Credit Supply Shocks and the Scarring Effects on Homeownership*

Carlos Garriga[†] Pedro Gete[‡] Aaron Hedlund[§]

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Abstract

Historically the availability of credit has been a key driver of owner-occupied housing. During the financial crises the credit contraction made it very difficult for households to purchase housing, homeownership across most MSAs in the U.S. declined even with a sizeable price correction. This paper documents the variation observed in the cross-section and constructs an equilibrium model of tenure decisions to evaluate whether credit supply shocks generate persistent or permanent scarring effects on homeownership. The model highlights a dichotomy that emerges between the short and long-run response to a different degrees of credit tightening as prospect homeowners need to accumulate a downpayment. The effects of credit supply shocks on homeownership are adversely magnified in areas when rents increase, the return of savings decreases, or the housing supply is very inelastic by creating a rental trap. The ability to circumvent the downpayment constraint diminishes when the decision to purchase a house is driven by life-cycle motives.

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[†]Federal Reserve Bank of St. Louis. E-mail: *carlos.garriga@stls.frb.org*

[‡]IE Business. E-mail: *Pedro.Gete@ie.edu*

[§]University of Missouri and Federal Reserve Bank of St. Louis. E-mail: *hedlunda@missouri.edu*.

1 Introduction

Historically in most developed economies house prices and the homeownership rate have risen and fallen together. In recent years, however, this relationship has broken down as home prices have been increasing while the homeownership rate has been declining. This divergence has occurred in the aftermath of the financial crises in a large number of developed economies (i.e. Canada, Spain, Germany, United Kingdom, and the United States to name a few). In the U.S. national house prices have more than recovered from the housing crash while the homeownership rate has fallen to historically low levels. This national trend is common across several U.S. metro areas, but the size of the decoupling between house prices and homeownership varies substantially across localities.

This paper documents the variation observed in the cross-section for house prices, homeownership in response to credit supply shocks across U.S. MSAs. The analysis reveals three general patterns: First, metro areas with relatively low house prices and high homeownership (i.e. Atlanta, Charlotte, Cleveland, and Detroit). After the financial crisis homeownership fell from over 70% in 2005 to around 65% but started to recover around 2013. Second, metro areas with moderate prices and moderate homeownership rates (i.e. Chicago, Dallas, Minneapolis, and Tampa) had a larger decline and the current level of homeownership still remains low compared to the peak years. Finally, metro areas with high home prices and low homeownership rates (i.e. New York, San Francisco, San Diego, and Washington, DC) have had the largest decline and continue at a historically low level. The variation in the behavior of rents, housing supply, and local conditions interact with our empirical measure of the credit supply shock.

To assess the importance of credit supply shocks, the analysis uses a structural macroeconomic model with heterogeneity and incomplete markets, portfolio choice, and a rich credit market that features long-term mortgage contracts and the possibility of foreclosures in equilibrium. Households face the decision to rent apartment space each period or purchase a house, which they can finance using a combination of accumulated savings and mortgage debt. Even without aggregate shocks, uninsurable income risk generates constant churn between renting and owning that is affected by the presence of credit constraints. This allows to determine whether credit supply shocks generate persistent or permanent scarring effects on homeownership across MSAs.

The model highlights a dichotomy that emerges between the short and long-run response to a different degrees of credit tightening as prospect homeowners need to accumulate a downpayment. The effects of credit supply shocks on homeownership are adversely magnified in areas when rents increase, the return of savings decreases, or the housing supply is very inelastic by creating a rental trap.

The benchmark calibration captures the distribution of credit observed in the U.S. as well as some other relevant housing and financial aggregate and cross-sectional moments. The main experiments then subject the stationary economy to differing magnitudes of a permanent, unexpected credit supply shock that tightens the downpayment constraint applicable at origination under a variety of specifications that depends in the response of rents, returns to savings, housing supply, income risk, and housing elasticity in the individual preferences. For the benchmark calibration, which features a non-binding 125% loan-to-value cap at origination and a utility function with housing and consumption as complements, homeownership falls by 2.4 percentage points in the initial aftermath of imposing a 20% down payment requirement. Most of this decline comes from a depressed flow of renters into homeownership rather than an exodus of homeowners into renting. During this period of declining homeownership, however, renters begin accumulating assets, which sows the seeds for a long-run homeownership recovery.

Increasing the magnitude of the credit supply shock by requiring a higher downpayment has large and persistent effects in the dynamics of homeownership. The transition path exhibits a stark and protracted adjustment phase. In the absence of permanent rent increases or deprived supply there is no perceptible change to the long-run homeownership rate.

The elasticity of substitution is a key parameter that governs the dynamics of housing and consumption. When the benchmark case is recalibrated with Cobb-Douglas preferences that create greater substitutability between housing and consumption, a credit supply shock that requires a 20 percent downpayment has very small negative effect in the long-run homeownership. Relative to the benchmark case, the long-run homeownership rate is reduced by 2.6 percentage points, which is quite modest given that nearly one-fifth of outstanding loans and over 85% of originations for new purchases are at above 80% leverage prior to the tightening. However, beneath this long-run stability, patterns emerge from the short run dynamics that highlight the role of substitutability. With complements, homeownership and consumption recover in tandem, whereas with substitutes, consumption recovers much more quickly at the expense of housing.

How important is the response of the housing supply determining the dynamics of homeownership? In principal in areas with a high supply elasticities homeownership is more affected by credit, whereas in areas with low elasticity the high price seems to be the main road block. In the benchmark model areas in which credit supply shocks generate large declines in house prices tend to generate smaller movements in homeownership. For example, in the extreme case of a fixed total housing stock, introducing a 20% down payment requirement switches out the short-run homeownership decline from before with a 8% temporary fall in house prices. However, just as with homeownership, house prices exhibit long-run mean reversion for different preference elasticity between housing and non-housing consumption.

The results are also sensitive to the dynamics of rents and interest rates in a fairly asymmetric way. According to the model, homeownership does respond in the long run to changes in interest rates. Thus, the homeownership boom from 64%

to 69% can be viewed as the combination of a temporary response to looser down payment requirements and a permanent response to lower interest rates. The credit supply shock also interacts with the interest rate. On the one hand it becomes more costly for renters to save for the downpayment, but on the other hand it makes the cost of borrowing cheaper. If interest rates don't affect house prices because the housing supply elasticity is high, then, the scarring effects of the credit contraction are mitigated by having low rates. In the case of low housing supply elasticity, the low rates are capitalized in house prices and the scarring effects are larger.

The ability to circumvent credit supply shocks that tighten downpayment constraint is diminished when the decision to purchase a house is driven by life-cycle motives. To explore the importance of this dimension not present in the benchmark economy, the quantitative experiments are repeated with a re-calibrated model with life cycle features. In this setting new households start life as renters with low income and zero assets (i.e. there are no bequests, inter vivos transfers, or intergenerational persistence in earnings). Relative to the benchmark model, the homeownership rate exhibits a more exaggerated short-run response to tighter down payments, the scarring effects are more persistent but not permanent as the long-run level had a small decline. The aggregate effects mask important changes across the age distribution, while the homeownership rate does fall for young households—for the simple reason that they take longer to accumulate assets for a down payment—it increases for older households. This finding can be explained by the fact that, while the rent-to-own rate falls, the own-to-rent rate acts as a counterbalance by falling as well. Homeowners anticipate that, if they were to ever become renters, the higher down payment barrier slows any possible future transition back into homeownership. Homeowners are therefore more reluctant to switch from owning to renting in the first place.

The different results bring a fairly general finding that the homeownership responds in the short run to evolving credit conditions but exhibits no significant long-run relationship with moderate changes, even with stark assumptions about the life cycle.

1.1 Relationship to the Literature

This paper is related to several different strands of economic literature. On the empirical side, many papers have examined the relationship between down payment requirements and homeownership. Acolin, Bricker, Calem and Wachter (2017) provide a good summary of this literature and also prevent their own findings from 2010–2013 that being borrowing constrained significantly reduces the probability of an individual owning a house. Haurin, Hendershott and Wachter (1997) come to a similar conclusion for the period 1985–1990. At a more aggregated level, Chiuri and Jappelli (2003) show that countries with higher down payment ratios have lower homeownership, even after various controls. More recently, Anenberg, Hizmo, Kung and Molloy (2017) construct a richer measure of mortgage credit availability across the credit score distribution, and they exploit geographical variation to demonstrate that borrowing constraints played an important role during the recent housing cycle.

