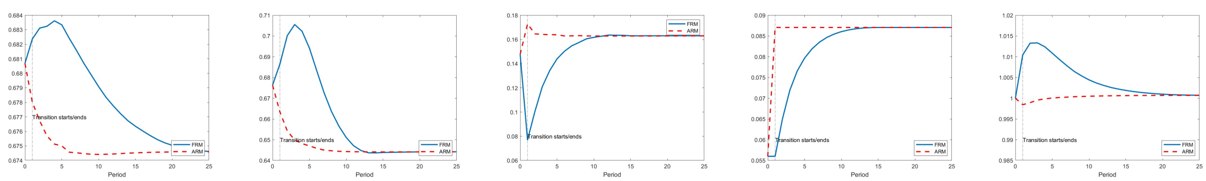
Some argue central banks should increase their inflation targets by several percentage points (e.g., Ball 2013; Blanchard, Dell'Ariccia, and Mauro 2010). We examine the housing market implications of an unanticipated, one-period increase in the target from 2% to 5%. Our counterfactual delivers two insights. First, changing the inflation target would significantly impact housing markets: increasing inflation from 2% to 5% implies a 0.6 percentage point decline in home ownership and a 3 percentage point fall in the (steady-state) DTI ratio. Second, whether mortgages have fixed or adjustable rates matters: the transition in home ownership rates and DTI ratios is slower with FRMs than with ARMs. In fact, the lock-in effect results in home ownership initially increasing for several periods in the FRM economy before gradually declining to the new steady state.

With FRMs, an unexpected increase in inflation benefits mortgagors because the real interest rate on existing mortgages declines and the DTI ratio falls due to faster nominal income growth (see Figure 6.b). However, the decline in the DTI ratio with FRMs is prolonged since the mortgage lock-in effect (Fonseca and Liu 2024; Gerardi, Qian, and Zhang 2024; Liebersohn and Rothstein 2024) incentivizes mortgagors to continue as owners rather than transition to renting after negative income shocks and to not refinance. As a result, the average interest rate on outstanding mortgages rises slowly, taking nearly 24 years (12 periods) to reach the steady state (see Figure 6.b). Combined with the positive wealth effect for mortgagors, this leads to an initial rise followed by a slow decline in home ownership with FRMs (see Figure 6.a), and a longer transition than that following a sudden fall in inflation (see Figure 5).

The transition is faster with ARMs than with FRMs. With ARMs, rates jump to the new steady state (Figure 5.d), causing an increase in the number of homeowners who transition to renting and accelerating the fall in the aggregate DTI ratio (Figure 5.b). Despite these forces speeding up the transition, it still takes nearly 20 years for ownership to reach the steady state.

These experiments imply that increasing inflation targets would have larger real effects than suggested by proponents such as Ball (2013) and Blanchard, Dell'Ariccia, and Mauro (2010). Although the redistributional implications of an unanticipated change in inflation are not new, our experiments highlight the asymmetry in the extent of redistribution between a permanent fall and an increase in trend inflation with fixed-rate mortgages. This also means that a credible discussion of increasing the inflation target could lead lenders to pre-emptively increase rates, which would have real effects on housing markets.[32] Our experiments imply that a change in the inflation target would have real, long-term effects on housing markets.

Figure 6: Permanent Increase in Inflation: 2% to 5%



(a) Ownership (b) DTI (c) Refinance (d) Avg Mort. Rate (e) Consumption

Note: This figure presents the path of ownership, the DTI ratio, the fraction of households who increase the mortgage balance (refinance), the debt-weighted average mortgage rate, and aggregate consumption after inflation increases from 2% to 5% in the first period. The refinancing cost is 2.5%.

Discussion: Our work adds two novel insights to the literature on the redistributive effects of surprise inflation (Doepke and Schneider 2006; Meh and Terajima 2011) arising from differences in household portfolios. First, our steady-state analysis shows that even *without unexpected changes* in inflation redistributing wealth, the level of inflation has real impacts on housing markets and consumers. Second, our transition experiments show that with FRMs, refinancing reduces the magnitude of redistribution after a surprise fall in inflation since mortgagors with an FRM can refinance at a lower rate. In contrast, following a surprise increase in inflation, the mortgage lock-in effect sees mortgagors holding onto mortgages with low real rates, which results in a larger redistribution from lenders to borrowers.

We find that a monetary policy decision to change the level of trend inflation (such as a change in an inflation target or the 1980s disinflation)—even in the absence of a change in real interest rates—leads to prolonged transmission lags of up to 20 years. Our finding that transitions after an increase or decrease in trend inflation can depend on the nature of mortgage contracts is related to a growing literature on housing and the transmission

[32] We abstract from house price effects here which could offset some of the benefits for existing homeowners if house prices declined.

of monetary policy. For example, Garriga, Kydland, and Šustek (2017) find that cyclical transmission of monetary policy is larger in an ARM economy than an FRM economy. While we find that this is true for a decrease in trend inflation, we also show that the option to refinance makes these differences smaller because even with an FRM, a fall in inflation is quickly passed through into average mortgage rates via refinancing. In contrast, after an unexpected increase in trend inflation, the mortgage lock-in effect with an FRM leads to a decrease in homeowners transitioning to renting and an initial increase in home ownership, followed by a prolonged decline towards the new steady state. This path differs markedly from that of an ARM economy, where home ownership and debt fall smoothly along the transition to the new steady state. This also leads to differences in (non-housing) consumption because consumption experiences a transitory increase in an FRM economy relative to an ARM economy since mortgagors gain from mortgages with low real rates. As a result, our findings indicate that mortgage market structure can have a large impact on the *transitions* following a change in a central bank's inflation target.

7 Empirical Episodes

Large, unanticipated permanent changes in trend inflation are rare in advanced economies. In this section, we examine the housing market implications of the Volcker disinflation, which saw a sharp fall in inflation in the early 1980s in the US and most advanced economies. Our analysis focuses on the US experience (in part due to the availability of microdata from the SCF and ACS), although we also discuss the experience in Canada and other countries. Specifically, we briefly discuss a second episode: the creation of the euro in 1998. This is an interesting episode since Italy, Spain, Portugal, and Greece experienced significant declines in trend inflation while other (northern) countries saw little change in inflation.

Both the 1980s fall in inflation and the entry into the euro were followed by large increases in mortgage debt. Our analysis of the 1980s and 1990s indicates that roughly a quarter of the rise in the US mortgage DTI ratio was due to the fall in inflation. We also find that the impact of lower inflation was amplified by financial innovations that lowered US refinancing costs. Our comparison with Canada, where mortgage securitization arrived later and at a smaller scale than in the US, also supports our conclusion that lower inflation contributed to the rise in the aggregate mortgage DTI ratio. In Section 7.3, we show, consistent with our model, that Southern European countries that experienced larger declines in inflation and nominal interest rates after committing to join the euro area also saw larger increases in mortgage debt.

7.1 The 1980s Decline in US Inflation and Mortgage Debt

The early 1980s disinflation was termed by Goodfriend and King (2005) "the most widely discussed and visible macroeconomic event" of recent US history. Although much attention has been devoted to the disinflation and the 1980s recession (Goodfriend and King 2005), less work has asked whether this episode had long-lasting real economic impacts. In this section, we quantify the significant real impacts of the 1980s disinflation on housing markets.

Our counterfactuals build on the insights of Section 6 in three ways. First, we focus on the period from 1980 to 2001 since the housing market transition after a change in steady-state inflation can take 20 years. Second, we find that the level of refinancing costs affects the impact of inflation. This is important because financial innovation lowered refinancing costs in the 1980s and 1990s, which we incorporate in our counterfactuals. Third, our analysis in 6.2.1 indicated that while ARMs and FRMs have similar steady implications, they can lead to different transitional dynamics. We examine these implications in Section 7.2.

We find that the 1980s disinflation can account for an 8 percentage point increase in the US mortgage DTI ratio, nearly a third of the 26 percentage point rise over the period from 1983 to 2001. When we take into account the fall in refinancing costs, lower inflation and refinancing costs account for over half of the rise in the DTI ratio. In our experiments and the data, young and middle-aged households experienced a larger rise in DTI ratios, and average house size rose for younger owners. We then examine the transitional implications of the sharp fall in inflation from nearly 10% to 4% in the early 1980s, followed by a gradual decline to near 2% by the late 1990s. Consistent with our steady-state analysis, we find that the transition was nearly complete by 2001.

