Failure to Launch: Housing, Debt Overhang, and the Inflation Option During the Great Recession

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Abstract

Can inflation cure mortgage debt overhang and mitigate the severity of housing busts? Focusing on the Great Recession, I address this question through the lens of a quantitative macroeconomic model of illiquid housing, endogenous mortgage pricing, and equilibrium default. First, I show that an increase in financial frictions accounts for half of the drop in real house prices, household net worth, and consumption during the Great Recession. However, a shock to housing liquidity is key to explaining the drop in housing sales, the increase in average time on the market, and the persistence of high foreclosure sales. A temporary surge of inflation leads to a moderate improvement in real house prices and inflation, though the endogenous contraction of mortgage credit partially offsets the direct debt erosion. However, a policy of nominal price level targeting that institutes high initial inflation followed by an extended disinflation leads to more promising results.

Keywords: Housing; Liquidity; Mortgage Debt; Foreclosure; Inflation

JEL Classification Numbers: D31, D83, E21, E22, G11, G12, G21, R21, R31

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1 Introduction

In response to the Great Recession and the unprecedented collapse in the housing market, the U.S. government has undertaken dramatic interventions to stimulate the economy out of its slump. However, the Federal Reserve has diligently avoided any attempt to push inflation above its usual two percent target.[1] Even when signaling its discontent with the low level of inflation and its willingness to take additional action, the Fed has continually re-invoked its long-run target, as it did in September 2010:

> *"Measures of underlying inflation are currently at levels somewhat below those the Committee judges most consistent, over the longer run, with its mandate to promote maximum employment and price stability."*

On the one hand, these actions demonstrate an understandable reluctance by the Fed to put at risk its hard-won inflation fighting credibility. On the other hand, household debt has throttled the economy for several years with economic growth only recently demonstrating signs of durable strength. Even as the foreclosure share of house sales falls below 10% from a peak of 30%,[2] real house prices and existing house sales remain almost 20% and 30%, respectively, below their peaks. Figure 1 plots the federal funds and inflation rates, real house prices, existing sales and average time on the market from 2004 – 2014.

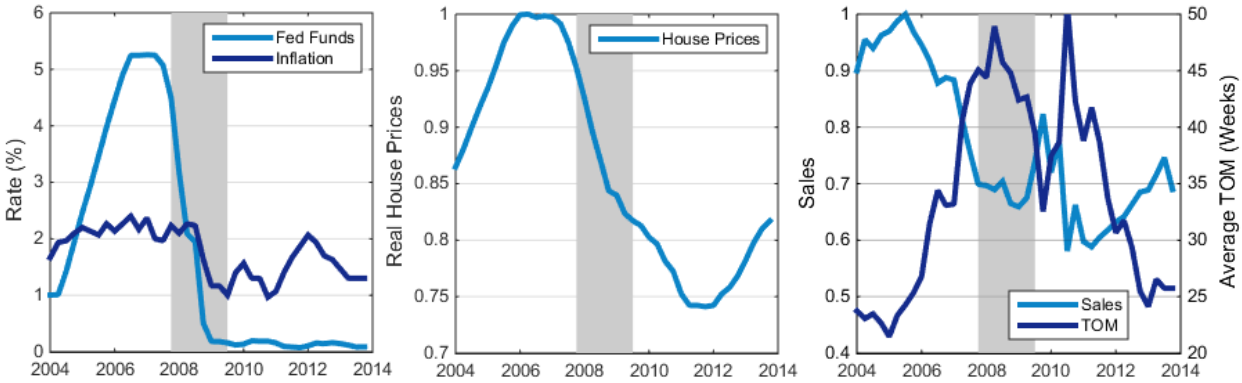


Figure 1: Fed funds and inflation; real house prices; existing sales and time on the market

The protracted recession and sluggish recovery have led to calls at various points for a temporary regime of higher inflation to battle debt's long shadow. At a summit in 2012, Robert Engle pushed for this view:

[1] See http://www.federalreserve.gov/faqs/economy_14400.htm.

[2] See http://economistsoutlook.blogs.realtor.org/2014/10/16/rapidly-diminishing-reo-foreclosure-sales/.

"If we had just a little bit of inflation and house prices went up, all the sudden they would be above the mortgages."

Paul Krugman has expressed a similar sentiment:

"If we could manage 4 or 5 percent inflation...so that prices were 25 percent higher, the real value of mortgage debt would be substantially lower than it looks on current prospect – and the economy would therefore be substantially farther along the road to sustained recovery."

In this paper, I address whether an explicit policy of inflating away mortgage debt can effectively improve economic dynamics during and after a deep recession. To do so, I construct a macroeconomic model along the lines of Hedlund (2013) and Hedlund (2014) that features illiquid housing, endogenous mortgage pricing, and equilibrium default.

In the model, households value consumption and housing services, which they receive either by owning a house or by renting. Households face uninsurable individual earnings risk and can accumulate buffer savings. Illiquidity arises in the housing market due to matching frictions á la directed search. Lastly, lenders in the mortgage market originate long-term, individually priced mortgages that take into account default risk and long-run inflation.

To motivate the analysis, I focus on two channels of inflation. First, inflation erodes the real value of debt and creates housing equity. This additional equity serves multiple purposes. By raising the value of collateral, it reduces default premia for new mortgages. In addition, the equity cushion makes it easier for homeowners to post competitive list prices to sell their houses quickly. This reduced time on the market proves especially key for distressed homeowners, as it gives them an alternative escape from burdensome debt besides default.

However, just as inflation erodes the burden of debt to borrowers, it also erodes the return to lenders. In response, lenders increase the cost of credit for *new mortgages.* With short-term mortgages and Walrasian housing markets, the increased cost of credit should significantly attenuate, if not fully eliminate, the debt eroding benefits of inflation to homeowners. In such a world, increased interest payments offset the erosion from inflation. However, long term mortgages— especially fixed rate mortgages— act as a form of nominal rigidity because lenders price default risk only at origination. As a result, an unexpected bout of inflation reduces the debt burden for current homeowners and increases the cost of credit for new borrowers. Illiquidity in housing markets plays a significant role as well because of the trade-off it generates between list price and expected time on the market. With Walrasian housing markets, mortgage debt only influences the decision to sell in a binary way: if the owner wants to sell and can pay off the mortgage balance with existing assets and receipt of the market value of the house, the owner sells; otherwise, the owner cannot sell. With illiquid

housing, mortgage debt restricts owners' choice of list price and, thus, expected selling time. Inflation provides additional pricing flexibility by eroding the value of this debt.

In this paper, I quantitatively evaluate these channels to answer whether, on balance, temporary inflation mitigates a deep housing bust or whether it hurts. However, first, I decompose the Great Recession into shocks to fundamentals (TFP, risk free rate), financial shocks, and a housing liquidity shock. I find that the financial shock— consisting of an increase in the origination cost and a reduction in maximum loan-to-value limits— dramatically increases the severity of the recession, but the housing liquidity shock— a hit to the matching function— proves key to generating a quantitatively accurate drop in house sales, increased time on the market, and prolonged clearing out of foreclosure inventories.

For the first policy intervention, I consider a temporary surge of inflation followed by a return to the pre-crisis target. In the case of a moderate inflation surge from 1.5% to 4.5% for four years, the policy has only modest effects. The dynamics of real house prices, time on the market, and net worth do not deviate much from their baseline paths, though the foreclosure rate does not spike as much. To disentangle the debt erosion effect of inflation from its impact on the cost of credit, I simulate the same policy under the assumption that lenders naively ignore the inflation increase. Under this scenario, inflating away mortgage debt considerably moderates the impact of the recession. In effect, households take advantage of under-priced credit to avoid foreclosure, to increase consumption, and to reduce distressed selling. Quantitatively, the spurt of inflation cuts the drop in real house prices by half.

I repeat the same experiment with a high inflation surge of 6% (from 1.5% to 7.5%) for four years. Here, inflation has a net positive impact on economic dynamics when taking into account both channels. Real house prices follow a path approximately 3 percentage points above the baseline trajectory, and foreclosures decrease by half. When I isolate the effect of debt erosion, the inflation surge proves so strong as to temporarily send real house prices *above* their steady state value. Consumption increases initially as well because of a surge in borrowing. Time on the market falls by 10 weeks relative to the baseline, and the foreclosure rate never budges from its long run level.

The results of these two inflation surge policies indicate both the strength of the debt erosion channel and the countervailing contraction in new credit. On balance, the effect of temporary inflation is nonlinear, with the 6 percentage point increase more than doubling the economic response to the 3 percentage point increase. Nevertheless, an alternative policy that mediates the credit contraction has an even more salient effect. Specifically, I consider a policy that temporarily increases inflation but then institutes an extended period of disinflation to bring the price level back to its original trajectory. With this policy, given the long term nature of mortgage contracts, lenders can expect real outstanding balances to

gradually recover from their deflated value caused by the inflation spike. The more potent version of this policy, which targets 7.5% inflation for 2 years followed by 7 years of 0% inflation, results in a shallower recession and a faster recovery.

1.1 Related Literature

This paper bridges the literature on models of default with the literature on housing market search frictions, both of which Hedlund (2013) and Hedlund (2014) describe in detail. In other related work, Mian, Rao and Sufi (2013) and Dynan (2012) establish the negative effect of debt overhang on consumption. Di Maggio, Kermani and Ramcharan (2014) and Aladangady (2014) look at the transmission of monetary policy through changes to household balance sheets. Doepke and Schneider (2006), Meh, Ríos-Rull and Terajima (2010), and Auclert (2014) discuss the redistributive implications of inflation and the Fisher channel. Benigno, Eggertsson and Romei (2014) and Leeper and Zhou (2013) establish a positive role for inflation during times of high debt. Sheedy (2014) makes the case for nominal GDP targeting to improve risk-sharing from the presence of noncontingent nominal debt. In the sovereign debt literature, Hilscher, Raviv and Reis (2014) and Reinhart and Sbrancia (2015) study the effectiveness of inflation to reduce public debt. Lessard and Modigliani (1975), Kearl (1979), and Piazzesi and Schneider (2012) study the real effects of high 1970s inflation.

In a closely related paper, Garriga, Kydland and Sustek (2015) study the transmission of monetary policy under adjustable rate and fixed rate mortgages. As in this paper, they take into account how inflation simultaneously erodes the the value of existing debt and increases the cost of new credit. However, whereas their model environment has two representative agents (homeowners and capital owners), this paper studies an economy with imperfect risk-sharing and an endogenous distribution of assets, debt, and housing. Furthermore, search frictions make housing illiquid in this paper. These added features allow me to study the effect of inflation on household portfolios, housing liquidity, foreclosures, and credit pricing—all with a focus on the Great Recession.

Chatterjee and Eyigungor (2015) also conduct a brief exercise that studies the effect of one possible inflationary policy on housing and foreclosures during the Great Recession. They find a sizeable reduction in foreclosures with no change in real house prices. However, debt overhang is effectively nonexistent in their setup because they model frictionless housing markets and forbid refinancing. Furthermore, their model of mortgages prevents them from studying price-level targeting policies, which I find demonstrate the most effectiveness.

Lastly, Arslan, Guler and Taskin (2015) study housing and foreclosures during the Great Recession along with the impact of a potential policy that restricts LTV at origination.