The aforementioned empirical findings are compatible with the implications of the structural model in this paper. At any given point in time, a tightening in down payment requirements shuts out constrained households from the owner-occupied market. However, the important lesson that emerges from the model is that asset accumulation gradually reverses the initial *aggregate* homeownership decline. Engelhardt (1996) validates this channel empirically by demonstrating how constrained households depress consumption to build savings for a down payment.

This paper also contributes to the structural literature. On the more theoretical side, Ortalo-Magné and Rady (1999) and Ortalo-Magné and Rady (2006) show the importance of credit constraints for homeownership, prices, and the housing ladder. Most related on the quantitative side, Chambers, Garriga and Schlagenhauf (2009) study the interplay between homeownership and the mortgage market. They find that the introduction of new loan products explains most of the rise in homeownership between 1994 and 2005. Like this paper, they also show that evolving down payments do not produce a permanent change in homeownership, but for far different reasons. In their framework, all homeowners who take out a fixed-rate mortgage are compelled to make the same down payment. By contrast, the model in this paper includes both an extensive and intensive margin for borrowing and matches the distribution of leverage. Their closed economy and uniform borrowing assumptions imply that a loosening in down payments necessarily increases the demand for borrowing. As a result, interest rates rise and suppress homeownership. The mechanism in this paper has nothing to do with general equilibrium interest rates but instead involves asset accumulation dynamics that are impacted by the degree of intratemporal substitution. In recent work, Li, Liu, Yang and Yao (2016) also establish the importance of such substitution between housing and consumption for explaining housing dynamics.

2 Data Sources

This paper utilizes several sources of rich, micro-level data. On the housing side, CoreLogic provides MLS listing-level data for much of the United States, with coverage increasing over time. From peak to trough, inflation-adjusted average closing prices fell by over 36% in the MLS, which is somewhat greater than the drop in prices reported by the Federal Housing Finance Agency (FHFA) and Case-Shiller in appendix figure 9. The MLS data also show that months of supply—which is a measure of housing illiquidity equal to the ratio of houses on the market to monthly sales—jumped by over 10 months during the crisis. Besides the MLS, this paper uses loan-level Equifax data to track mortgage default—which rose by over 5 percentage points—and to assist in constructing a county-level measure of net worth for the regressions in section 5.2. The remaining data on zip-code level income and county-level employment are publicly available from the IRS Statistics of Income

(SOI) and Bureau of Labor Statistics Quarterly Census of Employment and Wages (BLS QCEW), respectively. In addition, some of the regressions utilize industry employment data from the Census County Business Patterns (CBP). Appendix A provides additional details, and table 11 gives more complete summary statistics. The county-level heat maps in figure 1 illustrate the geography of the crisis. Notably, the areas which experienced the worst deterioration in house prices and months of supply also suffered the largest rise in mortgage defaults and income declines.[1] Consistent with Garriga and Hedlund (2019), this section establishes a strong connection between house price declines, drops in housing liquidity, local economic conditions and homeownership. To explore the effects of credit supply shocks and the scarring effects in homeownership it is important to understand the different dynamics of house prices, rents, credit supply, and homeownership across MSAs in the U.S. To identify these patterns, the analysis uses a K-means clustering algorithm. The algorithm begins by selecting three metro areas at random to represent the average pattern in homeownership rate and home price for each of the different groups. Metros areas are assigned to one of the different groups based on how similar their patterns are to the national pattern, where similarity is determined by comparing the value of the homeownership rate and the home price index to the targeted sub group representative pattern at each point in time. Once all metro areas have been assigned to groups, a new representative pattern for each of the different groups is calculated by finding the average home price and the average homeownership rate at each point in time across all of the metro areas assigned to the group. The algorithm repeats, re-assigning metro areas to groups and re-calculating each sub group representative patterns, until the partitions are stable. The house price index is normalized to not dominate the clustering process. The clustering algorithm captures three distinct patterns:

[1] According to figure 10 in the appendix, employment also falls in concert with house prices, consistent with Mian and Sufi (2014). Figures 11 and 12 show that average days on the market behaves similarly at the county level to months of supply.

1. **Metros with low prices and high homeownership rates:** In areas such as Atlanta, Charlotte, Cleveland, and Detroit, the increase in prices during the housing boom was much shallower than the national average. During the bust, average house prices even fell below 2000 levels, and are currently only 40% higher than in 2000. Homeownership rates fell from over 70% in 2005 to around 65% during the collapse, but slowly began to increase around 2013.

2. **Metro areas with moderate prices and moderate homeownership rates:** In metro areas in this group that include Chicago, Dallas, Minneapolis, and Tampa, house prices did not rise as high as the national average. During the crash prices fell back to near 2000 price levels, but faced a very rapid recovery. Prices in 2018 are around 80% higher than in 2000. Homeownership rates were relatively high in 2005 – around 70% – but fell to 60% by 2015. In 2018, the level of homeownership still remains very low compared to the pick years.

3. **Metro areas with high home prices and low homeownership rates:** These areas experienced rapid price growth during the boom (i.e. metro areas in this group include New York, San Francisco, San Diego, and Washington, DC). Prices remained well above 2000 price levels even during the crash and resumed rapid growth afterwards. Average prices in 2018 are nearly 125% higher than in 2000. Homeownership rates were low in 2005 – around 65% on average – and have been on a downward trend since then, falling to near 55% in 2018.

Figure 1 shows home prices for the metro areas in each of the groups. The thick red line shows the average price for the group, while each of the gray lines represents a metro area in the group. Similarly, Figure 2 shows homeownership rates for the metro areas in each of the groups, with the average shown in red and each metro area in gray. The grouping relies on both the house price and the homeownership rate in combination; metro areas with similar patterns in homeownership could be placed in

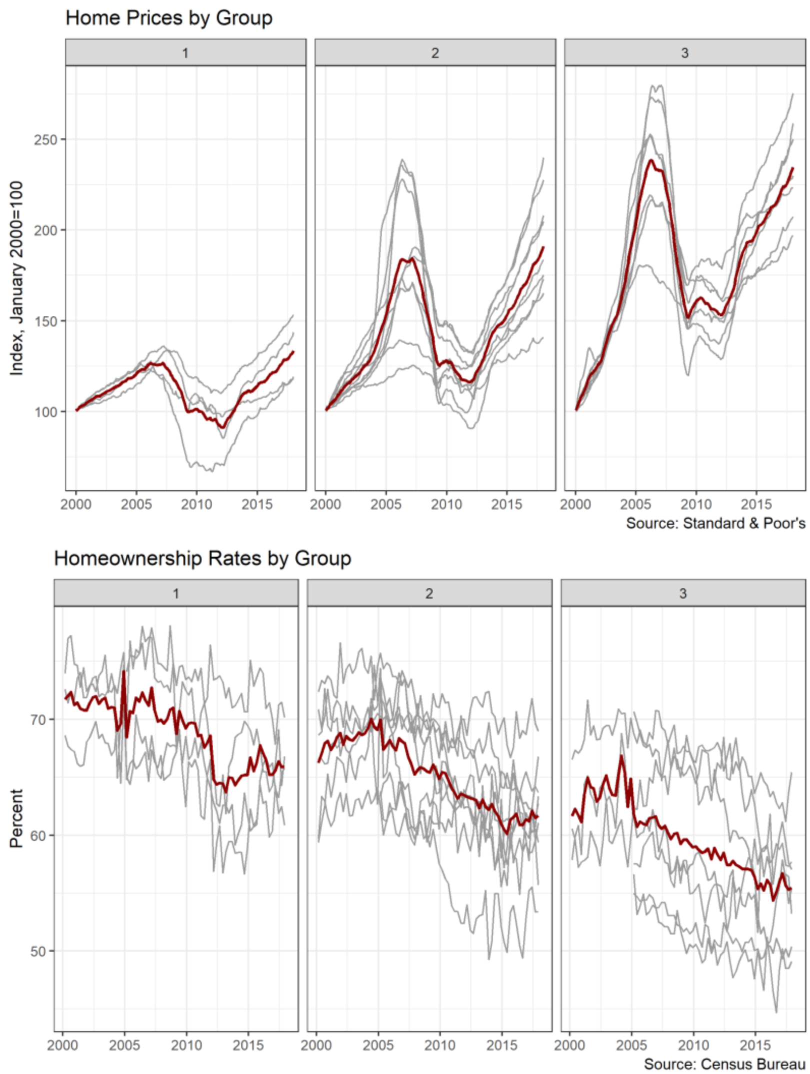

Figure 1: Patterns of House Price Dynamics and Homeownership

different groups if their patterns in home prices are very different.