7.1.1 Steady-State Comparison of 1983 and 2001

To quantify the contribution of the decline in inflation and refinancing costs to the rise in mortgage debt between 1983 and 2001, we compare the steady-state economy calibrated to 2001 to an economy where inflation is 8% (from 2.8%) and the refinancing cost is 2.5% (from 1%).[33] The counterfactual implies a 14 percentage point increase in the debt-to-income ratio between 1983 and 2001 (Table 3 Panel B)—more than half of the observed 26 percentage point increase in the mortgage DTI ratio. The combination of lower inflation and refinancing costs increases home ownership by 3.9 percentage points, somewhat more than the rise observed in the data.

Behind these changes lies a shift in the distribution of PTI ratios. Lower nominal interest rates (due to lower inflation) in 2001 compared to our 1983 counterfactual result in a larger

[33] These experiments correspond to a shift between points along the two lines in Figure 4.g.

Table 3: Effect of Inflation and Mortgage Financing Cost on Debt

Panel A: Parameters				
Parameters	2001 baseline	1983	2001 inflation, & 1983 closing	Δr $\uparrow 50bps$
Inflation	2.8	8	2.8	8
Closing cost	1	2.5	2.5	2.5
Risk-free rate	2	2	2	2.5
Panel B: Simulation and Data				
$\Delta_{1983-2001}$ aggregate DTI (data, NIPA)		26		
$\Delta_{1983-2001}$ ownership (data)		3		
Δ Aggregate DTI (model)		14	8	13.2
Δ Ownership model		3.9	3.4	3.3

Note: We compute the change in ownership and the DTI ratio from steady state in counterfactual analysis from the benchmark. DTI is the ratio of total mortgage debt divided by total personal disposable income from the National Income and Product Accounts (NIPA). The mortgage refinancing costs are the fees and charges for new mortgages reported by the FHFA.

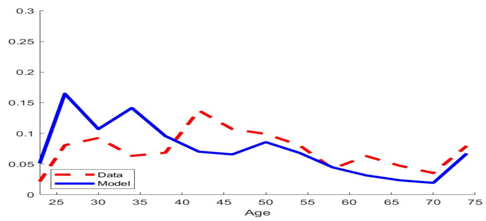
fraction of PTI ratios at origination below 20% (roughly 97% in 2001 versus 84% in 1983), while the fraction between 20% and 30% is more than 10 percentage points lower in 2001 than in 1983. The lower PTI makes purchasing a home more attractive for younger, borrowing-constrained renters. It also makes buying a larger home more attractive. As a result, the average house size of young and middle-aged owners is larger in 2001 than in 1983 (see Figure 7.c).

The rise in aggregate debt between our 1983 and 2001 experiments is driven by two forces. First, the increase in home ownership and house size leads to higher debt among younger homebuyers. Second, lower inflation back-loads real mortgage payment and leads to slower nominal income growth. This results in a slower fall in debt relative to income for middle-aged mortgagors, which pushes up aggregate DTI. To decompose the contribution of inflation and refinancing costs, we examine a counterfactual where inflation falls to 2.8% but refinancing costs remain at 2.5% (Table 3 panel B). This experiment attributes 6 percentage points to the 1.5 percentage point decline in refinancing costs, with the remaining attributed to the fall in inflation.

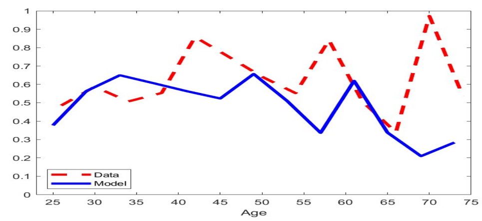
To provide a metric of the effects of inflation on mortgage debt and home ownership, we increase the steady-state risk-free rate (which changes mortgage rates and the return on savings) by 50 basis points (last column in Table 3). This reduces the aggregate DTI ratio (ownership) by 13 (3.3) percentage points, close to the effect of a 5.2 percentage point change in inflation (for a refinancing cost of 2.5%). This further highlights the quantitative importance of anticipated inflation for housing markets.

Decomposition: One diagnostic of our experiments is to compare the contribution by

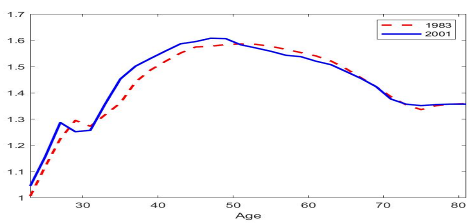
Figure 7: Steady-State Comparison: 1983 versus 2001



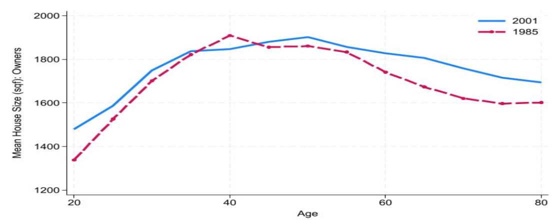
(a) Contribution by Age to Increase in DTI (Model and Data)



(b) Intensive Margin (Model and Data)



(c) House Size by Age (Model)



(d) Mean United Size (Data, AHS)

Panel (a) plots the contribution to the rise in the aggregate DTI ratio in the model and data of different age groups. Panel (b) plots the intensive margin contribution to the rise in the DTI ratio in the model and data for different age groups. Panel (c) compares house size in the 1983 and 2001 model steady states. Panel (d) shows the trimmed mean unit size of owners using the 1985 and 2001 American Housing Survey.

age to the rise in mortgage debt in our simulations to the US SCF in 1983 and 2001. In both the model and the SCF, the rise in debt is primarily accounted for by the intensive margin of higher debt of middle-aged homeowners.[34] Our decomposition attributes roughly 70% of this rise in debt per mortgagor to the back-loading effect of lower inflation and 30% to households buying larger homes.

To decompose the contribution by age to the rise in aggregate DTI, we compute the growth in average debt by age, weighted by the share of mortgagor households in each age group.[35] Given the modest sample size of the SCF, we group households into four-year age bands from ages 20–24 to 70–74 and over 75. The contribution of age j is $\left[\frac{d^j_{t+\tau}}{d^j_t}\frac{d^j_t}{\bar{D}_t}\alpha^j_{t+\tau}\right] / \left[\frac{\bar{D}_{t+\tau}}{\bar{D}_t}\right]$, where $\bar{D}_t$ is average debt at t, $\frac{\bar{D}_{t+\tau}}{\bar{D}_t}$ is the growth of debt from t to $t+\tau$, d^j_t is debt of age j households at t, and α^j_t is the population share of age j.

Consistent with the data, owners aged 30–55 contributed more than half of the counterfactual rise in mortgage debt (see Figure 7.a). We further decompose the increase in debt $\frac{d^j_{t+\tau}}{d^j_t}$ between an *intensive margin* of higher debt per mortgagor $\frac{x^j_{t+\tau}}{x^j_t}$ and an *extensive margin*

[34]The contribution by age to the rise in mortgage debt varies over time, which suggests that there could be cohort effects reflecting macroeconomic conditions when households entered the housing market.

[35]Dynan and Kohn 2007 show that the effect of US age distribution shifts between 1983 and 2001 is to slightly *lower* the DTI ratio (see Appendix F). The model simulations assume no change in age structure.

of the change in the number of mortgagors $\frac{\nu_{t+\tau}^j}{\nu_t^j}$ for age group j.[36] The intensive margin is the primary driver of higher debt in our experiments and the data (see Figure 7.b). The rise in debt is not driven by a change in house prices since the (real) price of housing relative to non-housing goods is fixed in the simulations. Similarly, over the 1980s and 1990s, the real price of US housing (deflated by the CPI) did not rise substantially. This leaves two mechanisms: a slower pay-down of debt relative to income, and higher debt due to larger homes.