2 The Model

In this section, I construct a discrete time, infinite horizon open economy with two production sectors: a composite good sector that produces the numeraire consumption good and a construction sector that builds houses. On top of this basic structure, the model contains the following ingredients: i) uninsurable, idiosyncratic household earnings risk, ii) search frictions in the housing market, iii) nominal mortgage contracts, and iv) equilibrium mortgage default. Below, I describe the model in detail.

2.1 Households

2.1.1 Endowments

Households are infinitely lived and receive a stochastic labor endowment, $e \cdot s$, which they supply inelastically to the labor market. The persistent component $s \in S$ follows a finite Markov chain with transitions $\pi_s(s'|s)$, and the transitory component $e \in E \subset \mathbb{R}_+$ is drawn from the cumulative distribution function $F(e)$. Households draw their initial s from the invariant distribution $\Pi_s(s)$.

2.1.2 Preferences

Households have preferences over composite consumption c and housing services c_h, which they can receive either by "renting" or by owning a house. Renters purchase housing services in a frictionless spot market each period, subject to a maximum of $c_h \leq \underline{h}$. Homeowners buy and sell houses $h \in H = \{\underline{h}, h_2, h_3\}$ in a decentralized, frictional housing market. To capture the utility premium to owning, a house of size h generates a dividend $c_h = \overline{\psi}h$ of housing services each period, where $\overline{\psi} \geq 1$. However, with probability p_ψ, homeowners become mismatched and receive housing service dividends of $c_h = \underline{\psi}h < \overline{\psi}h$ until they move to a different house.[3] Let $g = (h, \psi)$ denote the homeowner's housing state. Households discount the future at the rate β.

[3] I do not allow mismatched homeowners to rent elsewhere while trying to sell their house. All homeowners are owner-occupiers in the model.

2.2 Technology

2.2.1 Composite Good Production

A representative firm produces the composite good using a constant returns to scale production function with capital K_c and labor N_c as inputs,

$$Y_c = A_c F_c(K_c, N_c).$$

Total factor productivity A_c is constant in the steady state but will vary during the Great Recession. Firms rent capital from the international market at cost $(r + \delta_c)$, where r is the international (exogenous) risk-free rate and δ_c is the capital depreciation rate. There is no time to build. The cost of labor is w per unit of labor efficiency.

The profit maximization conditions of the composite good firm are

$$r + \delta_c = A_c \frac{\partial F_c(K_c, N_c)}{\partial K_c} \tag{1}$$

$$w = A_c \frac{\partial F_c(K_c, N_c)}{\partial N_c}. \tag{2}$$

2.2.2 Rental Housing

I abstract from a formal rental housing market in the model. Instead, a class of producers called landlords operate a linear, reversible technology that converts units of the composite good into housing services at the rate A_h.[4] Landlords sell these housing services to renters at unit price r_h.

The profit maximization condition of landlords is

$$r_h = \frac{1}{A_h} \tag{3}$$

2.2.3 Housing Construction

Home builders construct new houses using a constant returns to scale production function with land/permits L, structures S_h, and labor N_h,

$$Y_h = F_h(L, S_h, N_h).$$

Builders purchase new land/permits from the government at price p_l, pay wage w per unit of labor efficiency, and purchase structures S_h from the composite good sector. As in Hedlund

[4] Jeske, Krueger and Mitman (2013) follow a similar approach.

(2013), Hedlund (2014), and Favilukis, Ludvigson and Van Nieuwerburgh (2013), the government supplies a fixed amount $\overline{L} > 0$ of new land/permits each period and all revenues go to unproductive government consumption. Home builders do not experience any construction lags and sell directly to real estate firms at price p_h per unit of housing. When real estate firms purchase housing, they combine it into houses of size $h \in H$ to sell to prospective buyers. Individual houses depreciate stochastically with probability δ_h.[5] In the aggregate, the housing stock evolves according to

$$H' = (1 - \delta_h)H + Y'_h$$

The profit maximization conditions of home builders are

$$1 = p_h \frac{\partial F_h(\overline{L}, S_h, N_h)}{\partial S_h} \tag{4}$$

$$w = p_h \frac{\partial F_h(\overline{L}, S_h, N_h)}{\partial N_h}. \tag{5}$$

2.3 Housing Market

2.3.1 Real Estate Sector

A representative real estate firm facilitates housing trades in the decentralized housing market. As in Hedlund (2013) and Hedlund (2014), real estate firms dispatch real estate agents to trade bilaterally with buyers and sellers. First, real estate agents purchase new houses from home builders and existing houses from sellers. Then, real estate agents sell the houses to prospective buyers. I assume that real estate firms cannot hold housing inventories. As such, they act simply as market makers that transfer houses from buyers to sellers. The main benefit of this structure is that it admits a block recursive equilibrium in the housing market, thereby considerably simplifying computation.

2.3.2 Directed Search for Houses

Buyers Prospective buyers direct their search for houses by choosing a desired price $x_b \geq 0$ and a house size $h \in H$. Formally, buyers enter submarket $(x_b, h) \in \mathbb{R}_+ \times H$. With probability $p_b(\theta_b(x_b, h))$, a buyer matches with and purchases a house from a real estate agent, where $\theta_b(x_b, h)$ is the ratio of real estate agents to buyers, i.e. the market tightness of submarket

[5] Complete depreciation averts the need to deal with situations where mortgaged homeowners suddenly find themselves underwater because a portion of their house depreciates. As I discuss later, I assume complete mortgage forgiveness in the low probability event that a house depreciates.

(x_b, h). The probability that a real estate agent finds a buyer is $\alpha_b(\theta_b(x_b, h)) = \frac{p_b(\theta_b(x_b,h))}{\theta_b(x_b,h)}$. The function $p_b : \mathbb{R}_+ \to [0, 1]$ is continuous and strictly increasing with $p_s(0) = 0$; α_s is strictly decreasing. It is possible that $\alpha_b > 1$, in which case the same real estate finds multiple buyers, to which the agent sells one house each.

Successful buyers immediately move into their house and switch from renter status to homeowner status with state $g = (h, \overline{\psi})$. Unsuccessful buyers remain as renters until the next period. The real estate firm incurs a cost $\kappa_b h$ for each real estate agent it hires in submarket (x_b, h). Both sides of the market take $\theta_b(x_b, h)$ parametrically.

Sellers Sellers of existing houses, which includes homeowners and lenders selling foreclosed properties, simply choose a selling price $x_s \geq 0$ that they commit to honoring if they match with a real estate agent. In the parlance of directed search, sellers enter submarket (x_s, h), where h is the size of house they are selling. With probability $p_s(\theta_s(x_s, h))$, a seller successfully matches and sells the house, *provided they are able to pay off their mortgage.*[6] A homeowner with cash at hand y and mortgage debt m must therefore sell at a price $x_s \geq m - y$. Real estate agents find sellers with probability α_s, where p_s and α_s are analogous to p_b and α_b, respectively. The real estate firm incurs a cost $\kappa_s h$ for each real estate agent it hires in submarket (x_s, h). Both sides of the market take $\theta_b(x_b, h)$ parametrically.

The profit maximization conditions of the real estate firm are

$$\kappa_b h \geq \overbrace{\alpha_b(\theta_b(x_b, h))}^{\text{prob of match}} \overbrace{(x_b - \mu h)}^{\text{profit}} \tag{6}$$

$$\kappa_s h \geq \underbrace{\alpha_s(\theta_s(x_s, h))}_{\text{prob of match}} \underbrace{(\mu h - x_s)}_{\text{profit}} \tag{7}$$

with $\theta_b(x_b, h) \geq 0$, $\theta_s(x_s, h) \geq 0$, and complementary slackness holding.

The profit to a real estate agent that purchases a house from a seller is $\mu h - x_s$, where μh represents the value to the real estate agent of receiving a house that can be sold to a prospective buyer. Therefore, real estate firms continue sending agents to submarket (x_s, h) until the expected profit no longer exceeds the cost $\kappa_s h$.

Analogously, a real estate agent that sells a house to a buyer receives $x_b - \mu h$. In both cases, real estate agents are indifferent between trading in new houses or existing houses, which results in the shadow value of housing $\mu = p_h$.

Block Recursivity As the above analysis shows, the menu of market tightnesses does not depend directly on the distribution of household characteristics (particularly income, assets,

[6] Short sales create the potential for moral hazard, which I abstract from here.

and debt). Instead, $\theta_s(x_s, h)$ and $\theta_b(x_b, h)$ are functions only of p_h, as in Hedlund (2013) and Hedlund (2014):

$$\theta_b(x_b, h) = \alpha_b^{-1}\left(\frac{\kappa_b h}{x_b - p_h h}\right) \tag{8}$$

$$\theta_s(x_s, h) = \alpha_s^{-1}\left(\frac{\kappa_s h}{p_h h - x_s}\right) \tag{9}$$

2.4 Financial Markets

Households save through the use of one period real bonds that trade at price $q_b = \frac{1}{1+r}$, where r is the (exogenous) risk-free rate. In addition, homeowners can borrow in the form of long term, fixed rate nominal mortgage contracts.

2.4.1 Mortgages

Mortgage lenders price new mortgage contracts taking into account borrower risk characteristics and the aggregate environment. In particular, a borrower with assets b', house $g = (h, \psi)$, and persistent labor efficiency s that takes out a mortgage of nominal size M' receives $q_m^0(M', b', g, s)M'$ in nominal units at origination. Perfect competition partitions the mortgage market and assures zero ex-ante profits loan-by-loan.

To capture all forms of mortgage debt– second liens, HELOCs, etc.– I assume mortgage contracts have no predefined maturity date. Instead, homeowners gradually accumulate equity at their own pace. However, homeowners that want to tap into their equity must refinance by paying off their old mortgage and taking out a new, re-priced mortgage.

Lenders incur a proportional origination cost ζ and servicing costs ϕ over the life of each mortgage. During the repayment phase, lenders face three sources of risk. First, if the house depreciates, the lender must forgive the loan balance.[7] Second, homeowners can decide to default in a given period by not making any payment. In this situation, with probability φ, the lender forecloses on the borrower and repossesses the house. With probability $1 - \varphi$, the lender ignores the skipped payment until the next payment comes due.[8] The last source of repayment risk to lenders is inflation π, which erodes the real value of payments.

Mortgage lenders price depreciation risk and long run inflation risk into the fixed rate r_m common to all borrowers. However, lenders front-load borrower-specific default risk into the price q_m^0 borrowers receive at origination. To summarize, a homeowner with existing nominal

[7] This assumption prevents the model from generating artificially high foreclosure rates.

[8] I calibrate the model with period length one quarter. Therefore, one skipped payment in the model means 3 months of skipped payments in the data. Many of these mortgages do not end up in foreclosure.

balance M that chooses new balance M' owes $M - q_m M'$ if $M' \leq M$ or $M - q_m^0(M', b', g, s)M'$ if $M' > M$, where $q_m \equiv \frac{1}{1+r_m}$.