The three groups have some features in common. First, in all three groups, the average homeownership rate rose or remained stable as home prices increased during the 2000 to 2005 period. Next, average homeownership rates fell as home prices dropped during the 2006 to 2011 period. Finally, homeownership rates remain low even as home prices have recovered to their pre-recession level.

The divergence between home prices and the homeownership rate is most pronounced in the third group, the group of high cost cities that includes Boston, Los Angeles, Miami, New York, San Diego, San Francisco, and Washington, DC. These cities may attract the most investment from institutional and foreign investors. However, the divergence is occurring to some extent in all three groups and therefore may reflect something more fundamental, such as a shift in the desire to own a home and not just difficulties accessing credit, or affordability issues. The pattern observed for the U.S. as a whole or across MSA is consistent with the global trends in housing markets discussed by Garriga and Gete (2018).

3 A Simple Model

Households with income e enjoy consumption c, shelter s, and terminal wealth y,

$$\mathcal{U}(c, s, y) = \omega \ln(c) + (1 - \omega) \ln(s) + \phi \ln(y).$$

Households can obtain shelter either by renting an apartment $a \in [0, \overline{a}]$ at cost r_a or by purchasing a house $h > \overline{a}$ (for simplicity, there is only one house) at price p. Renters save in the form of bonds b at price $\frac{1}{1+r}$, while homeowners can both save and borrow in bonds up to a maximum leverage ratio ϑ, i.e. $b \geq -\vartheta ph$. Renters have terminal wealth $y_{rent} = b$, while homeowners also liquidate their house, $y_{own} = ph + b$.[2]

Conditional on renting, households solve

$$\begin{aligned} U_{rent}(e) = \max_{c,a,b} \omega \ln(c) + (1 - \omega) \ln(a) + \phi \ln(b) \text{ subject to} \\ c + r_a a + \frac{1}{1+r} b \leq e \\ c \geq 0, a \in [0, \overline{a}], b \geq 0 \end{aligned} \tag{1}$$

[2]This simple setup assumes that homeowners cannot rent out their houses as apartments.

Conditional on owning, households solve

$$
\begin{aligned}
U_{own}(e) = \max_{c,b} \omega \ln(c) + (1-\omega)\ln(h) + \phi \ln(ph+b) \text{ subject to} \\
c + ph + \frac{1}{1+r} b \leq e \\
c \geq 0, b \geq -\vartheta ph
\end{aligned}
\tag{2}
$$

By defining $\widetilde{b} \equiv ph + b$, the problem can be re-written as

$$
\begin{aligned}
U_{own}(e) = \max_{c,\widetilde{b}} \omega \ln(c) + (1-\omega)\ln(h) + \phi \ln(\widetilde{b}) \text{ subject to} \\
c + \frac{r}{1+r} ph + \frac{1}{1+r} \widetilde{b} \leq e \\
c \geq 0, \widetilde{b} \geq (1-\vartheta) ph
\end{aligned}
\tag{3}
$$

The decision to buy is then given by

$$
U(e) = \max_{x \in \{0,1\}} (1-x) U_{rent}(e) + x U_{own}(e). \tag{4}
$$

When $h = \overline{a}$, $\vartheta = 1$, and $r_a = \frac{r}{1+r} p$ (the no-arbitrage condition if houses could be rented out), the budget sets between renting $\overline{a}$ and owning h are identical. Thus, a preference for owning only arises when either $\frac{r}{1+r} p < r_a$ or $h > \overline{a}$. However, down payments $1 - \vartheta > 0$ prevent some households from buying, as stated by theorem 1.

Theorem 1 (Borrowing Constraints and Homeownership) *Given* $\vartheta \in [0,1]$, *let* $\Gamma(\vartheta) = \{e \in \mathbb{R}^+ : x(e;\vartheta) = 1\} = \{e \in \mathbb{R}^+ : U_{own}(e;\vartheta) \geq U_{rent}(e)\}$ *be the ownership set for e. Tightening* ϑ *shrinks this set, i.e.* $\Gamma(\widetilde{\vartheta}) \subseteq \Gamma(\vartheta)$ *for all* $\widetilde{\vartheta} < \vartheta$.

The proof is in the appendix, and figure 2 gives a visual representation. Note that this static analysis ignores the ability of households to save in anticipation of buying a house. The quantitative analysis to come shows that allowing intertemporal behavior significantly alters the dynamic relationship between down payments and ownership.

4 The Quantitative Framework

The benchmark model is an infinite horizon, open endowment economy populated by a continuum of ex-ante identical households and a competitive financial sector.

4.1 Households

Household preferences over numeraire consumption c and shelter s are given by

$$\mathcal{U}(\{(c_t, s_t)\}_{t=0}^{\infty}) = \sum_{t=0}^{\infty} \beta^t \frac{\left(\left[\omega c_t^{\frac{\epsilon-1}{\epsilon}} + (1-\omega) s_t^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{1-\sigma}}{1-\sigma},$$

where shelter can either be obtained period-by-period from apartment space or acquired by purchasing durable owner-occupied housing. Households are ex-ante identical but receive uninsurable, idiosyncratic shocks $e \cdot z$ to their endowment of the numeraire good. The persistent component $z \in Z$ follows Markov transitions $\pi_z(z'|z)$ with stationary distribution $\Pi_z(z)$, and the transitory component $e \in E$ is

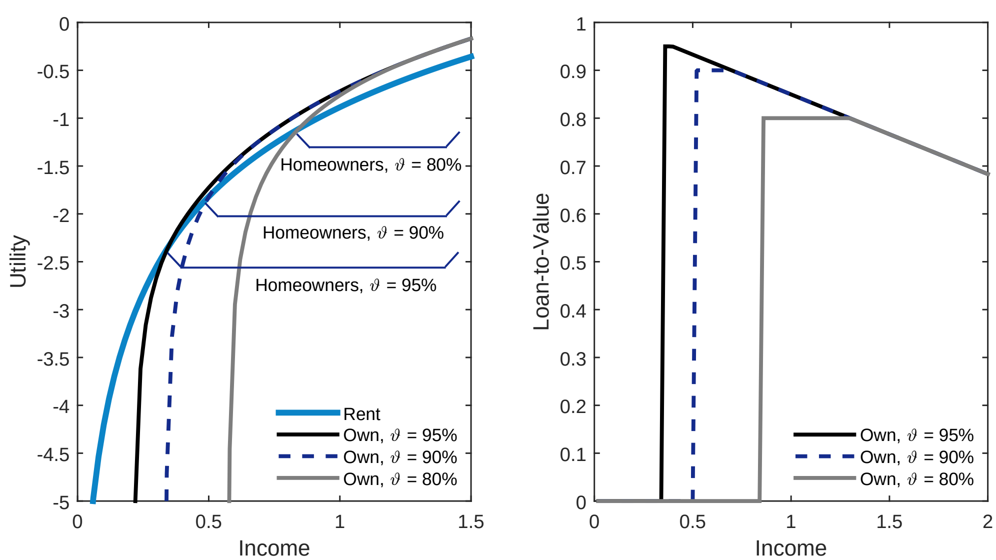

Figure 2: (Left) The buying cut-off for $\vartheta \in \{0.95, 0.9, 0.8\}$; (Right) Mortgage choice. The parameters are $\overline{a} = 1$, $h = 2.5$, $p = 1$, $r = 0.04$, $r_a = 0.05$, $\omega = 0.75$, and $\phi = 0.5$.

drawn from the cumulative distribution function $F(e)$. To self-insure, households can save using risk-free bonds, and owners can borrow using mortgages.