To estimate the contribution of the back-loading of mortgage payments (holding fixed household borrowing decisions), we construct a counterfactual real debt balance at 2.8% inflation based on a household's initial mortgage and amortization in the 8% inflation steady state. This yields a 9.6 percentage point increase in the DTI ratio, which implies that nearly 70% ($\frac{9.6}{14}$) of the increase in the aggregate DTI ratio in our experiments can be attributed to back-loading.

Up to a third of the rise in debt per mortgagor can be attributed to larger (average) houses in the 2001 counterfactual than in the 1983 counterfactual for owners under 50 (see Figure 7.c). Assuming that the entire increase in the value of houses (due to larger house sizes) is financed by debt, over 34% of the increase in debt is due to households choosing to buy larger homes when inflation is lower. A more conservative estimate holds the LTV ratio fixed in 2001, in which case the contribution of larger homes to the increase in debt between 1983 and 2001 is 16.5%.

While we lack a direct measure of housing services in the data, one proxy is the square footage of a house. Using the American Housing Survey in 1985 and 2001, we find that mean house size in the US increased (see Figure 7.d) among young and middle-aged home owners. Although it is not directly comparable to the average house size of homeowners in our model, the average size of newly constructed homes also increased sharply in the 1980s after falling in the 1970s due to an increase in the share of larger homes (see supplementary Appendix E).

Discussion: Our analysis adds several insights to the ongoing debate over what drove the rise in US mortgage debt in the 1980s and 1990s. While the fact that the intensive margin is the primary driver of higher debt is not new (e.g., see Dynan and Kohn 2007), our analysis contributes two novel drivers resulting from disinflation: the back-loading effect and the purchase of larger homes. By showing how a change in nominal variables can lead to higher debt, our analysis offers a theoretical rational for Green and Wachter (2010) finding

[36] The fractions of homeowners under 45 in 2001 and 1983 are similar. However, the fraction of those over 45 with a mortgage was higher in 2001 than in 1983, which points to a slower pay-down in mortgages in 2001.

that the decline in nominal mortgage rates (not real rates) is correlated with the rise in debt. Similarly, our analysis also helps resolve what Barnes and Young (2003) argue is a puzzling 1980s rise in debt at the same time that real mortgage rates were relatively high.

Other work has pointed to other mechanisms complementary to our analysis, such as financial innovation, which contributed to the rise in debt. Although our experiments capture one channel (lower refinancing costs) through which innovations could have impacted housing markets, Iacoviello and Pavan (2013) show that a decrease in down payments could have contributed to pushing US mortgage borrowing higher. Our finding of an important role for the fall in inflation seemingly contrasts with the conclusion by Gerardi, Rosen, and Willen (2010) that the rise in mortgage securitization was the primary driver of increased mortgage borrowing. However, while our analysis also supports financial innovations being a key driver, as we argue below, the cross-country evidence indicates that the fall in inflation was also an important factor.

7.2 The 1980s and 1990s: Implications of the Disinflation

We examine the direct effects on housing markets of the *transition* from high to low inflation during the 1980s disinflation. Given our focus on inflation, we abstract from important forces such as high unemployment during the early 1980s and 1990s recessions or the increase in income inequality. Although we anchor our analysis on the US, we also discuss the Canadian experience for several reasons. First, as in the US, inflation in Canada fell sharply in the early 1980s.[37] Second, the structure of Canadian housing markets as well as home ownership rates and mortgage DTI ratios are similar to those in the US. Third, although the typical amortization period in Canada is 25 years, mortgages in Canada generally have a term of 5 years or less, leaving the market closer to an ARM environment than an FRM environment.[38]

Our transition experiment begins in the steady state with 8% inflation and 2.5% mortgage closing costs when an unanticipated, permanent decline in inflation and mortgage refinancing costs is announced. The experiment inputs an initial decline from 8% to 4%, mirroring the sharp disinflation of the early 1980s, and then a linear decline from 4% to 2.8% over five periods, consistent with the level by the early 1990s. Mortgage refinancing costs decline linearly from 2.5% to 1% over seven periods, in line with FHFA data on fees and charges.

Consistent with our steady-state analysis, the housing market is close to the new steady state by 2001 (see Figure 8.a, b). DTI ratios (and home ownership) increase quickly after the initial decrease in inflation from 8% to 4% and continue to increase as inflation decreases.

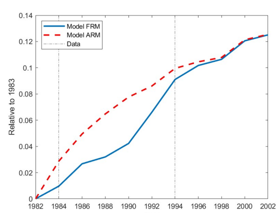
[37]See the Appendix. The Bank of Canada formally adopted inflation targeting in the early 1990s.

[38]Canadian prepayment regulations allow significant fees for the refinancing of fixed-rate mortgages of terms of 5 years or less, and, as a result, mortgage refinancing in Canada is uncommon.

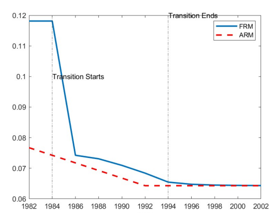
This differs from the gradual transition in Section 6.2.1, where DTI and home ownership initially decline for two reasons. First, the sharp initial drop in inflation and mortgage rates reduces the incentive to delay purchasing a home. Second, falling financing costs mean that mortgagors can refinance cheaply once rates fall further, which in the FRM economy reduces the incentive for renters to wait until the transition in inflation is complete.

The fall in nominal interest rates drives a surge in refinancing, which spikes in the first and last periods of the transition (see Figure 8.c). This is consistent with the sharp increase in US mortgage refinancing in the mid-1980s documented by Bennett, Peach, and Peristiani (2001), which was primarily motivated by borrowers seeking lower payments through refinancing at lower nominal interest rates. In our experiments, although refinancing narrows the gap between the average interest paid in the ARMs and FRMs economies, the pass-through of lower nominal rates is faster with ARMs than with FRMs (see Figure 8.b). Given the shorter terms in Canada, the average mortgage interest paid by mortgagors fell faster in the 1980s in Canada than in the US (see Figure 15.e).

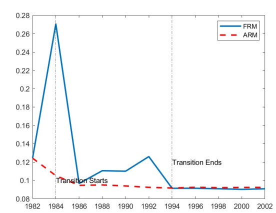
Figure 8: The 1980s Decline in Inflation in the US and Canada



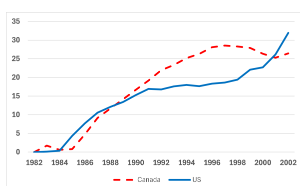
(a) DTI: Model



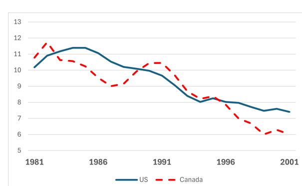
(b) Avg Rate: Model



(c) Refinancing



(d) DTI: Data



(e) Avg Rate Paid: Data

Note: Panels (a), (b) and (c) plot the 1980s US transition experiments. Inflation falls from 8% to 4% in the first transition period, and falls linearly to 2.8% over five periods. The refinancing cost falls from 2.5% to 1% linearly over six periods. The debt-to-income ratio is total outstanding mortgage debt divided by total household labour income in the model and total mortgage debt divided by household disposable income in the data. Panels (a) and (d) plot the change in the DTI ratio relative to 1982. The average interest rate is total interest payments divided by mortgage debt in the model and the data.

The rise in mortgage debt over the 1980s is faster in the ARM economy than in the FRM economy. One difference between our ARM economy and Canada is that the typical term is five years. This could contribute to the slower initial response to the fall in inflation in Canada, although the faster increase in DTI ratios in Canada over the late 1980s and early

1990s than in the US is consistent with our ARM economy (see Figure 15.d). As in the US, in Canada the average size of new homes increased in the 1980s and 1990s, with the average square footage of homes constructed in the 1980s 17% larger than that of homes built in the 1990s.[39] Also as in the US, the rise in DTI ratios was driven mainly by the intensive margin, since home ownership varied little in Canada in the 1980s, remaining near 62% from 1976 to 1986 before increasing to 62.6% in 1991 and 63.6% in 1996. Similarly, real house prices saw little sustained growth, with real house prices in the late 1990s at nearly the same level as in 1980.