The inverse mortgage rate q_m satisfies

$$q_m(r, \pi) = \frac{1 - \delta_h}{(1 + \phi)(1 + r)(1 + \pi)}. \tag{10}$$

Mortgage prices satisfy the following recursive relationship:

$$q_m^0(M', b', g, s; r, \pi)M' = \frac{q_m(r, \pi)}{1 + \zeta}\mathbb{E}\left\{\overbrace{p_s(\theta_s(x_s^{*\prime}, h))M'}^{\text{sell, repay}} + [1 - p_s(\theta_s(x_s^{*\prime}, h))]\left[\overbrace{d^{*\prime}\varphi \min\left\{P' J_{REO}(h), M'\right\}}^{\text{repossession}}\right.\right.$$
$$+ d^{*\prime}(1 - \varphi)\left(-\phi M' + \underbrace{(1 + \zeta)(1 + \phi)q_m^0(M', b^{*\prime\prime}, (h, \psi'), s'; r', \pi')M'}_{\text{continuation value of current } M'}\right) + (1 - d^{*\prime})$$
$$\left.\left. \times \left(\underbrace{M' - (1 + \phi)q_m(r', \pi')M^{*\prime\prime}\mathbf{1}_{[M^{*\prime\prime} \leq M]}}_{\text{borrower payment net of servicing costs}} + \underbrace{(1 + \zeta)(1 + \phi)q_m^0(M^{*\prime\prime}, b^{*\prime\prime}, (h, \psi'), s'; r', \pi')M^{*\prime\prime}\mathbf{1}_{[M^{*\prime\prime} \leq M]}}_{\text{continuation value of new } M^{*\prime\prime}}\right)\right]\right\} \tag{11}$$

where P' is the price level next period and $x_s^{*\prime}$, $d^{*\prime}$, $b^{*\prime\prime}$, and $M^{*\prime\prime}$ are the policy functions as a function of *next period's state* for list price, mortgage default ($\in \{0, 1\}$), savings, and mortgage balances, respectively. In the steady state, $(r', \pi') = (r, \pi)$.

By defining $m' = \frac{M'}{P}$ and $m^{*\prime\prime} = \frac{M^{*\prime\prime}}{P'}$ and dividing through by Pm', q_m^0 can be written as

$$q_m^0(m', b', g, s; r, \pi) = \frac{q_m(r, \pi)}{1 + \zeta}\mathbb{E}\left\{p_s(\theta_s(x_s^{*\prime}, h)) + [1 - p_s(\theta_s(x_s^{*\prime}, h))]\left[d^{*\prime}\varphi \min\left\{\frac{(1 + \pi)J_{REO}(h)}{m'}, 1\right\}\right.\right.$$
$$+ d^{*\prime}(1 - \varphi)\left(-\phi + (1 + \zeta)(1 + \phi)q_m^0(m', b^{*\prime\prime}, (h, \psi'), s', r', \pi')\right) + (1 - d^{*\prime})$$
$$\left.\left. \times \left(1 + (1 + \phi)\left[(1 + \zeta)q_m^0(m^{*\prime\prime}, b^{*\prime\prime}, (h, \psi'), s'; r', \pi') - q_m(r', \pi')\right]\frac{(1 + \pi)m^{*\prime\prime}}{m'}\mathbf{1}_{[(1+\pi)m^{*\prime\prime} \leq m']}\right)\right]\right\} \tag{12}$$

2.4.2 Foreclosure Process

As just discussed, with probability φ, a mortgage lender forecloses on a defaulting borrower and repossesses the house. In this event, the borrower's mortgage debt is erased and a flag ($f = 1$) is placed on their credit record. Borrowers with a credit flag are not permitted to borrow in the mortgage market. Credit flags are persistent and carry over to the following period with probability $\gamma_f \in (0, 1)$. The house repossession and borrowing exclusion represent the only costs of foreclosure to borrowers.

Once a lender completes the repossession, the house becomes an REO property. Lenders

proceed to sell the house in the decentralized housing market, albeit with a reduced search efficiency $\lambda \in (0,1)$ and subject to a selling price discount of χ. The intermediary absorbs all mortgage losses but must pass along profits to the borrower in the unlikely event that sales revenues exceed the remaining mortgage balance.

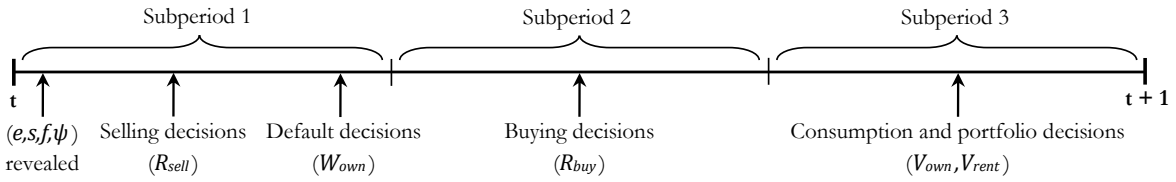
The value to a lender in repossessing a house h is

$$\begin{aligned} J_{REO}(h) &= R_{REO}(h) - \xi h + \frac{1-\delta_h}{1+r} J_{REO}(h) \\ R_{REO}(h) &= \max\left\{0, \max_{x_s \geq 0} \lambda p_s(\theta_s(x_s,h)) \left[(1-\chi)x_s + \xi h - \frac{1-\delta_h}{1+r} J_{REO}(h)\right]\right\} \end{aligned} \tag{13}$$

where ξ is the cost of holding onto the house (maintenance, property taxes, etc.) and $R_{REO}(h)$ is the option value of trying to sell the house.

2.5 Household Problem

2.5.1 Timeline



Each period is divided into three subperiods. At the beginning of subperiod 1, households learn their stochastic labor efficiency components, e and s, their credit score $f \in \{0,1\}$, and in the case of homeowners, the fitness of their match, $\psi \in \{\underline{\psi}, \overline{\psi}\}$. The individual state of a homeowner is cash at hand y, adjusted mortgage debt $m \equiv \frac{M}{P^=}$, house $g = (h, \psi)$, and persistent labor component s. The individual state of a renter is simply (y, s, f).

Now I work through the household value functions, starting at the end of the period and moving backward.

Consumption/Saving At the end of the period, renters decide how much to consume of the composite good and of housing services and how much to save in bonds. Homeowners decide how much to consume of the composite good, how much to save in bonds, and how to adjust their mortgage balance.

In nominal terms, homeowners face the following budget constraint:

$$Pc + P\xi h + Pq_b b' + M - q_m(\cdot)M' \leq Py$$

where $q_m(\cdot) = q_m$ if $M' \leq M$ and $q_m(\cdot) = q_m^0(\cdot)$ otherwise.

Dividing through by P and replacing $\frac{M}{P}$ with $\frac{P^-}{P}\frac{M}{P^-} = \frac{P^-}{P}m = \frac{m}{1+\pi}$ gives the budget constraint in terms of the numeraire consumption good,

$$c + \xi h + q_b b' + \frac{m}{1+\pi} - q_m(\cdot)m' \leq y.$$

From the constraint, one major effect of inflation becomes clear: it reduces the value of outstanding mortgage debt. For stationary r and π, the household value functions are below.

Homeowners with Good Credit:

$$\begin{aligned} V_{own}(y,m,g,s,0) = \max_{b',m' \leq \vartheta p_h, c \geq 0} & u(c,\psi h) + \beta \mathbb{E} \left[\begin{array}{l} (1-\delta_h)(W_{own} + R_{sell})(y',m',(h,\psi'),s',0) \\ +\delta_h(V_{rent} + R_{buy})(y',s',0) \end{array} \right] \\ & \text{subject to} \\ & c + \xi h + q_b b' + \frac{m}{1+\pi} - q_m(m',b',g,s)m' \leq y \\ & q_m(m',b',g,s) = \begin{cases} q_m^0(m',b',g,s) & \text{if } m' > \frac{m}{1+\pi} \\ q_m & \text{if } m' \leq \frac{m}{1+\pi} \end{cases} \\ & y' = we's' + b' \end{aligned} \tag{14}$$

where ϑ is an exogenous upper bound on leverage for new mortgages.

Homeowners with Bad Credit:

$$\begin{aligned} V_{own}(y,0,g,s,1) = \max_{b',c \geq 0} & u(c,\psi h) + \beta \mathbb{E} \left[\begin{array}{l} (1-\delta_h)(W_{own} + R_{sell})(y',0,(h,\psi'),s',f') \\ +\delta_h(V_{rent} + R_{buy})(y',s',f') \end{array} \right] \\ & \text{subject to} \\ & c + \xi h + q_b b' \leq y \\ & y' = we's' + b' \end{aligned} \tag{15}$$

Renters with Good Credit:

$$\begin{aligned} V_{rent}(y,s,0) = \max_{c \geq 0, 0 \leq c_h \leq \underline{h}} & u(c,c_h) + \beta \mathbb{E} \left[(V_{rent} + R_{buy})(y',s',0) \right] \\ & \text{subject to} \\ & c + r_h c_h + q_b b' \leq y \\ & y' = we's' + b' \end{aligned} \tag{16}$$

Renters with Bad Credit:

$$\begin{aligned} V_{rent}(y,s,1) = \max_{c\geq 0, 0\leq c_h\leq \underline{h}} & u(c,c_h) + \beta \mathbb{E}\left[(V_{rent} + R_{buy})(y',s',f')\right] \\ & \text{subject to} \\ & c + r_h c_h + q_b b' \leq y \\ & y' = we's' + b' \end{aligned} \tag{17}$$

House Buying Renters (which includes successful home sellers from subperiod 1) direct their search to a submarket (x_b, h) of their choice. Renters with bad credit are bound by the constraint $y - x_b \geq 0$, while renters with good credit are bound by the constraint $y - x_b \geq \underline{y}_s$, where $\underline{y}_s < 0$ captures the ability of new buyers to take out a mortgage in subperiod 3. The option value $R_{REO}(y,s,f)$ to attempting to buy is as follows:

$$R_{buy}(y,s,0) = \max\{0, \max_{\substack{h\in H,\\ x_b\leq y-\underline{y}_s}} p_b(\theta_b(x_b,h))[V_{own}(y-x_b,0,(h,\overline{\psi}),s,0) - V_{rent}(y,s,0)]\} \tag{18}$$

$$R_{buy}(y,s,1) = \max\{0, \max_{\substack{h\in H,\\ x_b\leq y}} p_b(\theta_b(x_b,h))[V_{own}(y-x_b,0,(g,\overline{\psi}),s,1) - V_{rent}(y,s,1)]\} \tag{19}$$

Mortgage Default The value function for a homeowner deciding whether to default is

$$\begin{aligned} W(y,m,g,s,0) = \max\Bigg\{ & \varphi(V_{rent} + R_{buy})\left(y + \max\left\{0, J_{REO}(h) - \frac{m}{1+\pi}\right\}, s, 1\right) \\ & + (1-\varphi)V^d_{own}(y,m,g,s,0), V_{own}(y,m,g,s,0)\Bigg\} \end{aligned} \tag{20}$$

where

$$\begin{aligned} V^d_{own}(y,m,g,s,0) = \max_{b',c\geq 0} & u(c,\psi h) + \beta \mathbb{E}\left[\begin{array}{l} (1-\delta_h)(W_{own} + R_{sell})(y',m,(h,\psi'),s',0) \\ +\delta_h(V_{rent} + R_{buy})(y',s',0) \end{array}\right] \\ & \text{subject to} \\ & c + \xi h + q_b b' \leq y \\ & y' = we's' + b' \end{aligned} \tag{21}$$

House Selling Homeowners in subperiod 1 decide whether to try to sell their house. For owners of house size h who want to sell, they choose a list price x_s and direct their search

to submarket (x_s, h). Their value functions are

$$R_{sell}(y,m,g,s,0) = \max\{0, \max_{x_s \geq \frac{m}{1+\pi}-y} p_s(\theta_s(x_s,h)) \left[(V_{rent} + R_{buy}) \left(y + x_s - \frac{m}{1+\pi}, s, 0 \right) - V_{own}(y,m,g,s,0) \right] \} \tag{22}$$

$$R_{sell}(y,0,g,s,1) = \max\{0, \max_{x_s} p_s(\theta_s(x_s,h))[(V_{rent} + R_{buy})(y + x_s, s, 1) - V_{own}(y,0,g,s,1)]\} \tag{23}$$

Note that sellers with mortgage debt m must choose a price x_s sufficiently high to pay off their debt upon sale, i.e. $y + x_s \geq \frac{m}{1+\pi}$. The higher is the inflation rate π, the less binding is the constraint.