4.2 The Markets for Shelter

Consistent with empirical evidence, the owner and rental markets are segmented by quality, with apartments $a \in [0, \overline{a}]$ inferior to houses $h \in H$, i.e. $\overline{a} \leq \min H \equiv \underline{h}$.[3] Apartment space provides shelter $s = a$, is produced from the numeraire good using a linear technology at the rate A, and is traded competitively at unit price $r_a = 1/A$.[4]

Houses require proportional holding costs δ each period (e.g. maintenance, property taxes), provide shelter $s = h$, and are produced at marginal cost p using a linear, reversible construction technology.[5] Different from the Walrasian paradigm, housing trades are subject to endogenous delays and transaction costs that arise from search frictions. Hedlund (2016) goes into depth developing the microfoundations, but the essential overview is as follows. Aspiring sellers choose a list price x_s and successfully trade with probability $\eta_s(x_s; p)$. The larger discount sellers accept, $p - x_s$, the quicker they expect to sell. Buyers make a bid x_b for house h and buy with probability $\eta_b(x_b; p)$, which increases in x_b.

4.3 Financial Market Arrangements

Households save using one-period risk-free bonds and borrow using long-term defaultable mortgage contracts. Competitive banks intermediate all financial market trades with households and have access to external financing at exogenous interest rate r. Thus, bonds are traded at price $q = \frac{1}{1+r}$, while the more complicated mortgage pricing equation is given by (6) below.

[3] See Halket, Nesheim and Oswald (2017).

[4] Sommer, Sullivan and Verbrugge (2013) and Davis, Lehnert and Martin (2008) show that real rents have been remarkably stable over the past few decades despite the large swings in house prices.

[5] This benchmark assumption of perfect elasticity gives credit constraints the greatest chance of impacting homeownership rather than prices. The opposite case of a fixed stock is considered later.

The ability of borrowers to default is sometimes exercised in equilibrium. As a result, banks price this risk into new mortgages at origination, and borrowers face individually-tailored prices $q_m(X)$ that reflect the default risk associated with their state vector $X = (m', b', h, z)$. Mathematically, when a borrower choose mortgage m', they are taking on debt with face value m' that they gradually repay over the duration of the loan. In exchange for this "promised" repayment, the bank delivers $q_m(X)m'$ in up-front resources. In subsequent periods, homeowners can choose among three options: default, refinance (i.e. pay off the existing loan and take out a new loan after paying a proportional origination cost ζ), or make a regular payment $l \geq \underline{l}$, where $\underline{l}$ is the minimum payment amount. Borrowers can then roll over unpaid balances at the rate $r_m = (1+r)(1+\phi)$, where ϕ represents a loan servicing cost. Thus, for borrowers making regular payments, debt follows $m' = (m - l)(1 + r_m)$.

Some clarifying remarks are in order. First, mortgages do not have fixed durations or face rigid amortization schedules in this setup. Besides facilitating computational tractability by shrinking the state space, this assumption implicitly stands in for the availability of additional mortgage instruments—second mortgages, home equity lines of credit, etc—that allow borrowers to adjust the path of their *cumulative* debt.

Second, the long-term duration of mortgages ensures that down payment requirements only apply *at origination.* Importantly, existing borrowers are not expected to inject equity in the event that requirements tighten for any reason. In other words, there is no *forced* deleveraging. Similarly, if a borrower who initially appears safe at the time of mortgage origination subsequently experiences a negative shock that increases the difficulty of repayment, banks do not have the ability to adjust mortgage terms to reflect higher default risk. Lastly, again for reasons of tractability, all default risk is priced into $q_m(X)$ rather than in the rollover rate r_m.

4.3.1 Consequences of Foreclosure

Defaulting borrowers lose their house and have a credit flag $f = 1$ placed on their record that excludes them from future borrowing until the flag disappears with probability $1 - \lambda_f$. Banks manage the selling of their foreclosure (REO) properties subject to the same market frictions faced by other sellers. Banks also lose a fraction χ in foreclosure costs upon selling. The value of repossessing house h is

$$J_{REO}(h) = \max_{x_s \in \{\infty\} \cup \mathbb{R}^+} \underbrace{\eta_s(x_s, h)}_{\text{prob of selling}} \underbrace{(1-\chi)x_s}_{\text{revenue}} + [1 - \eta_s(x_s, h)] \left[\underbrace{-\delta p h}_{\text{maintenance}} + \frac{1}{1+r} J_{REO}(h) \right] \tag{5}$$

where $x_s = \infty$ indicates the choice to not list the house for sale at all. When housing market conditions are stable, banks always prefer to attempt a sale rather than continually pay maintenance and time costs on their inventories. However, banks may time the market strategically when housing conditions are in flux.

4.3.2 Mortgage Pricing

At the time of origination, mortgage prices reflect the external cost of financing to the bank, servicing costs, and borrower-specific default risk. Because mortgages are long term contracts, competitive pricing is determined by the recursive equation

$$\begin{aligned}(1+\zeta)q_m(X) = \frac{1}{1+r_m}\mathbb{E}\Bigg\{ & \overbrace{\eta_s(x_s', h)}^{\text{sell + repay}} + \overbrace{[1 - \eta_s(x_s', h)]}^{\text{no sale (fail/do not try)}} \Bigg[\overbrace{d' \underbrace{\min\left\{\frac{J_{REO}(h)}{m'}, 1\right\}}_{\text{recovery ratio}}}^{\text{default}} \\ & + (1-d')\Bigg\{ \underbrace{\mathbf{1}_{[\text{Refi}]}}_{\text{repay in full}} + \mathbf{1}_{[\text{No Refi}]}\Bigg(\underbrace{l'}_{\text{payment}} + \underbrace{(1+\zeta)q_m(X')\frac{m''}{m'}}_{\text{continuation for } m''=(m'-l')(1+r_m)} \Bigg)\Bigg\}\Bigg]\Bigg\}\end{aligned} \tag{6}$$

where x_s' is the household's list price choice (which includes not listing at all), and $d' \in \{0, 1\}$ is the decision whether to default. The left side of (6) reflects expenditures per unit of m' by the bank at origination, and the right side equals expected discounted revenues. The law of large numbers ensures that banks earn zero profits loan-by-loan.

4.4 Household Choices

At the beginning of each period, all households learn their endowment shocks (e, z) and their credit status $f \in \{0, 1\}$. Homeowners then decide whether to list their house for sale and, if so, which list price x_s to select. After selling outcomes are realized, remaining homeowners with mortgage debt choose whether to default, refinance, or make a regular payment. Afterwards, renters looking to buy enter the market and choose their desired house h and bid price x_b. Consumption and portfolio decisions are then made at the end of the period. In addition to $f \in \{0, 1\}$, the state vectors for homeowners and renters are $X_{own} = (y, m, h, z)$ and $X_{rent} = (y, z)$, respectively, where cash at hand y represents the sum of the endowment $e \cdot z$ and bonds b.