Our findings challenge a common narrative that financial innovation was the main driver of the rise in mortgage debt during the 1980s and 1990s (see, e.g., Sommer, Sullivan, and Verbrugge 2013; Gerardi, Rosen, and Willen 2010; Iacoviello and Pavan 2013). Although we find an important role for innovations that lowered US refinancing costs, a potential critique is that our paper conflates the contribution of the decline in inflation and financial innovation to the rise in debt. A key marker of innovation in the US mortgage market is the rise in securitization from roughly 10% of mortgages in 1980 to over 50% by the late 1990s (e.g., Gerardi, Rosen, and Willen 2010; Rosen 2007). Canada also saw a rise in mortgage securitization in the late 1980s as a result of government policy (see Mordell and Stephens 2015). However, the share of outstanding mortgages accounted for by securitized assets remained under 5% until 1994, and even by 2000 only about 10% of debt was securitized (Mordell and Stephens 2015).[40] This points to a smaller role for financial innovation in Canada than in the US—despite a similar growth in mortgage DTI ratios after the fall in inflation.

The cross-country evidence reinforces the Canada-US comparison. In most advanced economies, the 1980s decline in inflation was followed by an increase in household debt (see Appendix G.2).[41] Girouard and Blöndal (2001) report financial liberalization measures in a number of OECD countries. What is striking are both the differences between countries in the timing of interest rate deregulation and mortgage securitization, and the large differences between countries in the extent of securitization (Hoffmann and Nitschka (2012)). The co-movement between inflation and household debt during the 1980s—despite cross-country differences in mortgage markets (Campbell 2013) and securitization—is consistent with our counterfactuals where a permanent fall in inflation (and nominal interest rates) leads to a

[39] See Supplementary Appendix E for details.

[40] Only half of securitization took place through private vehicles. Differences in securitization and housing finance may have been important during the 2001–08 period (MacGee 2009).

[41] Using the IMF Global Debt Database, we document that debt rose following the fall in inflation. For a discussion of unsecured debt, see Livshits, MacGee, and Tertilt (2010) and Livshits, MacGee, and Tertilt (2016).

rise in DTI ratios.

Our transition experiment is parsimonious and abstracts from cyclical fluctuations in employment and the mortgage spread. Both of these forces are likely to slow home ownership and could contribute to the quicker rise in home ownership in our simulation than in the data (see Figure 8.a). More generally, as our transition experiments in Section 6.2.1 show, the timing of the rise in home ownership and debt is sensitive to expectations over interest rates and future refinancing costs. Despite these caveats, our experiments help explain the surge in refinancing and the rise in DTI ratios—and match the increase in home ownership by the late 1990s.

7.3 The Euro and Housing Markets

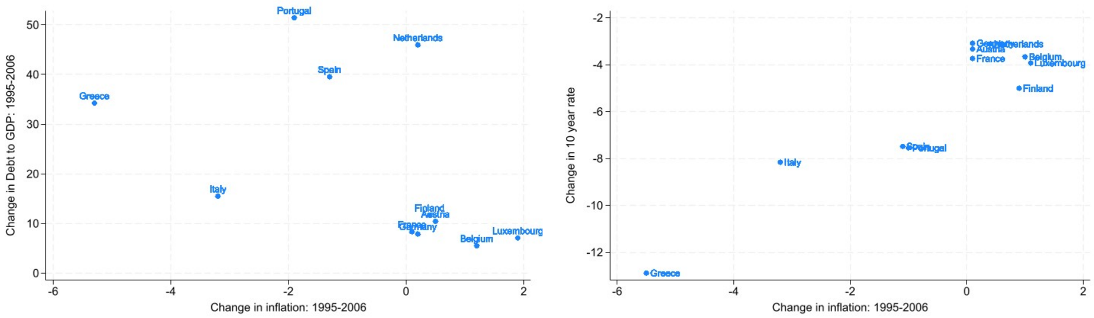
The introduction of the euro offers a natural experiment for the impact on housing markets of a permanent change in inflation. After the 1992 Maastricht Treaty that committed European Union countries to form a monetary union, the 1990s saw a convergence in inflation rates across the founding eurozone countries—Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain—until the introduction of the euro in 1998. Importantly, this resulted in a significant and permanent decline in inflation in the southern countries (Italy, Portugal, and Spain, as well as Greece, which joined in 2001) and little change in inflation in the northern countries as well as convergence across countries in nominal interest rates (e.g., Lane 2006; Franks et al. 2018).

Although real 10-year bond yields (a proxy for mortgage rates) fell in all countries, the decline in nominal interest rates between 1995 and 2006 was larger in the southern countries, where inflation fell more (Figure 9.b). The convergence in inflation was followed by housing market dynamics broadly consistent with the predictions of our model. The increase in DTI ratios between 1995 and 2006 in Italy, Portugal, Spain, and Greece—the countries that saw the largest fall in inflation and nominal interest rates after the introduction of the euro—was much larger than the increase in Austria, Belgium, Finland, France, Germany, or Luxemberg (Figure 9.a). On average, a 1 percentage point decrease in inflation is associated with a 4 percentage point increase in the debt-to-GDP ratio.[42]

Our analysis suggests that the rapid post-euro rise in mortgage debt in southern eurozone countries should have been (at least partially) anticipated as the result of a permanent fall in

[42]The Netherlands seemingly contradicts our model because it saw a large rise in debt without a fall in inflation. Behind this lies a shift towards interest-only mortgages starting in the mid 1990s, as interest-only mortgages rose from 3.4% of Dutch mortgages in 1993 to 44% in 2006 (Rouwendal (2007)). This rise in debt is consistent with the Danish experience after the 2003 introduction of interest-only mortgages (Bäckman and Khorunzhina 2024). Consistent with our mechanism, Bäckman and Khorunzhina (2024) argue that the introduction of interest-only loans in Denmark relaxed PTI ratio constraints.

Figure 9: Change in Household Debt to GDP, Inflation and Bonds Yields: 1995 to 2006



(a) DTI and Inflation

(b) Inflation and 10-year Interest Rate

Note: The DTI ratio is measured by household debt, loans and debt securities as a percent of GDP from the IMF Global Debt Database. Inflation data comes from IMF. The yield on 10-year government bonds is from the European Central Bank. We chose 1995 as the starting point due to data availability.

inflation. While the magnitude of the rise in debt was likely amplified by the fall in country interest rate premia, the experience following the entry into the euro supports our argument that the level of trend inflation has real effects on housing markets.

8 Conclusion

The life-cycle housing tenure choice model we develop shows that the structure of standard fixed-amortization mortgages generates quantitatively relevant long-run non-neutralities because anticipated inflation alters the timing and composition of households' housing and non-housing consumption, borrowing, and home ownership. Higher trend inflation raises nominal interest rates and front-loads real mortgage payments, increasing payment-to-income ratios for younger, often borrowing-constrained households. These effects lower steady-state home ownership and debt-to-income ratios, with the magnitude depending on refinancing costs.

We find that transitions between steady states following an unanticipated permanent change in trend inflation (such as the early 1980s disinflation) can take 20 years. Interestingly, we find that the option to refinance fixed-rate mortgages results in a similar path for mortgage interest payments with FRMs and ARMs following an unanticipated decline in inflation. In contrast, an increase in inflation results in a faster rise in mortgage interest payments with ARMs than FRMs as borrowers with an FRM delay refinancing due to the mortgage lock-in effect. As a result, transitions are more protracted after an increase in inflation with FRMs. Our findings suggest that changes in the level of inflation targeted by a central bank are likely to have significant and prolonged impacts on housing markets.

Our finding that the 1980s disinflation (which lowered nominal interest rates) was an important contributor to the subsequent rise in the US mortgage DTI ratio is novel. The dramatic rise in mortgage debt in the US—and many other developed countries—remains an important macroeconomic trend that is not well understood. The 1980s and 1990s rise in mortgage debt in the US and Canada is particularly puzzling since it took place while real house prices rose little. Our analysis also helps explain why it was only after 2000 (Justiniano, Primiceri, and Tabbalotti 2019, Kaplan, Mitman, and Violante 2020) that the seeds for the global financial crisis were set.