2.6 Equilibrium

Definition 1 *For given interest rate r and inflation π, a stationary recursive equilibrium is a collection of value/policy functions for households and mortgage lenders; market tightness functions θ_s and θ_b; prices w, p_h, q_m^0, q_m, q_b, and r_h; a stationary distribution Φ of households and a stationary distribution of REO housing stock H_{REO} such that:*

1. ***Household Optimality:*** *The value/policy functions solve (14) – (23).*
2. ***Production Firm Optimality:*** *Conditions (1) – (5) are satisfied.*
3. ***Lender Optimality:*** *Conditions (10) – (13) are satisfied.*
4. ***Market Tightnesses:*** *$\{\theta_b(x_b,h)\}$ and $\{\theta_s(x_s,h)\}$ satisfy (8) – (9).*
5. ***Shadow Housing Price:*** *$D_h(p_h) = S_h(p_h)$.*
6. ***Labor Market Clears:*** *$N_c + N_h = \sum_{s \in S} \int_E e \cdot sF(de)\Pi_s(s)$.*
7. ***Stationary Distributions:*** *the distributions Φ and H_{REO} are invariant with respect to the Markov process induced by all relevant exogenous processes and policy functions.*

where $D_h(p_h)$ is the total demand for housing by buyers and $S_h(p_h)$ is the total supply for housing provided by home builders, homeowners, and lenders managing reposessed (REO) properties. See Hedlund (2013) for more details.

3 Bringing the Model to the Data

I calibrate the model to match selected features of the U.S. economy during 2003 – 2005, prior to the tightening of monetary policy and the subsequent Great Recession. Some model parameters I calibrate ex ante from the literature or from direct observation of the data. The remaining parameters I calibrate jointly. Below, I discuss the calibration in greater detail.

3.1 Households

3.1.1 Endowments

The log of labor efficiency, $\ln(e \cdot s) = \ln(s) + \ln(e)$, follows

$$\begin{aligned} \ln(s') &= \rho \ln(s) + \varepsilon' \\ \varepsilon' &\sim \mathcal{N}(0, \sigma_\varepsilon^2) \\ \ln(e) &\sim \mathcal{N}(0, \sigma_e^2). \end{aligned}$$

I calibrate the persistent component of labor efficiency using estimates from Storesletten, Telmer and Yaron (2004) ($\rho = 0.952$, $\sigma_\epsilon = 0.17$). I follow the procedure described in Hedlund (2013) to convert their annual parameter estimates to quarterly estimates. Next, I approximate this process with a three-state Markov chain using the Rouwenhorst (1995) method. I follow a similar approach to McKay, Nakamura and Steinsson (2015) and set a small value of $\sigma_e = 0.05$ for the transitory component.

3.1.2 Preferences

Households have CES period utility given by

$$u(c, c_h) = \frac{([\omega c^{\frac{\nu-1}{\nu}} + (1-\omega) c_h^{\frac{\nu-1}{\nu}}]^{\frac{\nu}{\nu-1}})^{1-\sigma}}{1-\sigma}.$$

I set the intratemporal elasticity of substitution between composite consumption and housing services to $\nu = 0.13$, in line with estimates from Kahn (2009), and Flavin and Nakagawa (2008). Risk aversion is set to $\sigma = 2$. The consumption share ω and discount factor β are determined in the joint calibration.

3.2 Technology

3.2.1 Producers

Production in both sectors is Cobb-Douglas,

$$Y_c = A_c K^{\alpha_K} N_c^{1-\alpha_K} \qquad Y_h = L^{\alpha_L}(S_h^{\alpha_S} N_h^{1-\alpha_S})^{1-\alpha_L}.$$

The capital share in non-housing is $\alpha_K = 0.26$, in line with Díaz and Luengo-Prado (2010) and Nakajima (2010). The capital depreciation rate is $\delta_K = 0.1$.[9] The technology parameter A_c is chosen to normalize mean quarterly earnings to 0.25. For house construction, the structures share is $\alpha_S = 0.3$, as in Favilukis et al. (2013). The land share is $\alpha_L = 0.33$ based on data from the Lincoln Institute of Land Policy.[10] Housing depreciates at an annual rate of 1.4%, which implies a quarterly value of $\delta_h = 0.0035$. Lastly, the rental housing technology A_h is set to generate an annual rent-price ratio of 6.5% (price-rent ratio of ≈ 15.4).

3.2.2 Housing Market

Matching in the housing market takes place according to two Cobb Douglas matching functions: one that matches sellers to real estate agents and the other that matches real estate agents to buyers. Match probabilities are given by $p_s(\theta_s) = \min\{\theta^{\gamma_s}, 1\}$ and $p_b(\theta_b) = \min\{\theta^{\gamma_b}, 1\}$. Substituting in (8) and (9) gives

$$p_s(\theta_s) = \begin{cases} 0 & \text{if } x_s > p_h h \\ \left(\frac{p_h h - x_s}{\kappa_s h}\right)^{\frac{\gamma_s}{1-\gamma_s}} & \text{if } (p_h - \kappa_s)h \le x_s \le p_h h \\ 1 & \text{if } x_s < (p_h - \kappa_s)h \end{cases} \quad p_b(\theta_b) = \begin{cases} 1 & \text{if } x_b > (p_h + \kappa_b)h \\ \left(\frac{x_b - p_h h}{\kappa_b h}\right)^{\frac{\gamma_b}{1-\gamma_b}} & \text{if } p_h h \le x_b \le (p_h + \kappa_b)h \\ 0 & \text{if } x_b < p_h h \end{cases}$$

The parameters κ_b, κ_s, γ_s, and γ_b are determined in the joint calibration. I set holding costs (maintenance, property taxes, etc.) to $\xi = 0.007h$.[11]

3.3 Financial Markets

To match values in the U.S. during 2003 – 2005, I set the inflation rate to 1.5%, the real risk-free rate to -0.5%, and the mortgage origination cost to 0.4%.[12] I set the mortgage servicing cost π such that the nominal mortgage rate is 6%. Lastly, I impose an exogenous

[9] The only role for δ_K is to drive a wedge between the rental rate of capital and the exogenous risk free rate r. The capital stock itself adjusts instantly to changes in r, given the open economy assumption and the absence of adjustment costs.

[10] http://www.lincolninst.edu/subcenters/land-values/price-and-quantity.asp

[11] See http://www.nytimes.com/2007/04/10/business/11leonhardt-avgproptaxrates.html?_r=0 for property tax data.

[12] Mortgage rates and fees can be found at http://www.fhfa.gov/Default.aspx?Page=252.

upper bound on leverage for new mortgages of $\vartheta = 1.25$ (125%), although this constraint is *non-binding* in the steady state. At the peak of the housing boom in 2005, the popularity of cash-out refinancing led to many instances of new mortgages with loan-to-value ratios in excess of 100%. See Herkenhoff and Ohanian (2013) for further discussion.

Foreclosure Process I set the foreclosure completion probability to $\varphi = 0.5$[13] and the persistence of bad credit flags to $\gamma_f = 0.95$.[14] I determine the REO sale loss χ and search efficiency γ in the joint calibration. Table 1 summarizes the independent parameters.

Table 1: Calibration: Independent Parameters

Description	*Parameter*	*Value*
Autocorrelation of Persistent Shock	ρ	0.952
Standard Deviation of Persistent Shock	σ_ϵ	0.17
Standard Deviation of Persistent Shock	σ_e	0.05
Intratemporal Elasticity of Substitution	ν	0.13
Risk Aversion	σ	2
Medium-Sized House	h_2	$2.75^{1/2}\underline{h}$
Large House	h_3	$2.75\underline{h}$
Maintenance, Property Taxes, Etc.	χ	$0.007h$
Capital Share	α_K	0.26
Structure Share	α_S	0.3
Land Share	α_L	0.33
Capital Depreciation	δ_K	10% (annualized)
Housing Depreciation	δ_h	1.4% (annualized)
Rent-Price Ratio	r_h	6.5% (annualized)
Inflation	π	1.5% (annualized)
Real Risk Free Rate	r	-0.5% (annualized)
Mortgage Origination Cost	ζ	0.4%
Mortgage Servicing Cost	ϕ	3.53% (annualized)
Maximum LTV	ϑ	125%
Probability of Foreclosure Completion	φ	0.5
Persistence of Bad Credit Flag	λ_f	0.95

[13]The 2013 RealtyTrac Foreclosure Market Report and 2008 OCC Mortgage Metrics Report (appendix D) provide evidence supporting this value. Herkenhoff and Ohanian (2013) and Calem, Jagtiani and Lang (2014) also contain insightful discussions of foreclosure delays.

[14]Fannie Mae and Freddie Mac do not generally underwrite mortgages to borrowers with foreclosure records until after 5 years.

3.4 Joint Calibration

I determine the remaining parameters to fit the model to certain aspects of U.S. macroeconomic data in the 2003 – 2005 period. Table 2 summarizes the joint calibration. The first set of targets are select household portfolio moments calculated from the 2004 Survey of Consumer Finances.[15] The next set of statistics includes the annual housing sales rate, mean buyer search time and mean seller search time[16], and the maximum bid and list spreads in the housing market. I target a maximum bid premium of 2.5%, consistent with Gruber and Martin (2003). For sellers, I target a maximum list price discount of 25%.[17] Lastly, I calibrate the model to match the average foreclosure price discount, the REO share of housing sales, and the quarterly foreclosure rate.[18]

Table 2: Calibration: Jointly Determined Parameters

Statistic	*Target*	*Model*	*Parameter*	*Value*
Homeownership Rate	68%	67.93%	$\underline{h}$	3.475
Median Net Worth	1.06	1.04	β	0.981
Mean Housing Wealth	3.99	3.97	ω	0.686
Median Housing Wealth	3.55	3.53	$\overline{\psi}$	1.2
Annual Sales Rate	0.10	0.10	p_φ	0.013
Mean Buyer Search Time (Weeks)	10	10.41	γ_b	0.1
Mean Homeowner Selling Time (Weeks)	17.33	17.27	$\underline{\psi}$	0.372
Maximum Bid Price Premium	2.5%	2.5%	κ_b	0.022
Maximum List Price Discount	25%	25%	κ_s	0.22
Foreclosure Discount	0.21	0.21	χ	0.17
REO Share of Sales	5%	4.96%	λ	0.6
Quarterly Foreclosure Starts	0.43%	0.47%	γ_s	0.44

3.5 Model Fit

Given the importance of mortgage leverage in any discussion of debt hangover, table 3 points out that the model also does quite well in matching the distribution of loan-to-value among mortgage holders as well as typical liquid asset holdings.