4.4.1 House Trading and Default Choices

The value function of owners at the beginning of the period with $f = 0$ is

$$\begin{aligned} W^0_{own}(X_{own}) = \max_{x_s \in \{\infty\} \cup \{x_s + y \geq m\}} & \eta_s(x_s, h) W^0_{rent}(y + x_s - m, z) + [1 - \eta_s(x_s, h)] \\ & \times \max\{V_{debt}(X_{own}), V^0_{own}(y - m, h, z), W^1_{rent}(y, z)\}. \end{aligned} \tag{7}$$

Conditional on actively listing on the market, the constraint $x_s + y \geq m$ states that borrowers must pay off all outstanding mortgage debt at the time of sale. In the event that a homeowner does not sell (either by choice or bad luck), they choose between making a regular payment, paying off their entire debt m with the option of subsequently originating a new loan, or defaulting and immediately becoming a renter with credit flag $f = 1$. Implicitly, equation (7) restricts homeowners to choices that yield non-empty budget sets in the portfolio choice phase of the period.[6]

Owners with bad credit (and therfore no mortgage), $f = 1$, have value function

$$W^1_{own}(X_{own}) = \max_{x_s \in \{\infty\} \cup \mathbb{R}^+} \eta_s(x_s, h) W^1_{rent}(y + x_s, z) + [1 - \eta_s(x_s, h)]\, V^1_{own}(y, h, z). \quad (8)$$

When facing the choice of whether or not to buy, renters solve

$$W^f_{rent}(X_{rent}) = \max_{\substack{h \in \emptyset \cup H, \\ x_b \in \mathcal{B}^f(h,z)}} \eta_b(x_b, h) V^f_{own}(y - x_b, h, z) + [1 - \eta_b(x_b, h)]\, V^f_{rent}(X_{rent}). \quad (9)$$

For buyers with access to credit, the set $\mathcal{B}^0(h, z) = \{x_b \in \mathbb{R}^+ : y - x_b \geq \underline{y}(h, z)\}$, where $\underline{y}(h, z) < 0$ captures the ability to borrow using mortgages. Buyers with no credit access can only buy using cash at hand, i.e. $\mathcal{B}^1(h, z) = \{x_b \in \mathbb{R}^+ : y - x_b \geq 0\}$.

4.4.2 Consumption and Portfolio Allocation Choices

Renters choose bonds b', consumption c, and apartment space a,

$$\begin{aligned} V^f_{rent}(X_{rent}) = \max_{\substack{b' \geq 0, c \geq 0, \\ a \in [0, \overline{a}]}} u(c, a) + \beta \mathbb{E} W^{f'}_{rent}(X'_{rent}) \text{ subject to} \\ c + r_a a + q b' \leq y \\ X'_{rent} = (e' z' + b', z'). \end{aligned} \quad (10)$$

Owners with debt choose payment $l \geq \underline{l}$, bonds b', and consumption c,

$$\begin{aligned} V_{debt}(X_{own}) = \max_{\substack{l \geq \underline{l}, b' \geq 0, \\ c \geq 0}} u(c, h) + \beta \mathbb{E} W^0_{own}(X'_{own}) \text{ subject to} \\ c + \delta p h + q b' + l \leq y \\ X'_{own} = (e' z' + b', (m - l)(1 + r_m), h, z'). \end{aligned} \quad (11)$$

[6] For example, homeowners who choose to refinance must be able to actually roll-over their existing debt into a new loan or have sufficient liquid assets to cover any shortfall.

where $\underline{l} \equiv \frac{r_m}{1+r_m} m$ is the interest-only minimum down payment. Owners with access to credit but no current mortgage choose loan m', bonds b', and consumption c,

$$
\begin{aligned}
V^0_{own}(y, h, z) = \max_{\substack{m' \geq 0, b' \geq 0, \\ c \geq 0}} u(c, h) + \beta \mathbb{E} W^0_{own}(X'_{own}) \text{ subject to} \\
c + \delta ph + qb' \leq y + q_m(m', b', h, z)m' \\
q_m(m', b', h, z)m' \leq \vartheta ph \\
X'_{own} = (e'z' + b', m', h, z').
\end{aligned}
\tag{12}
$$

where ϑ is the maximum loan-to-value ratio. For owners without credit access,

$$
\begin{aligned}
V^1_{own}(y, h, z) = \max_{b' \geq 0, c \geq 0} u(c, h) + \beta \mathbb{E} W^{f'}_{own}(X'_{own}) \text{ subject to} \\
c + \delta ph + qb' \leq y \\
X'_{own} = (e'z' + b', m' = 0, h, z').
\end{aligned}
\tag{13}
$$

5 Disciplining the Model

This section follows Hedlund (2018) in setting the model parameters to match features of the U.S. economy prior to the 2007–2011 housing crash. Some parameters are taken directly from the data or relevant literature, while the remainder are determined jointly within the model. Table 1 provides a summary.

5.0.1 External Parameters

The parameters for the stochastic endowment $e \cdot z$ come from adapting Storesletten, Telmer and Yaron (2004) to a quarterly setting and normalizing annual income to 1 using the procedure of Hedlund (2018). Following Castañeda, Díaz-Giménez and Ríos-Rull (2003), a fourth persistent income state is introduced for the top 1% to better match wealth inequality from the data. Risk aversion is set to $\sigma = 2$, and the elasticity of substitution between consumption and shelter is $\epsilon = 0.13$, following

Flavin and Nakagawa (2008) and Kahn (2009). However, the results also analyze an alternative Cobb-Douglas calibration. The discount factor β is determined jointly.

Construction costs are normalized to $p = 1$, and the annual price of apartment space is $r_a = 0.035$ to yield a 3.5% rent-price ratio. The mapping from p to $\eta_s(\cdot; p)$ and $\eta_b(\cdot; p)$ emerges from directed search and free-entry of market makers who facilitate trades between sellers and buyers. Hedlund (2016) gives more details of the search environment, but here, it suffices to present the reduced-form expressions

$$\eta_s(x_s; p) = \min\left\{1, \max\left\{0, \left(\frac{p - x_s}{\kappa_s h}\right)^{\frac{\gamma_s}{1-\gamma_s}}\right\}\right\}, \quad \eta_b(x_b; p) = \min\left\{1, \max\left\{0, \left(\frac{x_b - p}{\kappa_b h}\right)^{\frac{\gamma_b}{1-\gamma_b}}\right\}\right\}$$

where the parameters γ_s, γ_b, κ_s, and κ_b are determined jointly. In addition, a small utility cost ξ of failing to sell is introduced to prevent homeowners on the fence about selling from setting a list price that leads to extremely long time on the market.

Consistent with the low interest rate environment of the mid-2000s, the annual *real* risk-free rate is -1%, the annual servicing cost is $\phi = 0.051$ to generate a 4.1% *real* mortgage rate, and the origination cost is $\zeta = 0.4\%$. The maximum loan-to-value is set at a non-binding 125% to reflect the popularity of high leverage loans prior to the housing bust documented by Herkenhoff and Ohanian (2015). Lastly, the credit flag persistence $\gamma_f = 0.95$ corresponds to an expected five year wait before foreclosed borrowers regain access to credit, and the REO discount χ is determined jointly.

5.0.2 Jointly Determined Parameters

The joint calibration sets out to match moments of the data circa mid-2000s related to the housing market and portfolio holdings reported by the 2004 Survey of Consumer Finances. Regarding the housing market, particular attention is paid to matching foreclosure activity along with price spreads and trading delays from search frictions. As shown in table 1, the model replicates debt and asset holdings remarkably well.