Our analysis points to several directions for future research. While we focus on mortgages, a similar mechanism should also hold for fixed-amortization debt such as auto loans and corporate debt. Consistent with the US experience during the 1980s and 1990s, our analysis assumed constant real house prices. The increase in real house prices since 2000 raises the question of what factors account for the post-2000 rise in mortgage debt in many countries. Although we document similar aggregate increases in debt across countries, work that systematically compares changes in the distribution of household mortgage debt over time across countries with what we document for the US using the SCF could be informative.

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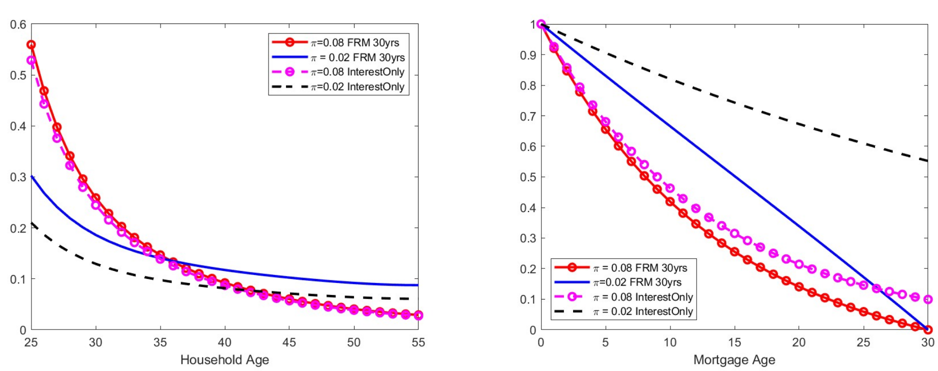
Appendix

A Inflation Mortgage Payments to Income and Debt: Interest-Only Mortgages

Section 2.2 illustrates how higher trend inflation front-loads mortgage payments and reduces the outstanding debt over amortization for fixed-rate and adjustable-rate mortgages. The mechanism also applies for interest-only mortgage contracts, which are popular in Denmark, the Netherlands, and Sweden. This occurs because the nominal loan balance remains fixed, while the nominal interest rate adjusts with inflation. Consequently, higher trend inflation leads to a decline in the real value of the loan balance.

To illustrate this, we compare the PTI ratios and real debt outstanding for FRM/ARM and interest-only mortgage contracts under both high- and low-inflation scenarios, using the parameters specified in our illustrative example. As Figure 10.a shows, the PTI is lower with interest-only mortgages compared to FRMs and ARMs. Most importantly, higher inflation front-loads the payment-to-income ratio for interest-only mortgages in the same way as it does for FRM and ARM loans. Meanwhile, Figure 10.b further demonstrates that inflation influences the trajectory of debt outstanding. Specifically, higher inflation accelerates the reduction in the real value of debt along the amortization path. This implies that in economies where interest-only mortgages are prevalent, lower trend inflation back-loads the PTI ratio and leads to a higher steady-state level of mortgage debt.

Figure 10: Mortgage PTI, DTI and Inflation



(a) PTI (b) Debt

Note: Panel (a) plots the payment-to-income ratio. Panel (b) shows the corresponding fraction of outstanding debt for a \$200,000 mortgage across different inflation rates and mortgage types.

B Proof for Two-Period Illustrative Model

This section provides the detailed solution to the two-period model in Section 3. When households are not subject to borrowing constraints, their optimal choices are characterized by:

$$
\begin{aligned}
c_1^* &= \frac{1+\frac{g}{1+r}}{1+\beta+\eta} \\
c_2^* &= \frac{\beta(1+r)(1+\frac{g}{1+r})}{1+\beta+\eta} \\
h^* &= \frac{\eta(1+r+g)}{P(1+\beta+\eta)(r^2+2r)}
\end{aligned}
\tag{16}
$$

When $c_1^* + \frac{(1+r_m)(1+r)}{2+r_m}Ph^* > 1$, i.e.

$$
(\frac{1+\frac{g}{1+r}}{1+\beta+\eta})[1+\frac{(1+r_m)(1+r)}{2+r_m}\frac{\eta}{\frac{r^2+2r}{1+r}}] > 1, \tag{17}
$$

then households are borrowing-constrained.

Lemma B.1. *When households are borrowing-constrained, an increase in the steady-state inflation reduces housing consumption h.*

The households' maximization problem can be rewritten in real terms, with a constraint $a \geq 0$ imposing no uncollateralized borrowing.

$$
\begin{aligned}
&\max_{c_1,h,c_2} \ln(c_1) + \eta\ln(h) + \beta\ln(c_2) \\
s.t.\ \ &c_1 + (\frac{(1+r_m)(1+r)}{2+r_m})Ph + a = 1 \\
&c_2 + \frac{(1+r)^2}{2+r_m}ph = g + ph + (1+r)a \\
&a \geq 0
\end{aligned}
\tag{18}
$$

Denote $x = \frac{(1+r_m)(1+r)}{2+r_m}$ as the effective housing cost in the first period and $y = (1 - \frac{(1+r)^2}{2+r_m})$ as the return to housing asset in the second period. Both x and y are increasing in inflation

π as $(1 + r_m) = (1 + \pi)(1 + r)$. Specifically

$$\begin{aligned}\frac{\partial x}{\partial \pi} &= \frac{(1+r)^2}{(2+r_m)^2} \\ \frac{\partial y}{\partial \pi} &= \frac{(1+r)^3}{(2+r_m)^2}\end{aligned} \tag{19}$$

Effectively, higher inflation forces households to save though home equity by borrowing less in the first period, which earns a return rate of $1 + r$.

When the borrowing constraint binds, a household's optimal choice is characterized by:

$$\begin{aligned}\hat{c}_1 &= 1 - xP\hat{h} \\ \hat{c}_2 &= g + yP\hat{h}\end{aligned} \tag{20}$$

where $\hat{h}$, the optimal housing consumption is given by

$$\frac{\eta}{\hat{h}} + \frac{\beta y P}{g + yP\hat{h}} = \frac{xP}{1 - xp\hat{h}} \tag{21}$$

Rewriting Equation 21:

$$(1 + \beta + \eta)xyP^2\hat{h}^2 + [(1 + \eta)xg - (\beta + \eta)y]P\hat{h} - \eta g = 0 \tag{22}$$

Solving Equation 22, we get:

$$\hat{h} = \frac{[(\beta + \eta)y - (1 + \eta)xg] + \sqrt{[(1 + \eta)xg - (\beta + \eta)y]^2 + 4(1 + \beta + \eta)xy\eta g}}{2P(1 + \beta + \eta)xy} \tag{23}$$

Taking the total differentiation of equation 22:

$$\frac{\partial \hat{h}}{\partial \pi} = -\frac{(1 + \beta + \eta)(P^2\hat{h}^2)[x\frac{\partial y}{\partial \pi} + y\frac{\partial x}{\partial \pi}] + (1 + \eta)gP\hat{h}\frac{\partial x}{\partial \pi} - (\beta + \eta)P\hat{h}\frac{\partial y}{\partial \pi}}{2(1 + \beta + \eta)xyP^2\hat{h} + (1 + \eta)xPg - (\beta + \eta)yP} \tag{24}$$

The denominator:

$$\begin{aligned}&2(1 + \beta + \eta)xPyP\hat{h} + (1 + \eta)xPg - (\beta + \eta)yP \\ &= 2(1 + \beta + \eta)xPyP\hat{h} + (1 + \eta)xPg - [(1 + \beta + \eta)xPyP\hat{h} + (1 + \eta)xPg - \frac{\eta g}{\hat{h}}] \\ &= (1 + \beta + \eta)xPyP\hat{h} + \frac{\eta g}{\hat{h}} > 0\end{aligned}$$

The numerator:

$$(1+\beta+\eta)(P^2\hat{h}^2)[x\frac{\partial y}{\partial \pi}+y\frac{\partial x}{\partial \pi}]+(1+\eta)gP\hat{h}\frac{\partial x}{\partial \pi}-(\beta+\eta)P\hat{h}\frac{\partial y}{\partial \pi}$$
$$=[(1+\beta+\eta)(xP\hat{h}(1+r)+yP\hat{h})+(1+\eta)g-(\beta+\eta)(1+r)]P\hat{h}\frac{\partial x}{\partial \pi}$$
$$=[-(\beta+\eta)(1+r)(1-xP\hat{h})+(1+\eta)(g+yP\hat{h})+xP\hat{h}(1+r)+\beta yP\hat{h}]P\hat{h}\frac{\partial x}{\partial \pi}$$