[15] In all calculations, I include only households that are in the bottom 95% of the earnings *and* net worth distributions. I define net worth as liquid assets + housing wealth (primary residence) − mortgage debt. Liquid assets is financial wealth − quasi-liquid retirement accounts.

[16] In the model, I focus on sellers moving at least in part because of mismatch. Data source: National Association of Realtors

[17] Most sellers choose list prices far from this lower bound; setting x_s this low simply guarantees an immediate sale. See Hedlund (2013) for evidence on selling discount magnitudes.

[18] See Pennington-Cross (2006) and the National Delinquency Survey for more detailed information.

Table 3: Model Fit

Statistic	Model	Data
Median LTV	58.6%	57.9%
Percent of Mortgagors with LTV $\geq$ 70%	40.6%	34.6%
Percent of Mortgagors with LTV $\geq$ 80%	24.4%	21.9%
Percent of Mortgagors with LTV $\geq$ 90%	15.3%	11.4%
Percent of Mortgagors with LTV $\geq$ 95%	7.0%	7.1%
Median Liquid Assets	0.10	0.12

4 Results

4.1 A Brief Roadmap

To give a brief overview of the main quantitative exercises, I begin by simulating the housing bust during the Great Recession. From there, I decompose the Great Recession to evaluate the impact of financial and liquidity shocks, which I discuss below. Next, to preview the main policy exercise, I investigate the effects of long run inflation on the housing and mortgage markets. Lastly, I move to the main quantitative exercise, which involves studying the effects of different implementations of higher inflation during the housing bust.

4.2 Simulating the Great Recession

In this section, I simulate a Great Recession and recovery that takes place in three phases. I compute a perfect foresight transition path starting from the original state and progressing through each phase. In other words, households are caught completely by surprise when the recession hits. However, at each point along the transition path, households are perfectly aware of when each phase of the recession ends and which path the economy takes. Given the surprise nature of the recession, mortgage lenders experience ex-post losses. In a closed economy, I would need to specify how these losses are distributed among the population of households. However, I study an open economy and focus only on the bottom 95% (in earnings and net worth) of households, very few of whom own equity in financial institutions. As such, I assume losses are absorbed by unmodeled wealthy agents and international investors.

4.2.1 Phase 1: The Crash (4 Years)

In phase 1, the real risk free rate jumps from -0.5% to 3.3% for four quarters (corresponding to the tightening of monetary policy in 2005) and TFP in the composite good sector drops

by 5% for 12 periods.[19] In addition, I simulate an exogenous credit crunch that increases the mortgage origination cost from 0.4% to 1.2%[20] and reduces the exogenous maximum loan-to-value on new mortgages from 125% to 90%. Lastly, I simulate an exogenous drop in housing liquidity[21] in the form of a shock to selling probabilities, $\tilde{p}_s(\theta_s(x_s, h)) = 0.5p_s(\theta_s(x_s, h))$. Lastly, the probability of lender repossession decreases from $\varphi = 0.5$ to $\varphi = 0.2$.[22]

4.2.2 Phase 2: The Slow Recovery (4 Years)

In phase 2, selling probabilities $p_s(\theta_s(x_s, h))$ and the probability of lender repossession return to their pre-crisis levels. Similarly, the real risk free rate returns to -0.5% and TFP is back on trend. However, the mortgage origination cost remains elevated and the maximum LTV for new mortgages stays at 90%.

4.2.3 Phase 3: Return to Normalcy

In phase 3, the credit crunch ends, which causes the origination cost to drop back down to 0.4% and the maximum LTV on new loans to rise to 125%. Admittedly, it is possible that the liberalized credit conditions at the height of the housing boom may never return. However, extremely low downpayments appear to be making a comeback[23], and it may be only a matter of time before cash-out refinancing resumes its previous popularity. Either way, the computational results change little if I assume a perpetual 90% LTV limit, as it has a negligible effect on *long run* house prices.

4.2.4 Baseline Results

In the baseline economy, the recession causes a rapid 20% crash in real house prices along with a 40% drop in sales and an increase in the average time houses sit on the market from 17 weeks to 40 weeks. In the data, real house prices[24] dropped by 20% between 2007–2010, sales fell by 40%, and time on the market increased to almost 50 weeks. As shown in figure 2, house prices gradually recover over the subsequent eight years, while the sales rate recovers more rapidly. The end of the exogenous liquidity shock in year 4 causes the sales rate to temporarily spike and time on the market to plummet.

[19] See Fernald (2014) for evidence on TFP during the Great Recession.

[20] Source: Monthly Interest Rate Survey

[21] Housing liquidity also drops endogenously, but the matching shock amplifies it.

[22] See Herkenhoff and Ohanian (2013) for evidence of increasing foreclosure delays.

[23] Fannie Mae and Freddie Mac recently announced they will accept minimum downpayments of 3%. See http://blogs.wsj.com/totalreturn/2014/10/22/low-down-payments-are-coming-back/ and http://themortgagereports.com/16976/97-mortgage-low-downpayment-3-mortgage-rates.

[24] Source: FHFA Purchase-Only Index

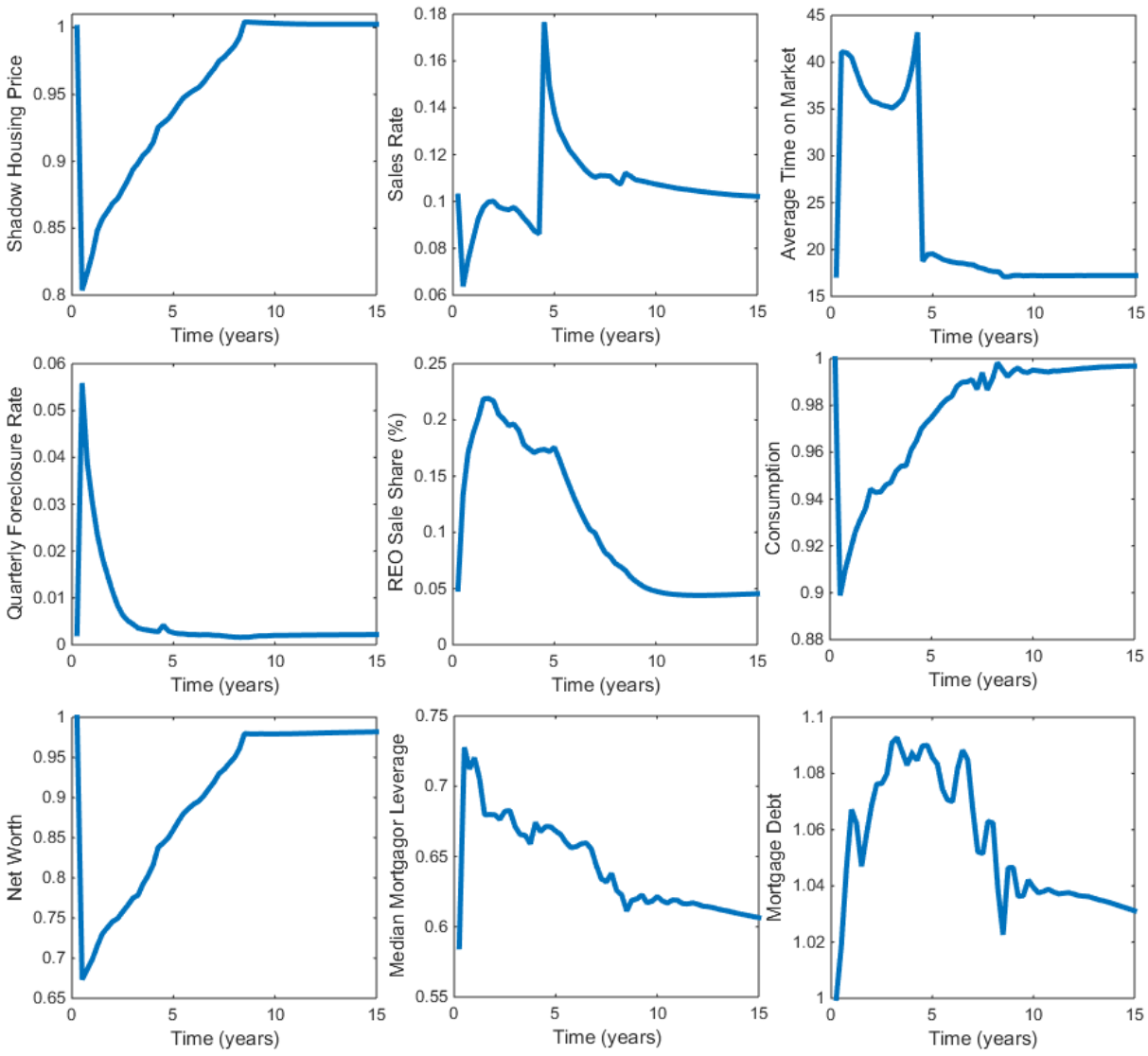


Figure 2: The baseline simulated Great Recession. The series for real house prices, consumption, net worth, and mortgage debt are normalized by their initial, pre-recession values.

Due to the precipitous house price drop in the first period of the recession, the quarterly foreclosure completion rate spikes to just over 5%, whereas in the data it rises more gradually.[25] After the initial spike, the simulated foreclosure rate returns to its steady state value after approximately 3 years. The share of households with bad credit, however, takes almost a decade to decrease from its recession high of 11% back to its steady state value of 3%. Similarly, the REO (lender repossessed) share of housing sales decreases gradually to 5% after hitting 22%. In the data, the REO sales share hits a peak of 27% in mid-2009.

The housing bust has significant spillover effects, as consumption of the composite good decreases by almost 10%. Even when TFP returns to normal after year 3, consumption remains substantially depressed. Looking at household portfolios, net worth decreases by 33% (compared to 44% in the data[26]) and closely tracks the slow return of house prices back to steady state. Naturally, leverage jumps at the moment that house prices drop, but a temporary accumulation of mortgage debt slows the deleveraging process.

4.2.5 Decomposing the Great Recession

Now I unpack the effects of the financial and liquidity shocks from the drop in TFP and the brief risk-free rate increase. To isolate the financial shocks, I re-compute the equilibrium transition path using the pre-recession steady state values of the mortgage origination cost and leverage constraint. As figure 3 clearly demonstrates, the increase in financial frictions has a profound impact on the dynamics of the economy. Absent these shocks, real house prices only decrease by 9%, compared to the 20% observed in the baseline case. The shallower housing bust substantially moderates the spike in foreclosures, which in turn, causes the REO sales share to peak at 17%, compared to 23% in the baseline economy. Also, the drop in net worth is moderated by 50%, and consumption only falls 6%, rather than 10%. Interestingly, the sales rate exhibits little change, but average time on the market falls by 5 weeks at the beginning of the recession compared to the baseline.

Next, I re-introduce the financial frictions but remove the exogenous shock to selling market match probabilities, $p_s(\theta_s(x_s, h)$. In this economy, the path of real house prices, the foreclosure rate, and net worth are essentially unchanged from the baseline. However, the sales rate actually *increases* during the housing bust in the absence of the liquidity shock as households seek to downsize. Even without the liquidity shock, average time on the market increases endogenously from 17 weeks to 25 weeks, though the increase is evidently less dramatic than in the baseline economy. Average time on the market stays significantly elevated for approximately 3 years before returning to its pre-crisis level. The combination

[25] According to the Mortgage Bankers Association, foreclosure starts peaked at 5.2% in 2009.
[26] See Wolff (2014).