Table 1: Model Calibration

Description	Parameter	Value	Target	Model	Source/Reason
		External Parameters			
Autocorrelation	ρ	0.952			Storesletten et al. (2004)
Persistent Shock	σ_z	0.17			Storesletten et al. (2004)
Transitory Shock	σ_e	0.49			Storesletten et al. (2004)
Top 1% Shock*	z_4/z_3	4			Kuhn and Ríos-Rull (2013)
Prob Enter Top 1%*	$\pi_{3,4}$	0.0041			Kuhn and Ríos-Rull (2013)
Prob Stay Top 1%*	$\pi_{4,4}$	0.9			Kuhn and Ríos-Rull (2013)
Elas of Substitution	ϵ	0.13			Flavin and Nakagawa (2008)
Risk Aversion	σ	2			Various
Holding Costs	δ	0.7%			Moody's
Construction Cost	p	1			Normalization
Rent-Price Ratio	r_a	3.5%			Sommer et al. (2013)
Risk-Free Rate	r	-1.0%			Federal Reserve Board
Servicing Cost	ϕ	0.051			4.1% Real Mortgage Rate
Origination Cost	ζ	0.4%			FHFA
Maximum LTV	ϑ	125%			Herkenhoff and Ohanian (2015)
Flag Persistence	λ_f	0.95			Fannie Mae
		Jointly Determined Parameters			
Homeownership Rate	$\overline{a}$	2.3000	69.2%	69.1%	Census
Starter House Value	$\underline{h}$	2.7500	2.75	2.75	Corbae and Quintin (2015)
Owner Housing Wealth	ω	0.8389	3.99	3.99	2004 SCF
Owner Mortgage Debt	β	0.9737	1.87	1.81	2004 SCF
Months of Supply**	ξ	0.0014	4.90	4.86	Nat'l Assoc of Realtors
Buyer Search (Weeks)	γ_b	0.0940	10.00	9.82	Nat'l Assoc of Realtors
Maximum Bid Premium	κ_b	0.0250	2.5%	2.5%	Gruber and Martin (2003)
Maximum List Discount	κ_s	0.1500	15%	15%	RealtyTrac
REO Loss	χ	0.0920	20%	20%	Pennington-Cross (2006)
Foreclosure Rate***	γ_s	0.6400	0.60%	0.67%	Nat'l Delinquency Survey
			Model Fit		
Median LTV			51.5%	56.4%	2004 SCF
Share with $LTV \geq 80\%$			18.2%	20.4%	2004 SCF
Share with $LTV \geq 90\%$			8.7%	9.5%	2004 SCF
Share with $LTV \geq 95\%$			4.4%	4.8%	2004 SCF
Mean Net Worth			2.62	2.78	2004 SCF
Mean Liq Assets			1.06	0.94	2004 SCF
Mean Owner Net Worth			3.13	3.19	2004 SCF
Mean Owner Liq Assets			1.20	1.01	2004 SCF
Med Owner Liq Assets			0.24	0.34	2004 SCF

*The ratio $s_4/s_3 = 4$ corresponds to $\text{earn}_{99\text{–}100}/\text{earn}_{95\text{–}99}$ from Kuhn and Ríos-Rull (2013). The transitions resemble table 20 but ensure that 1% have $s = s_4$. Also, $\pi_{i,4} = 0$ and $\pi_{4,i} = 0$ for $i = 1, 2$.

**Months of supply equals inventories divided by the sales rate.

***Foreclosure starts are 1.2% but Herkenhoff and Ohanian (2015) report that nearly half self-cure.

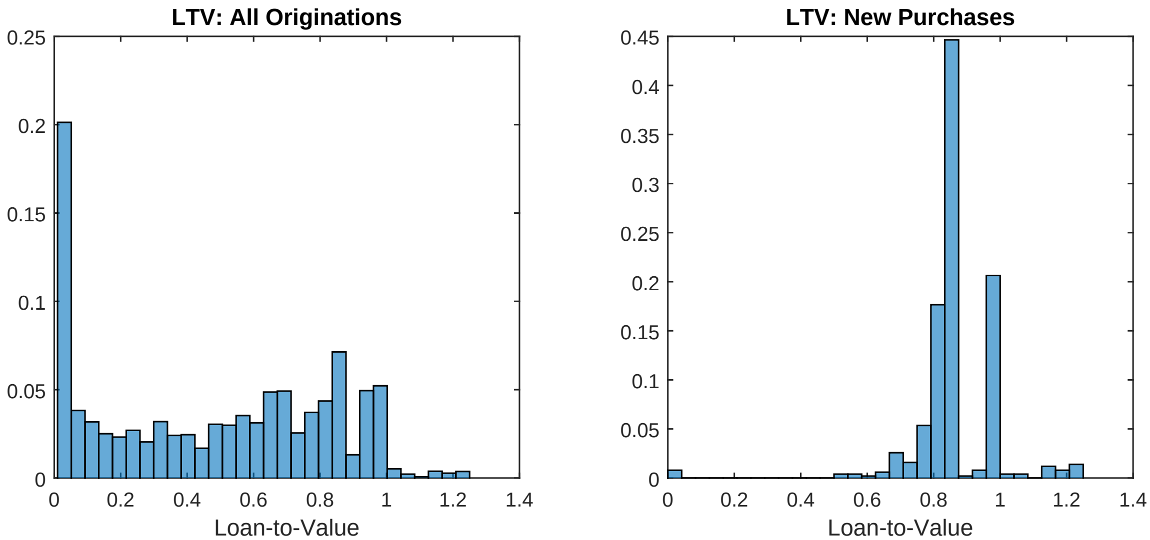

Figure 3: (Left) Loan-to-value distribution for all new mortgage originations; (Right) Loan-to-value distribution for new purchase-only loans.

6 Results

To determine the sensitivity of homeownership to credit constraints, the quantitative experiments analyze the dynamic response of the model economy to an unexpected, permanent tightening of down payment requirements. The benchmark results assume constant marginal cost reversible construction, which fixes p and gives an upper bound for the homeownership response. Later, the opposite case of a fixed total housing stock is briefly considered where price changes blunt the adjustment in quantities.

Recall that, in the benchmark calibration, mortgages are limited to 125% loan-to-value at origination. However, figure 3 demonstrates that this constraint is essentially non-binding. The left panel, which lumps together refinance and purchase loans, shows a sharp drop off above 100% LTV. Even without a constraint, most borrowers avoid these negative equity loans because banks embed a steep default premium into the mortgage price $q_m(\cdot)$. The right panel shows a similar drop-off for purchase loans, with significant bunching just to the right of 80% LTV and to the left of 100% LTV.

Given this bunching and the historical popularity of 20% down payment loans,

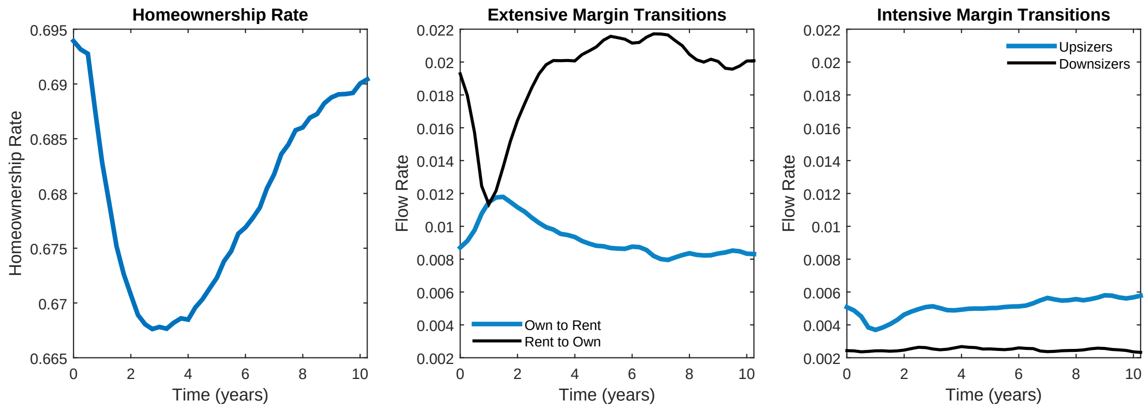

Figure 4: (Left) Total homeownership rate. (Middle) Transitions between owning and renting. (Right) Upsizers and downsizers.

the first experiment analyzes the dynamic effects of reducing the maximum leverage at origination to 80%. The experiment is then repeated with a more severe 50% minimum down payment requirement to investigate potential nonlinearities in the homeownership response. To assess the importance of substitutability between housing and consumption, a re-calibrated Cobb-Douglas specification is subjected to the same experiments. Lastly, all of the above is run again using an analogous pair of stylized life-cycle economies to test robustness and to provide insight about the impact of credit constraints on households at different stages of their lives.

6.1 Down Payments and the Importance of Time Horizon

After the imposition of a 20% minimum down payment, the homeownership rate declines gradually by 2.4 percentage points over the next three years. In the cross section, the largest drop occurs among middle income households occupying small houses, whereas low income renters and upper income homeowners barely change tenure status. Although these results align well with the static model intuition, focusing only on the trough gives an incomplete and misleading picture about the relationship between minimum down payments and homeownership.