When the borrowing constraint binds, Kuhn-Tucker implies

$$\frac{1}{\hat{c}_1}>\frac{\beta(1+r)}{\hat{c}_2} \text{ or } \frac{1}{1-xP\hat{h}}>\frac{\beta(1+r)}{g+yP\hat{h}}$$

Therefore, $[-(\beta+\eta)(1+r)(1-xP\hat{h})+(1+\eta)(g+yP\hat{h})+xP\hat{h}(1+r)+\beta yP\hat{h}]P\hat{h}\frac{\partial x}{\partial \pi}$

$$\geq[-\eta(1+r)(1-xP\hat{h})+\theta(g+yP\hat{h})+xP\hat{h}(1+r)+\beta yP\hat{h}]P\hat{h}\frac{\partial x}{\partial \pi}$$

According to Equation 21, $xP\hat{h}=(\eta+\frac{\beta yP\hat{h}}{g+yP\hat{h}})(1-xP\hat{h})$

$$[-\eta(1+r)(1-xP\hat{h})+\eta(g+yP\hat{h})+xP\hat{h}(1+r)+\beta yP\hat{h}]P\hat{h}\frac{\partial x}{\partial \pi}$$
$$\geq[\theta(1+r)xP\hat{h}+\eta(g+yP\hat{h})+\beta yP\hat{h}]P\hat{h}\frac{\partial x}{\partial \pi}>0$$

Thus $\frac{\partial h}{\partial \pi}<0$: Housing consumption decreases in inflation.

Lemma B.2. *When households are borrowing-constrained at any positive inflation level, an increase in the steady-state inflation reduces consumption in the first period and increases consumption in the second period.*

$$\frac{\partial \hat{c}_1}{\partial \pi}=\frac{\partial(1-xP\hat{h})}{\partial \pi}=-\frac{\partial xP\hat{h}}{\partial \pi} \tag{25}$$

$$\begin{aligned}\frac{\partial xP\hat{h}}{\partial \pi}&=P\hat{h}\frac{\partial x}{\partial \pi}+x\frac{\partial P\hat{h}}{\partial \pi}\\&=P\hat{h}\frac{\partial x}{\partial \pi}-\frac{x(1+\beta+\eta)(P^2\hat{h}^2)[x\frac{\partial y}{\partial \pi}+y\frac{\partial x}{\partial \pi}]+(1+\theta)gxP\hat{h}\frac{\partial x}{\partial \pi}-(\beta+\eta)xP\hat{h}\frac{\partial y}{\partial \pi}}{2(1+\beta+\eta)xyP\hat{h}+(1+\theta)xg-(\beta+\eta)y}\\&=\frac{[x(1+r)-y][(\beta+\eta)-(1+\beta+\eta)xP\hat{h}]}{2(1+\beta+\eta)xyP\hat{h}+(1+\eta)xg-(\beta+\eta)y}P\hat{h}\frac{\partial x}{\partial \pi}\end{aligned} \tag{26}$$

According to Equation 23:

$$
\begin{aligned}
P\hat{h} &= \frac{[(\beta+\eta)y-(1+\eta)xg]+\sqrt{[(1+\eta)xg-(\beta+\eta)y]^2+4(1+\beta+\eta)xy\eta g}}{2(1+\beta+\eta)xy} \\
&< \frac{[(\beta+\eta)y-(1+\eta)xg]+\sqrt{[(1+\eta)xg-(\beta+\eta)y]^2+4(1+\eta)(\beta+\eta)xy\eta g}}{2(1+\beta+\eta)xy} \\
&= \frac{[(\beta+\eta)y-(1+\eta)xg]+\sqrt{[(1+\eta)xg+(\beta+\eta)y]^2}}{2(1+\beta+\eta)xy} \\
&= \frac{\beta+\eta}{(1+\beta+\eta)x}
\end{aligned}
$$

i.e. $xP\hat{h} < \frac{\beta+\eta}{(1+\beta+\eta)}$ which implies $\frac{[x(1+r)-y][(\beta+\eta)-(1+\beta+\eta)xP\hat{h}]}{2(1+\beta+\eta)xyP\hat{h}+(1+\eta)xg-(\beta+\eta)y}P\hat{h}\frac{\partial x}{\partial \pi} > 0$

Therefore $\frac{\partial xP\hat{h}}{\partial \pi} > 0$ and $\frac{\partial \hat{c}_1}{\partial \pi} < 0$

Similarly,

$$
\begin{aligned}
\frac{\partial \hat{c}_2}{\partial \pi} = \frac{\partial (g+yP\hat{h})}{\partial \pi} &= P\hat{h}\frac{\partial y}{\partial \pi} + y\frac{\partial P\hat{h}}{\partial \pi} \\
&> P\hat{h}\frac{\partial x}{\partial \pi} + x\frac{\partial P\hat{h}}{\partial \pi} > 0
\end{aligned} \tag{27}
$$

as $\frac{\partial y}{\partial \pi} = (1+r)\frac{\partial x}{\partial \pi} > \frac{\partial x}{\partial \pi}$, $x > y$, and $\frac{\partial P\hat{h}}{\partial \pi} < 0$

The mechanism formalzied above is missing from many common specifications of how mortgages enter budget constraints in DGSE models. For example, consider an infinitely lived household environment in the spirit of Iacoviello (2005) where the borrowing constraint takes the form of a maximum LTV constraint. In steady state, a rise in inflation results in no change in the PTI, and thus the level of trend inflation does not impact household choices. To see this, note that the level of inflation drops out of the flow budget constraint in steady state:

$$
\begin{aligned}
&P_t c_t + (1+\bar{r}_m)D_t = P_t w_t + D_{t+1} \\
&\text{In stationary equilibrium, inflation is constant} \\
&\frac{c_t}{w_t} + (1+\bar{r}_m)\frac{D_t}{P_{t-1}w_{t-1}}\frac{P_{t-1}w_{t-1}}{P_t w_t} = 1 + \frac{D_{t+1}}{P_t w_t} \\
&\frac{c_t}{w_t} + \frac{(1+\bar{r}_m)}{1+\pi}D\bar{T}I = 1 + D\bar{T}I
\end{aligned} \tag{28}
$$

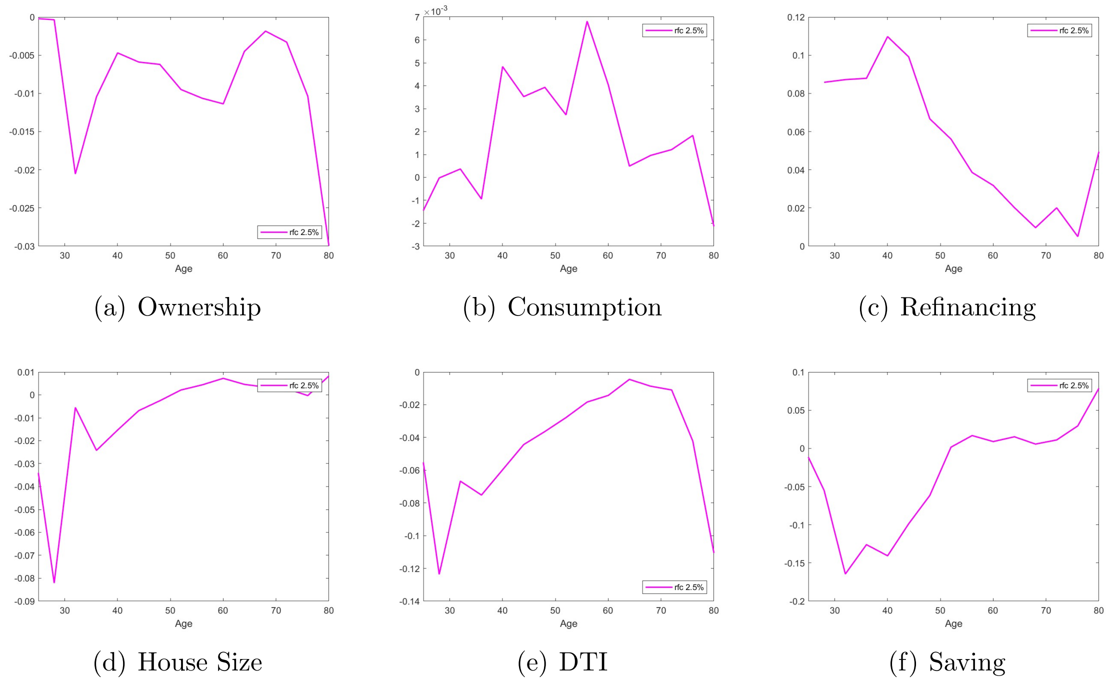
This is consistent with a constant PTI (and DTI) given by $(1+\bar{r}_m)D\bar{T}I\frac{P_{t-1}w_{t-1}}{P_t w_t} - D\bar{T}I =$