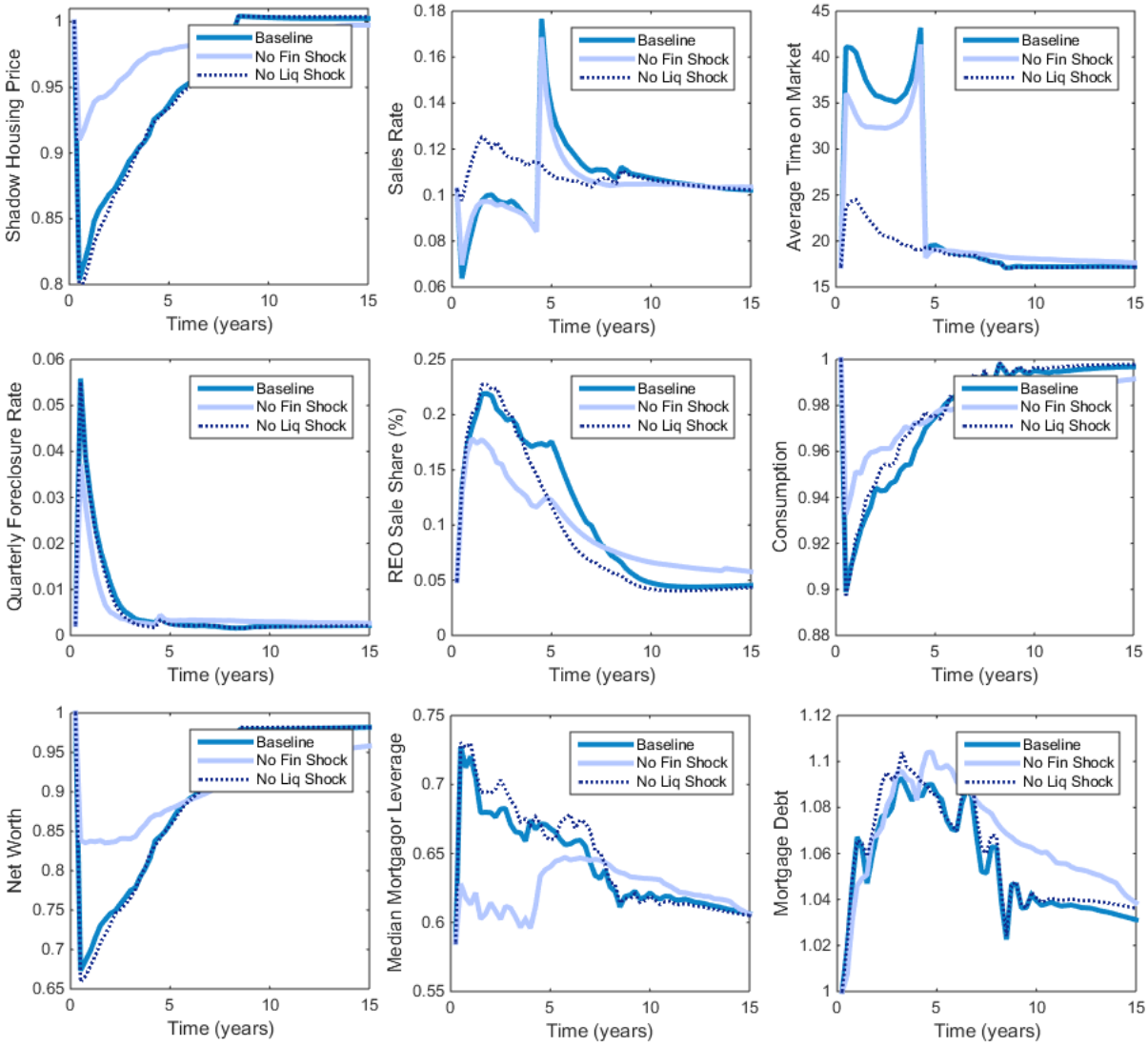


Figure 3: Baseline economy; no financial shocks; no liquidity shock

of increased non-REO sales and a quicker return to normal for average time on the market causes the REO sales share to return to steady state more quickly than in the baseline economy. Interestingly, the absence of a liquidity shock also causes a modest increase in consumption relative to the baseline 3 years into the recovery, fueled mostly by a modest increase in mortgage debt. As discussed in Hedlund (2013) and Hedlund (2014), mortgage credit availability increases with housing liquidity for two reasons: (i) financially distressed homeowners are more easily able to quickly sell their house and pay off their mortgage, and (ii) the value to lenders of a repossessed house increases because the house can be sold faster.

4.3 The Inflation Option

In this section, I investigate how explicitly inflationary monetary interventions could have changed the course of the economy during the Great Recession. I do not delve into the mechanics of specific Federal Reserve actions; rather, I focus on the effects of the different inflation paths themselves. Two primary and opposing channels of inflation motivate the quantitative exercise. On the one hand, higher π reduces the value of real mortgage debt $\frac{\pi}{1+\pi}$ at the beginning of the period. This inflating away of mortgage debt accomplishes two objectives. First, it reduces the burden of mortgage debt, thereby alleviating financial distress and reducing foreclosures. Second, it loosens the selling constraint $y + x_s \geq \frac{m}{1+\pi}$ in the housing market. For highly indebted homeowners, a binding constraint reduces their ability to sell quickly. An increase in π loosens this constraint and reduces time on the market, which further reduces foreclosures by allowing distressed homeowners to sell and avoid default.

From the perspective of mortgage lenders, higher inflation presents a mixed bag. Most directly, higher inflation reduces the real value of mortgage payments. On the other hand, by alleviating financial distress and increasing liquidity in the housing market, higher inflation reduces default probabilities. The overall effect on real mortgage revenues, and therefore on mortgage prices q_m^0, is a quantitative matter.

4.3.1 Steady State Effects of Higher Inflation

Before conducting the counterfactual transition path exercises, I look at the steady state effects of higher inflation. First, I consider an increase in long-run inflation from 1.5% to 4.5%. Table 4 shows only a modest economic response. In particular, the homeownership rate, leverage distribution, and annual rate of foreclosure starts remain essentially unchanged. Increasing inflation still further, to 7.5%, has little impact. In short, money appears almost superneutral in the model.

Table 4: The Effects of Higher Long-Run Inflation

Statistic	Baseline	$\pi = 4.5\%$	$\pi = 7.5\%$	$\pi = 4.5\%^*$	$\pi = 7.5\%^*$
Homeownership Rate	67.9%	68.1%	68.0%	71.8%	78.5%
Percent of Mortgagors with LTV $\geq 70\%$	40.6%	40.7%	42.5%	43.4%	99.1%
Percent of Mortgagors with LTV $\geq 80\%$	24.5%	24.2%	27.6%	26.7%	83.3%
Percent of Mortgagors with LTV $\geq 90\%$	15.3%	14.9%	15.3%	17.5%	33.0%
Percent of Mortgagors with LTV $\geq 95\%$	7.0%	7.5%	8.0%	4.1%	15.9%
Annual Foreclosure Starts	1.89%	1.8%	1.88%	1.73%	0.50%

*Equilibrium is solved using mortgage prices q_m^0 from the baseline steady state, where $\pi = 1.5\%$.

To disentangle the debt erosion effect of inflation from the credit response, I re-solve for the steady state of the higher inflation economy using the mortgage prices q_m^0 from the *baseline* economy. Now, inflation exhibits a profound and nonlinear impact on the economy. At $\pi = 4.5\%$, the homeownership rate increases by 3 percentage points to 71.8% and households modestly increase their leverage. At $\pi = 7.5\%$, homeownership jumps by 10 percentage points to 78.5% and households accumulate extreme amounts of debt. Yet, even with the increase in leverage, the foreclosure rate *drops* precipitously in the high inflation economy. Part of the decrease in foreclosures comes from rapid debt erosion at the individual level, which implies that financially distressed households quickly regain equity in their houses. An accompanying increase in median liquid assets from 0.1 to 0.37— financed largely by borrowing— further reduces foreclosures by giving households more protection from idiosyncratic shocks.

Inflation and Selling Behavior Figure 4 shows the effect of inflation on house selling behavior. The first two panels plot list price and expected time on the market, respectively, as a function of leverage for a low-asset homeowner. In the baseline economy, sellers with 75% – 80% leverage sharply lower their price and face an expected time on the market of only 7 weeks (almost a 100% probability of selling in the initial period). As discussed in Hedlund (2013), households with low asset holdings and moderately high debt are financially distressed and face prohibitively bad terms on new credit because lenders view them as risky. Absent a positive shock to their labor earnings, these households have exactly one path of escape: posting a low list price to sell their house quickly, which they can do with the amount of equity they have. Here, inflation reduces the plight of distressed sellers and removes the need to post fire sale prices. Therefore, inflation actually *increases* time on the market for these homeowners, as shown in the dip in panel 3.

At leverage beyond 80%, distressed homeowners begin losing the equity cushion that facilitates low list prices. Debt overhang sets in and causes higher time on the market. High