Figure 4 shows that the homeownership rate almost completely recovers after

10 years. Furthermore, the temporary decline comes more from a depressed flow of renters into homeownership than from an exodus of homeowners into renting. In fact, the entire increase in the own-to-rent rate occurs among borrowers with leverage above 75%, but they account for a smaller fraction of homeowners over time. The long term nature of mortgage contracts is key to this result, with collateral requirements only applied upon origination of new loans and not to existing borrowers. For the same reason, panel 3 reveals that higher down payment requirements slow movement up the property ladder without increasing the fraction of homeowners who downsize.

6.1.1 Transitioning from the Short Run to the Long Run

Multiple factors account for the long-run resilience of the homeownership rate to tighter credit. First, the non-degenerate portfolio choice problem implies that borrowing-constrained households are not necessarily the same as those on the margin between buying and renting. Recall that, in the initial equilibrium, the overwhelming majority (86%) of new purchases are made with less than a 20% down payment. Yet, when the 20% minimum is imposed, rent-to-own transitions fall by less than half, and fewer than 5.4% of buyers are completely shut out by an empty budget set. Instead, most buyers prefer to have resources left over for saving, which creates another margin for adjustment other than forgoing the decision to buy.

Furthermore, because they face the lowest default premia, upper-income buyers actually take out the most leverage at the time of purchase. The average loan-to-value for lower-income, middle-income, and upper-income buyers is initially 77%, 84%, and 97%, respectively. Yet, even while upper-income buyers are the most *borrowing* constrained after down payments increase, their homeownership rate remains stable.[7]

The ability to gradually save for a down payment is also a long-run stabilizing

[7] Across the entire universe of new loans, the average leverage at origination for lower-income, middle-income, and upper-income borrowers is 41%, 55%, and 39%, respectively. Thus, even though upper-income households borrow the most when buying, middle-income homeowners extract the most equity when refinancing.

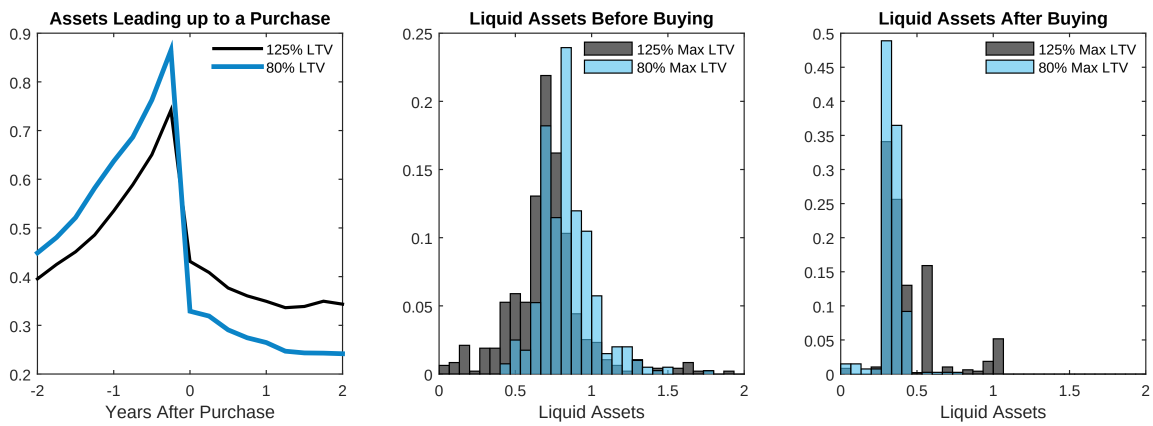

Figure 5: (Left) Liquid assets of new buyers leading up to the date of purchase. (Middle and Right) Distribution of assets before and after purchase, respectively.

force for homeownership. Panel 1 of figure 5 shows asset dynamics leading up to a new home purchase. More stringent down payment requirements create a longer build-up period followed by a steeper decline after buying. The middle panel illustrates the cross-sectional increase in asset accumulation before buying, and the right panel exhibits the post-purchase decline. Thus, just as in prototypical one-asset incomplete markets models, agents build savings to buffer themselves against the constraint.

6.1.2 Homeownership with Very Large Down Payment Requirements

The same dichotomy between short-run and long-run dynamics occurs after raising the down payment requirement to a more severe 50%. Moreover, the *magnitude* of the short-run homeownership response is highly nonlinear with respect to the stringency of borrowing constraints. Upon imposition of the tighter limits for new loans, the share of existing borrowers with leverage above the threshold is three times larger in the 50% case compared to the 20% case, but the short-run decline in homeownership is nearly *five* times as large and much more protracted, as shown by the left panel of figure 6. Also, recall that implementing a 20% minimum down payment prompted a fall in the rate of rent-to-own transitions with only a modest rise in own-to-rent flows. However, the middle panel demonstrates that a more severe tightening of credit

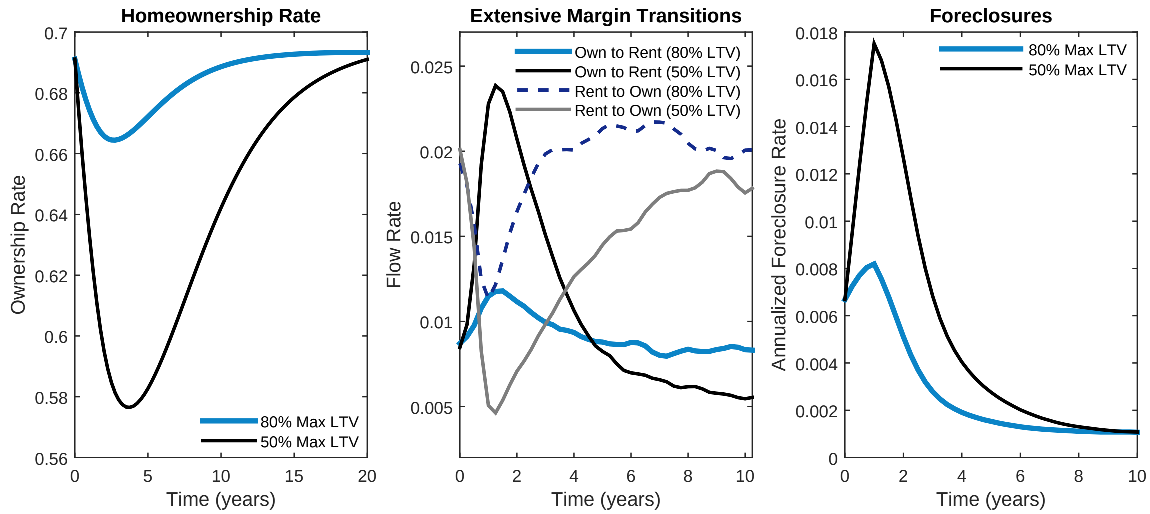

Figure 6: Comparison of the response to a 20% vs. 50% minimum down payment.

causes a temporary surge in the flow of homeowners switching to renting. A portion of this exodus comes from foreclosures, as indicated by the right panel, although these "involuntary" flows are stable between 15% and 20% of all own-to-rent transitions.

What accounts for the nonlinear homeownership response? First, the decision to default is a nonlinear function of home equity that depends on credit access. When borrowing limits tighten, homeowners with leverage above the new threshold can no longer respond to negative shocks by extracting equity through refinancing. The only remaining consumption-smoothing avenues are to sell or default. Homeowners prefer to sell, but debt overhang from the list price constraint $x_s + y \geq m$ exacerbates illiquidity-induced trading delays and pushes some unsuccessful sellers into default.