$\frac{(1+\bar{r}_m)}{1+\pi} D\bar{T}I - D\bar{T}I = rD\bar{T}I$. In stationary equilibrium with constant DTI, PTI is not affected by inflation.

C Steady State with Higher Mortgage Financing Cost

Section 6.1 shows how higher inflation affects household choices under 1%. Here we report the steady-state analysis comparing trend inflation when the mortgage financing cost is 2.5%. As in the case with a 1% refinancing cost, higher inflation reduces home ownership rates, average house size, debt-to-income (DTI) ratios, consumption, and savings among households aged 20 to 40.

Figure 11: Steady-State Comparison



(a) Ownership (b) Consumption (c) Refinancing

(d) House Size (e) DTI (f) Saving

Note: Panels (a) through (f) present the steady-state ownership rate, consumption, refinancing, house size among owners, DTI and saving by age under 8% inflation relative to 2% inflation with a refinancing cost of 2.5%.

D Transitions

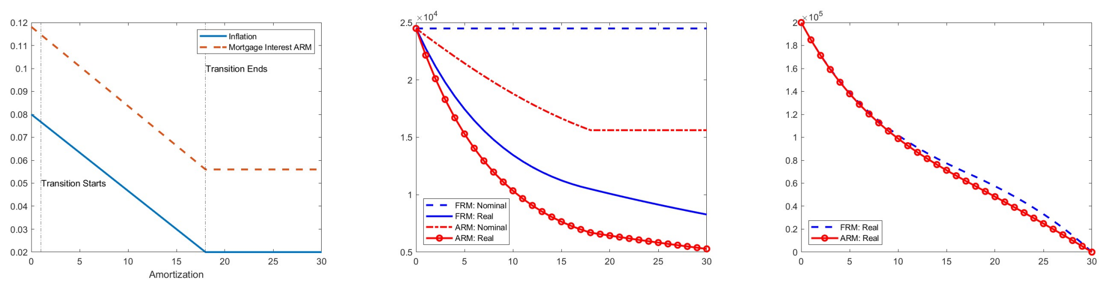
This section provides details about the transition experiments we run in Section 6.2.

D.1 Downward Gradual Transition without Refinancing

First, we examine the benefits of refinancing along the gradual decline in inflation. Specifically, we revisit the example of a $200,000 mortgage loan in Section 2.2 and compare the payment path for a mortgage issued right before the transition starts under an FRM contract that is *not* refinanced with an ARM contract in which interests and payments are adjusted with inflation in the gradual transition experiment where inflation drops from 8% to 2% over 18 years (see Figure 12).

When the FRM is not refinanced, the nominal payments are higher than those of an ARM. By the end of the transition (year 18), the FRM payment is 55% higher than the ARM payment. In addition, despite the higher (interest) payments, the outstanding FRM balance is higher (Figure 12.c). This large difference between FRM and ARM does not appear in our experiments since FRM mortgagors *choose to refinance*, and thus mortgage interest payments in the FRM and ARM economies (Figure 5.d and h) closely track one another.

Figure 12: Downward Gradual Inflation Transition: FRM and ARM



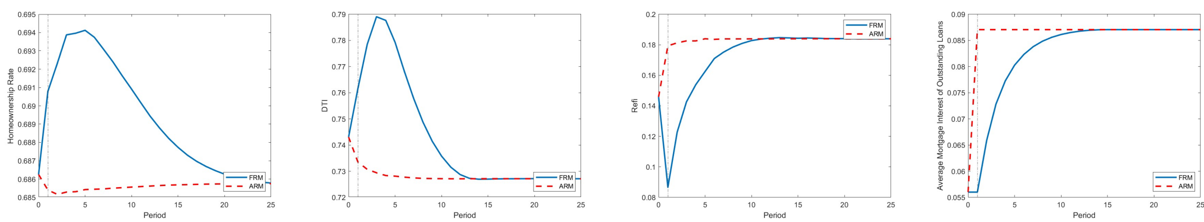
(a) Inflation and Mortgage Rates along the Transition (b) Nominal and Real Mortgage Payments along the Transition (c) Real outstanding Debt along the Transition

Note: This figure presents the mortgage rates, mortgage payments and debt evolutions for FRM and ARM contracts signed right before the gradual transition starts. All real values are evaluated at the period when the mortgage contract is signed (i.e., amortization period 0)

D.2 Upward Transition under Low Refinancing Cost

We conduct a robustness check for the upward transition where we set refinancing costs to 1%. We start with the 2% inflation initial steady state and increase the inflation to 5% all of a sudden. Consistent with the finding in the steady state analysis that the refinancing cost plays an important role in determining the implications of trend inflation, we find larger responses in the home ownership rate and DTI for a sudden upward transition. Compared to the simulation where a 2.5% refinancing cost is applied, we see a temporary rise in the home ownership rate and DTI, although the magnitude of the ownership increase is small (less than 1 percentage point). The fraction of owners who refinance decreases more as the level of home ownership is higher at the initial steady state with lower refinancing cost. Comparing the average mortgage rates on outstanding loans under high and low refinancing costs reveals that low refinancing costs marginally speed up the transition. It takes three periods to reach the middle point of the transition for a 1% refinancing cost and four periods for the 2.5% refinancing cost. This is because that lower refinancing cost marginally increases households' incentive to refinance when they experience negative income shocks and therefore update their mortgage rates.

Figure 13: Permanent Increase in Inflation (lower refinancing cost): 2% to 5%



(a) Ownership

(b) DTI

(c) Refinance

(d) Avg Mortgage Rates on Outstanding Loans

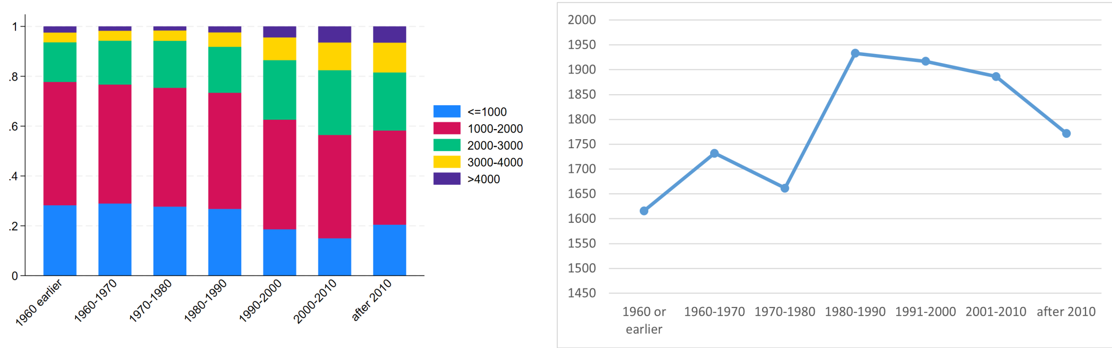
Note: This figure presents the path of ownership, DTI, the fraction of households who increase the mortgage balance (refinance), debt-weighted average mortgage rate, and aggregate consumption after inflation increases from 2% to 5% in the first period under a refinancing cost of 1%.