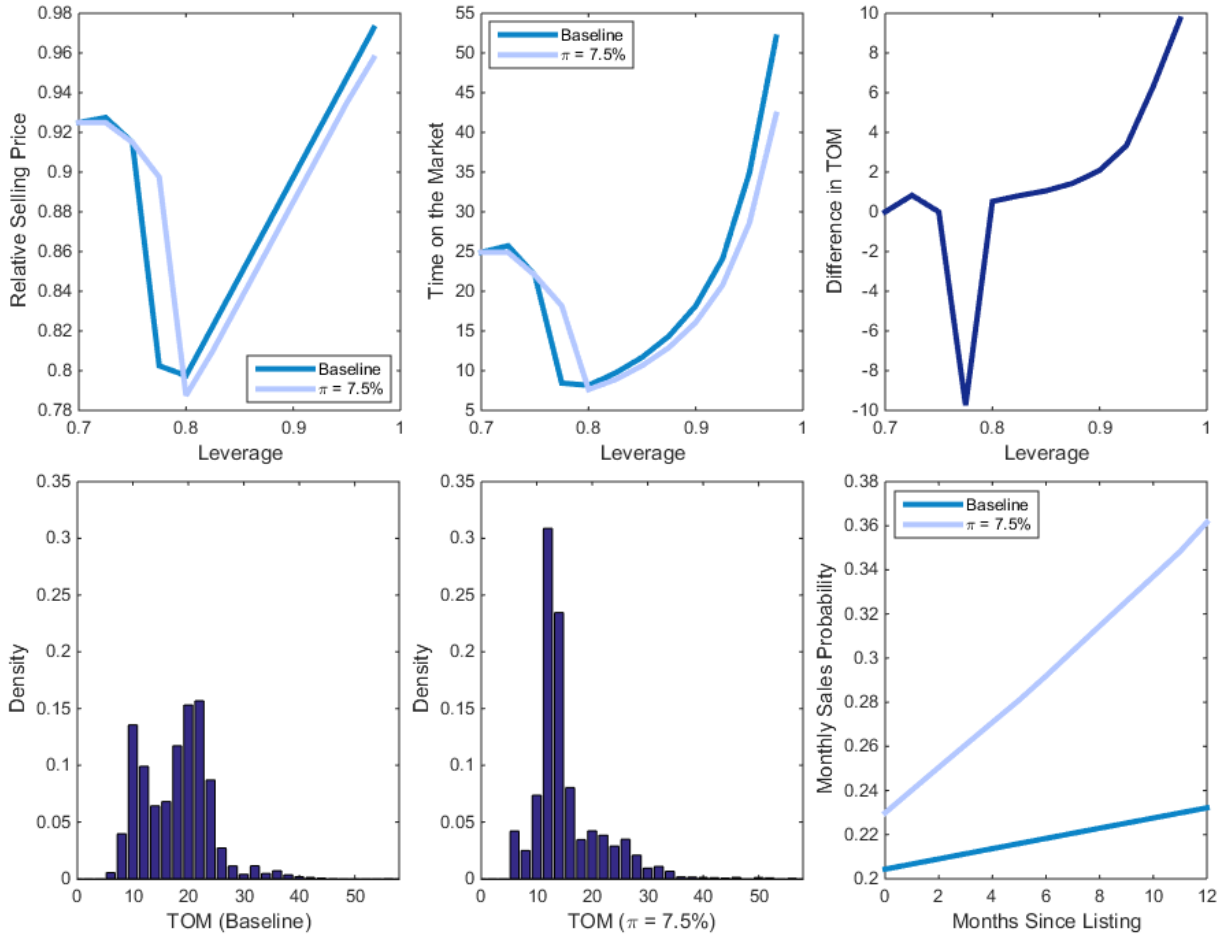


Figure 4: (Top left) List price as a function of mortgage leverage; (top middle) time on the market as a function of mortgage leverage; (top right) difference between baseline TOM and TOM in the high inflation economy; (bottom left) distribution of TOM in the baseline economy; (bottom middle) the direct effect of higher inflation on the distribution of TOM; (bottom right) simulated dynamics of monthly sales probabilities for an indebted seller in the baseline and high inflation economies

inflation partially alleviates this overhang by relaxing the selling constraint $y + x_s \geq \frac{m}{1+\pi}$ and lowering time on the market. Panel 5 shows the distribution of time on the market in the baseline equilibrium, and panel 6 shows the direct effect of higher inflation.[27] Note than high inflation simultaneously reduces the frequency of fire sales and the frequency of home sitting on the market for more than 20 weeks.

The full power of inflation shows up in its *dynamic* impact on time on the market. At the individual level, note that panels 1 - 3 show the snapshot effect of higher inflation on selling behavior, while panel 6 shows the dynamics of selling probabilities of a distressed homeowner. Converted to monthly probabilities, the seller in the baseline economy initially has a 21% chance of selling. This same seller in the high inflation economy has a slightly higher 23% of selling in the first month. Holding nominal mortgage debt fixed, inflation gradually erodes the real value of mortgage debt, thus increasing equity and allowing homeowners to more aggressively price their houses. In the baseline economy, if the seller fails to sell after a full year, the monthly probability of selling increases slightly to 23%. However, in the high inflation economy, the selling probability increases to 36% (a 50% jump). In short, higher inflation increases equity and housing liquidity at the individual level. This response carries over to the aggregate economy, where inflation alters the dynamic response of time on the market to the onset of a recession, as I describe in the next section.

4.3.2 A Temporary Surge of Inflation

The first policy I consider is one of a temporary surge of inflation lasting through phase 1 of the simulated recession. I consider a moderate inflation surge, where π increases from 1.5% to 4.5% before returning to 1.5%, and then I consider a high inflation surge where π reaches 7.5%. Given that lenders know the temporary nature of the inflation surge, I assume that they do not adjust the fixed rate q_m that they lock in for new mortgages. In essence, lenders only adjust mortgage rates in response to long term fluctuations in nominal interest rates. However, lenders *do adjust* mortgage prices q_m^0 in response to the direct and indirect effects of any inflation changes. The computational results do not change perceptibly when lenders adjust q_m on new mortgages in lockstep with short term nominal rate movements. For each experiment, I also simulate the inflation surge economy as if lenders either ignore or do not perceive the *direct effect* of the inflation surge. However, lenders still respond to induced changes in borrower behavior and in the real economy.

[27] Fixing prices, asset, and debt holdings from the baseline economy.

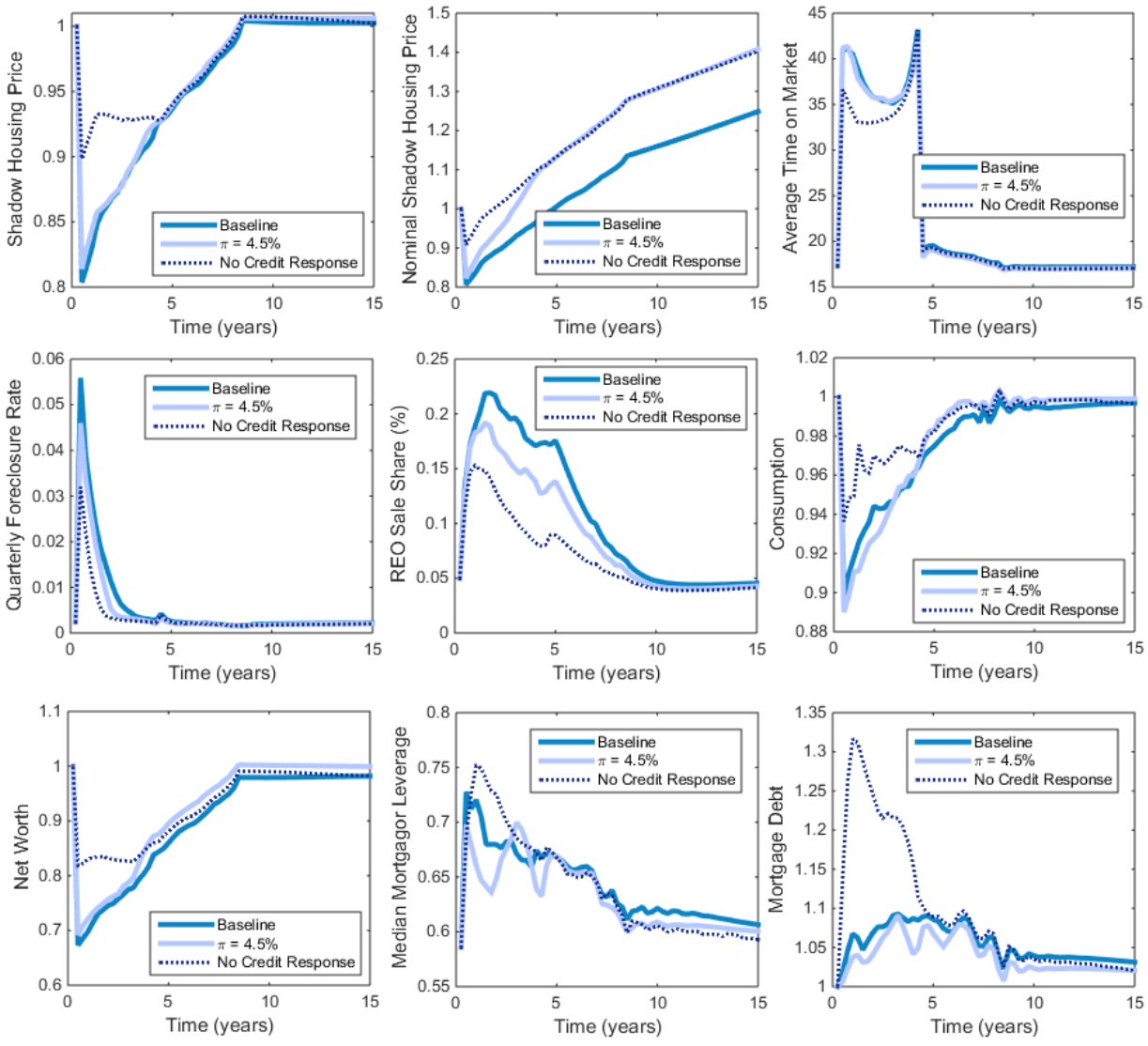


Figure 5: A temporary surge of inflation to $\pi = 4.5\%$ for 4 years

Moderate Inflation ($\pi = 4.5\%$) Figure 5 shows the effect of introducing 4 years of 4.5% inflation. The *real* price of housing barely budges from its baseline path, though the nominal price of housing quickly recovers to its steady state level and then continues on a path parallel to and above the baseline path of nominal house prices. Average time on the market barely responds to the rise in inflation, though the foreclosure rate moderates to some degree. The REO sales share peaks at 19%, compared to 22% in the baseline, and falls to 13% by the end of phase 1. Interestingly, consumption decreases modestly during the actual period of the inflation surge only to cross the baseline path in year 4. As expected, median leverage decreases rapidly at the onset of the inflation surge, though households react by increasing their borrowing to such an extent as to reverse the initial sharp leverage decline.

Overall, the 4.5% inflation surge appears to have relatively modest effects. However, if lenders fail to price the temporary higher inflation into q_m^0, the economy follows a substantially different trajectory than the baseline economy. In particular, the real price of housing only declines by 9%, rather than 20%, the spike in time on the market shrinks by 5 weeks early in the recession, and the REO sales share peaks at 15% instead of 22%. In addition, consumption falls by 6% compared to the baseline fall of 10%. Lastly, while net worth fares better under this scenario, it recovers relatively slowly because households take advantage of the mispriced mortgages and accumulate substantially higher debt in the short run.

High Inflation ($\pi = 7.5\%$) When the government institutes a policy of even higher inflation, the economy responds more noticeably. First, *real* house prices increase modestly compared to the baseline. Average time on the market falls only slightly, but the foreclosure rate drops dramatically. As shown in figure 6, the REO sales share never exceeds 9%. As in the case of the 4.5% inflation surge, consumption dips initially relative to its baseline path, only to cross and surpass that level after the inflation surge ends.

If lenders fail to price in the higher inflation, the economic response to the inflation surge is dramatic. Real house prices actually increase initially before slowing decreasing and then increasing again. The spike in average time on the market falls by 10 weeks compared to the baseline peak and foreclosures all but disappear. Household consumption is completely shielded from the effects of the recession because households substantially increase their mortgage borrowing during the surge period.

4.3.3 Inflation with Nominal Price Level Targeting

The previous results indicate that a temporary surge in inflation, if high enough, can have a stimulative effect on real house prices and consumption and can reduce foreclosures. However, particularly in the case of 4.5% inflation, the contraction in credit supply greatly

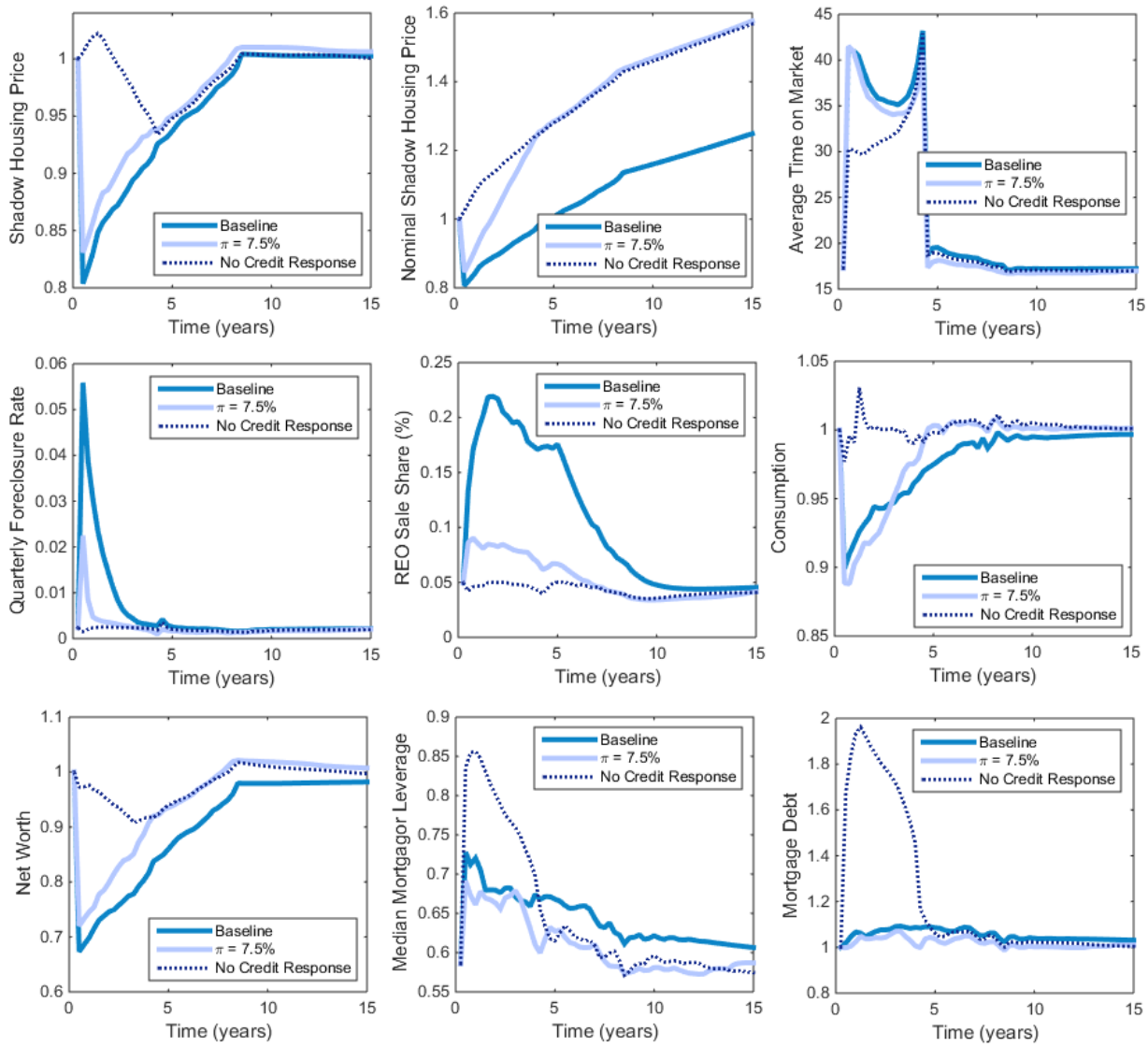


Figure 6: A temporary surge of inflation to $\pi = 7.5\%$ for 4 years

diminishes the debt eroding power of inflation.

The long term price level increase from inflation explains much of the drying up of credit because the value of debt payments to the lender never recovers from its deflated value. To possibly get around this dilemma, I consider a nominal price level targeting policy that follows a temporary inflation surge with a persistent disinflation that returns the price level to its original trajectory. Under this policy, the real value of debt initially decreases, but then slowly recovers during the period of disinflation. I consider two different implementations of the inflation price level targeting policy.

Two Implementations In the first implementation, the government targets 4.5% inflation until nominal house prices reach their pre-recession trajectory, which takes 3 years. Then, the government targets 0% inflation for 6 years, which is the length of time necessary for the disinflation to reverse the initial inflation surge. In the second implementation, the government targets 7.5% inflation until nominal house prices reach their pre-recession path, which takes 2 years. After that point, the government targets 0% inflation for 7 years to return the price level to its baseline trajectory.

Policy Results Figure 7 shows the results of these two implementations. Both policies succeed at increasing real house prices, decreasing average time on the market, decreasing foreclosures, and increasing consumption. The higher target of 7.5% has particularly noticeably effects, as the foreclosure rate barely budges beyond its steady state value. In addition, household net worth exceeds its baseline trajectory by 10 percentage points during much of the recession, and consumption increases by 2 percentage points starting mid-way through phase 1 of the recession.

5 Discussion

The results of the different quantitative experiments show that a temporary rise in inflation can positively impact the economy and reduce the drag from debt overhang. Inflation mitigates the drop in real house prices, net worth, and consumption, and importantly, it drastically reduces foreclosures by accelerating the deleveraging process. Two ingredients primarily account for this real effect of inflation. First, long-term mortgage contracts act as a form of nominal rigidity. In the model, I focus on fixed-rate contracts that have q_m set at origination. However, even adjustable rate mortgages are long-term contracts because lenders only price *default risk* at origination. With short-term mortgages, borrowers would have to repay their mortgages in full every period before taking out new, re-priced mortgages

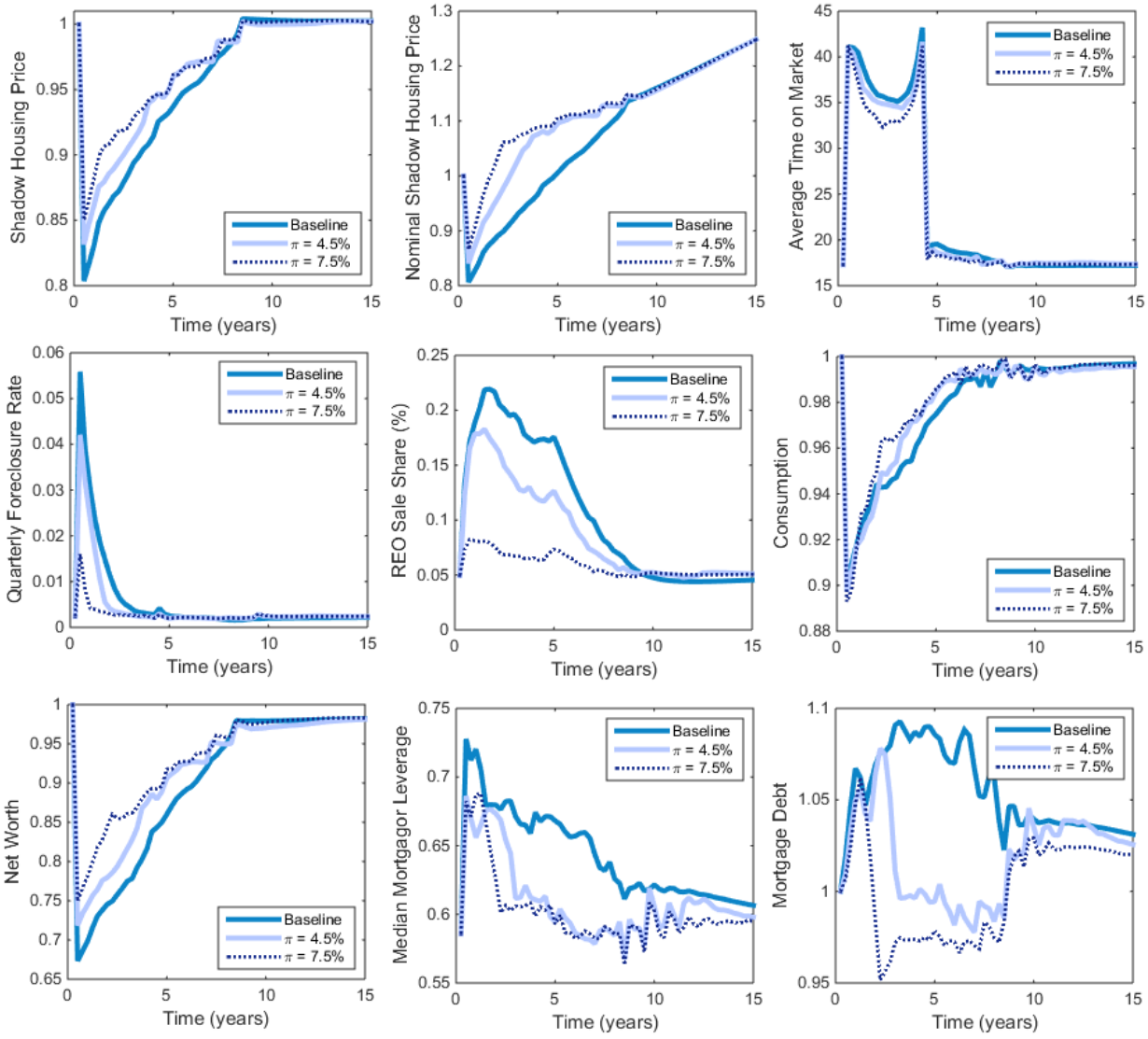


Figure 7: $\pi = 4.5\%$ for 3 years followed by 6 years of $\pi \approx 0\%$; $\pi = 7.5\%$ for 2 years followed by 7 years of $\pi \approx 0\%$

that reflect any changes to inflation and default risk. In effect, with short-term mortgages, lenders institute margin calls every period.

Housing illiquidity acts as the second ingredient to generate real effects of inflation. With perfectly liquid housing markets, all transactions occur with probability 1 at some market clearing price. The selling decision reduces to a binary choice: either sell, provided $y + p_h \geq \frac{m}{1+\pi}$, or do not sell. Debt restricts selling decisions only for homeowners unambiguously underwater on their mortgages. With housing illiquidity, many homeowners that could sell their house *eventually* still face a debt overhang problem. Debt limits their choice of list price and consigns them to sitting longer on the market. Inflation counteracts the effect of debt because it increases the set of feasible list prices and gives sellers the opportunity to increase their chance of selling quickly.

Naturally, the beneficial effects of inflation uncovered in these quantitative experiments need to weigh against other important considerations. First, the most effective policy studied here requires a considerable degree of commitment on behalf of monetary authorities. The commitment to extended disinflation following the initial surge of inflation greatly mitigates the credit contraction that would otherwise occur. However, should another crisis arise in subsequent years, the monetary authorities would have a strong temptation to abandon the disinflation. Secondly, and perhaps more importantly, the Federal Reserve has earned a hard-fought and valuable reputation for credibility in fighting inflation. Abandoning low inflation targets in the short-run to medium-run need not inherently undermine this credibility, though the possibility undoubtedly exists.

6 Conclusions

Debt, deleveraging, and default remain issues of high interest as the economy emerges from the Great Recession. This paper sheds light on the role inflation can play in mitigating some of the deleterious effects of mortgage debt overhang. In particular, a temporary surge of inflation, when coupled with commitment to a subsequent period of disinflation, reduces the magnitude of the recession and speeds up the recovery. By eroding the real value of debt, inflation creates home equity that increases housing liquidity, reduces foreclosures, and reduces default premia on new mortgages. In turn, the commitment to future disinflation reduces the contraction of credit from higher current inflation.

The results of this work suggest future avenues for research in and beyond the realm of housing. For example, to what extent can inflation alleviate overhang of other types of debt, such as sovereign debt? In the context of housing, how do inflationary interventions stack up against direct mortgage market interventions and fiscal interventions?

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