E Inflation, Mortgage Innovation and House Size

We examine the impact of inflation and mortgage financing costs on housing consumption by analyzing house size based on the year of construction, which can reflect contemporaneous housing demand. Figure 14.a shows the unit size of houses (including apartments) by year of construction using data from the AHS. By the 1990s—after the decline in inflation—there was a notable increase in the share of larger homes being built.

This pattern aligns with our simulations: lower inflation and reduced refinancing costs relax borrowing constraints for young homeowners, thereby increasing the average size of US homes. A similar trend is observed in Canada, where the average living space of newly constructed homes in three major provinces—British Columbia, Nova Scotia, and Ontario—increased by more than 10% between 1970 and 1990 (see Figure 14.b).

Figure 14: House Size by Year of Construction



(a) US (AHS 2019)

(b) Canada (British Columbia, Nova Scotia, and Ontario)

Note: This figure presents the distribution of unit sizes by the year of construction in the US and Canada.

F Age Decomposition

The decomposition exercises in Section 7.1.1 abstract from demographic changes. To assess the contribution of shifts in the US age distribution to aggregate DTI growth, we conduct an additional decomposition. Specifically, we break down the growth in DTI into two components: (1) changes in population shares—holding mortgage debt-to-income ratios constant at their 1983 levels for each age group—and (2) changes in the mortgage debt-to-income ratio itself.

$$\underbrace{D_t}_{\text{Aggregate DTI}} = \sum_a \underbrace{\alpha_{a,t}}_{\text{population share of age } a \text{ at time t}} \underbrace{d_{a,t}}_{\text{DTI of age } a \text{ households at time t}} \tag{29}$$

The DTI ratio is the ratio of the total mortgage debt to the total household income among all age a households: $DTI = \frac{\sum_{i\in a} MortgageDebt_{i,t}}{\sum_{i\in a} Income_{i,t}}$.

$$D_{2001} - D_{1983} = \underbrace{\sum_a \alpha_{a,2001}(D_{a,2001} - D_{a,1983})}_{\text{Contribution of change in DTI across different age groups}} + \underbrace{\sum_a D_{a,1983}(\alpha_{a,2001} - \alpha_{a,2001})}_{\text{Contribution of change in population structure}} \tag{30}$$

This decomposition implies that the total change in debt $D_{2001} - D_{1983} = 0.21$, and that the contribution from the change in DTI across age groups is 0.2129. The contribution from the change in population structure is small and negative at -0.0072. In other words, changes in demographic structure do not contribute to the rise in mortgage debt over this period.

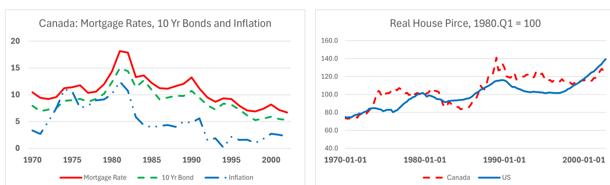
G Empirical Episodes: More Supporting Evidence

This section provides additional evidence in support of Section 7. We begin by highlighting the parallel disinflation and subsequent house price growth in the US and Canada. Then we demonstrate that periods of disinflation are typically followed by increases in household debt across many other developed countries.

G.1 Disinflation from the 1980s to 2000s: US and Canada

Similar to the US (see Figure 1a), Canada experienced declining inflation accompanied by a reduction in 10-year bond yields and mortgage rates from the 1980s to the 2000s (see Figure 15.a). Likewise, house prices remained largely stable until the late 1990s, after which they began to rise markedly (see Figure 15.b).

Figure 15: Inflation Decline in Canada in the 1980s



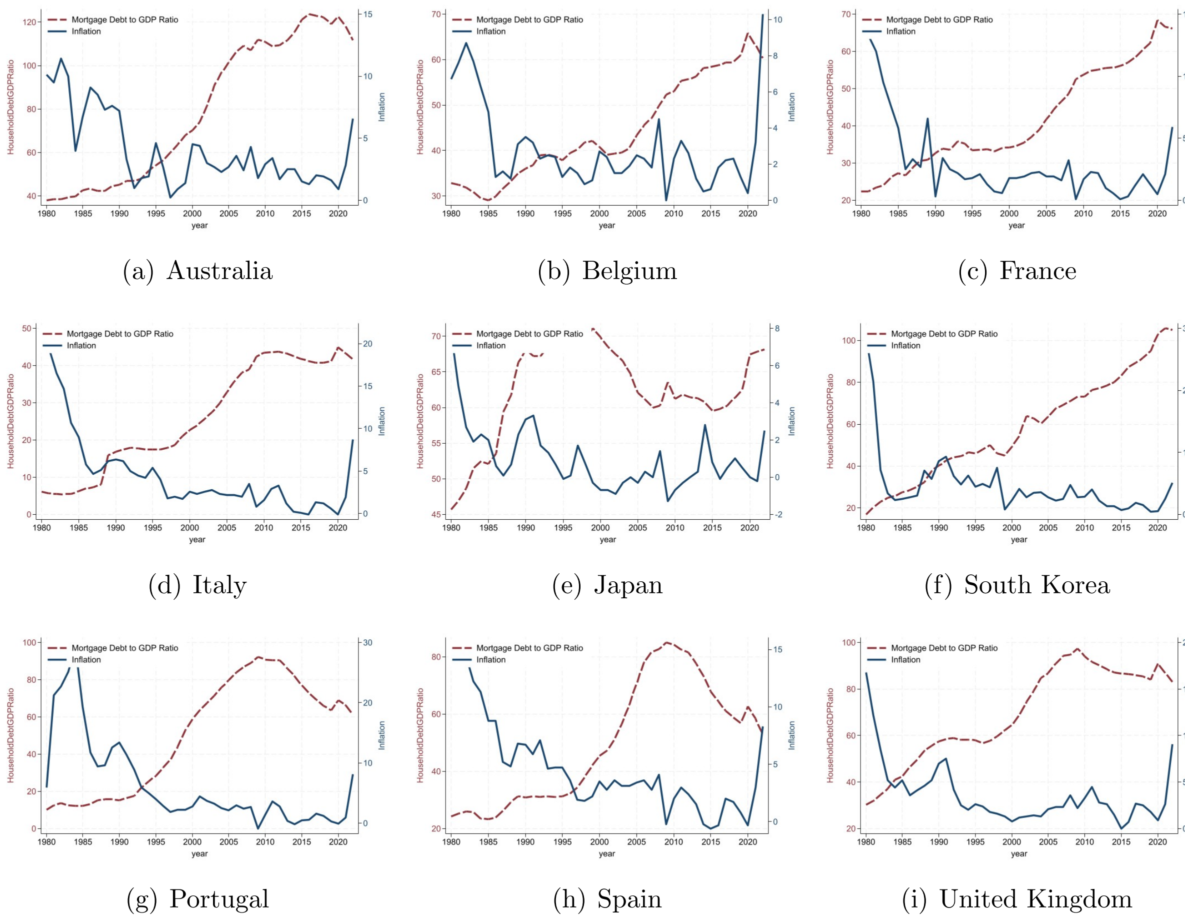
(a) Rates and Inflation (b) House Prices

Note: The average mortgage interest rate and 10-year bond yield are converted from monthly to annual by averaging and are from Statistics Canada Table: 10-10-0122-01.

G.2 Inflation and Household Debt Across Countries

The co-movement between inflation and household debt is prevalent across developed countries from 1980 to the early 2000s. Using data from the IMF Global Debt Database, we plot inflation and DTI and find a consistent pattern: as inflation declines, the household debt-to-GDP ratio rises in many countries (see Figure 16). This relationship holds despite differences in mortgage structures and the timing of mortgage market innovations.

Figure 16: Debt-to-GDP Ratio and Inflation



(a) Australia (b) Belgium (c) France

(d) Italy (e) Japan (f) South Korea

(g) Portugal (h) Spain (i) United Kingdom

Note: The ratio of household debt to GDP is measured by the household debt, loans and debt securities as a percent of GDP. Data is taken from the IMF Global Debt Database. Inflation data comes from the IMF. We include countries with data available since 1980 except for Germany (reunification) and the Nordic countries due to the collapse of the Soviet Union.