Long term debt represents a second source of nonlinearities. Figure 11 in the appendix shows that homeowners who become constrained by tighter credit do not simply bunch at the borrowing constraint. Instead, mass accrues throughout the entire left tail of the leverage distribution, which pushes down the average loan-to-value to 25%—far below the constraint. Even though most buyers make close to the minimum down payment, they gradually build equity over time which it is costly for them to extract through repeated refinancing. This prolonged period of asset

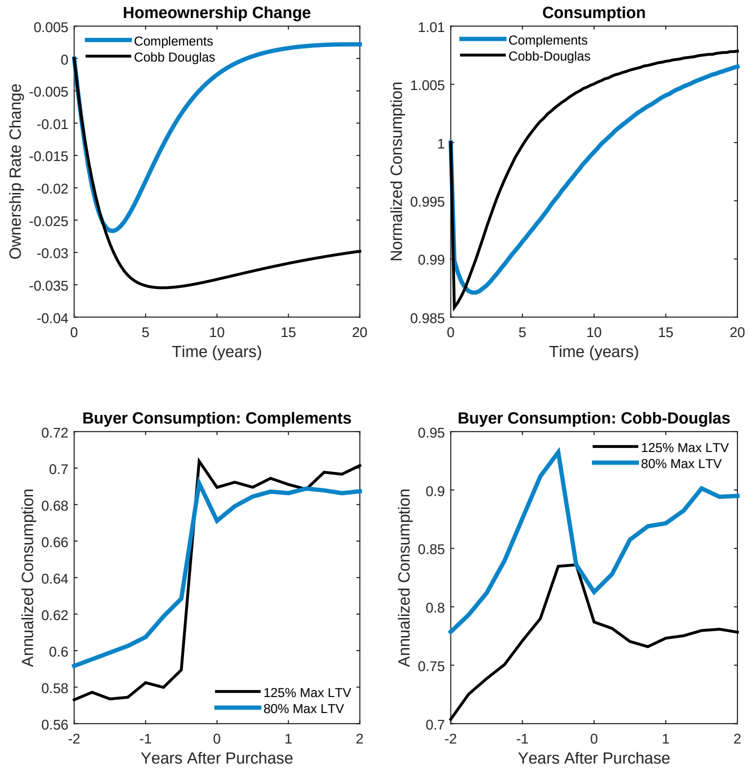

Figure 7: Comparison between the benchmark and Cobb-Douglas calibrations of the response to a 20% down payment requirement.

accumulation prior to purchasing also explains the slow recovery in homeownership.

6.2 Housing and Consumption: The Role of Substitution

The benchmark results—which feature housing and consumption as complements in the utility function—reveal a strong interplay between the homeownership rate and down payment requirements in the short run but no relationship in the long run. Figure 7 shows how these results hold up in the case of a 20% minimum down payment when the model is re-calibrated using a Cobb-Douglas specification. Qualitatively, the top left panel reveals that a higher degree of substitutability causes homeownership to remain permanently lower after a tightening of credit, though the pattern of overshooting and partial recovery still exists. Quantitatively, however, the impact of reducing the maximum leverage from 125% to 80% only

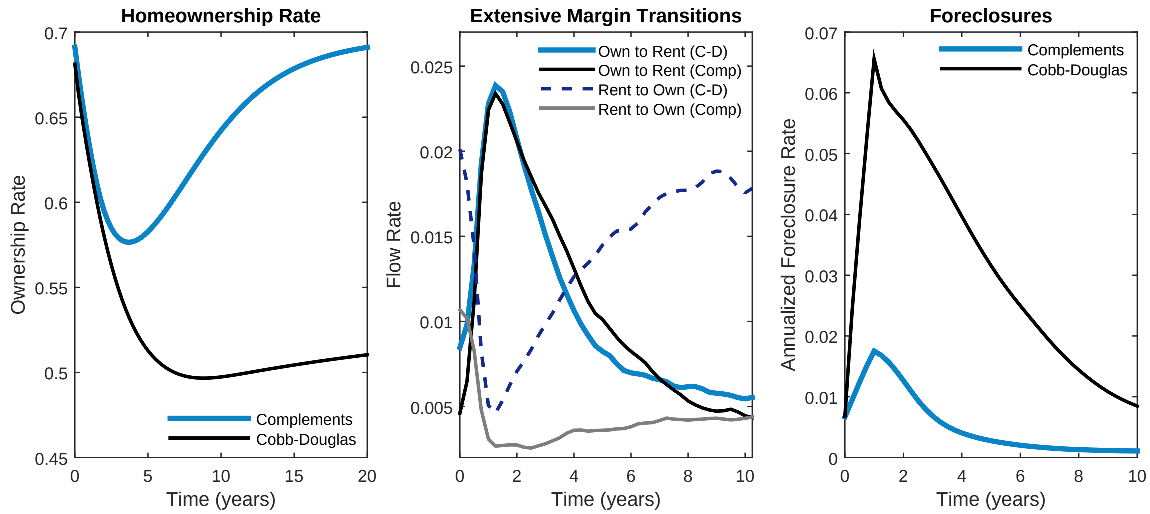

Figure 8: Comparison between the benchmark and Cobb-Douglas calibrations of the response to a 50% down payment requirement.

reduces the homeownership rate by 2.6 percentage points in the long run.

The remaining panels in figure 7 provide insight into how the dynamics of consumption under the two specifications differ and shape the resulting homeownership response. After an initial decline, consumption recovers much more rapidly with greater substitutability in preferences. With strong complementarity, households tolerate lower consumption while they build up assets for a larger down payment, whereas households in the Cobb-Douglas specification are more willing to shift from housing toward consumption.

The dynamics of consumption also exhibit significant differences between the two specifications surrounding the date of a house purchase. With complementary preferences and loose credit, consumption is flat leading up to the point of purchase and then jumps in tandem with the increase in shelter from houses being larger than apartments, $\underline{h} > \overline{a}$. Tightening down payments in this environment attenuates the jump in consumption upon purchase. By contrast, with greater substitutability in preferences, consumption grows more steeply during the asset build-up phase before *falling* at the time of purchase. When down payments are tightened in this case, the path of consumption before and after purchase shifts upward, caused mostly by a composition effect from a shift in the pool of buyers towards higher income.

6.2.1 Substitutability in the Midst of a Severe Credit Tightening

Nevertheless, for the central question at hand about the relationship between homeownership and down payments, neither specification predicts a strong long-run response to the introduction of a 20% minimum down payment. This parity quickly breaks down, however, if a severe 50% down payment requirement is introduced, as shown by figure 8. The left panel shows that homeownership drops to 50% with Cobb-Douglas preferences and remains permanently depressed. The middle panel gives some clues into the anatomy of this decline. Under both specifications, the rate of own-to-rent transitions temporarily increases before eventually reverting to its original level. However, in the Cobb-Douglas environment, approximately 60% of the homeownership exodus is attributable to foreclosures, which spike to a level three times higher than in the benchmark calibration. More importantly, the flow of renters into homeownership collapses in the Cobb-Douglas economy and never recovers, which is the crux of why homeownership stays low.

6.3 Long-Run Ownership: Credit Limits vs. Interest Rates

Barring a return to the pre-Great Depression mortgage environment, 50% minimum down payments are unlikely to ever again become a reality.[8] Otherwise, sections 6.1 and 6.2 showed that the long-term impact of implementing a 20% down payment—still mark a significant departure from current credit limits—would be modest or nil, depending on the preference specification. However, these findings do not imply that the homeownership rate is independent of credit entirely. To the contrary, changes in *interest rates* have long-run effects on homeownership. In the benchmark calibration, increasing interest rates by 2% causes homeownership to fall

[8]For some U.S. mortgage market history, see `https://www.stlouisfed.org/publications/central-banker/summer-2008/the-past-present-and-future-of-the-us-mortgage-market`

by 5.6% in the short run and 3% in the long run.[9] Likewise, reducing rates from an initially higher level produces the mirror image result. Thus, the rise in the U.S. homeownership rate between 1998 and 2006 can be viewed through the lens of the model as some combination of a *temporary* response to looser down payment requirements and a *permanent* response to lower interest rates. Since then, numerous changes in the housing and mortgage environment have likely conspired to suppress homeownership despite the continuation of low borrowing costs.

6.4 House Prices and Inelastic Supply

To maximize the response of quantities rather than prices to changes in down payment requirements, the analysis to this point has featured a constant marginal cost p for the reversible construction technology. However, even with the deck stacked in this manner, introducing a 20% down payment requirement has had little long-run impact on the homeownership rate. This section briefly considers the opposite case of a fixed total housing stock. The appendix provides the housing market clearing condition.[10]

As one might expect, figure 9 confirms that house prices decline after the imposition of a 20% down payment requirement, and the reduction in prices attenuates the fall in homeownership. Regardless of the specification for preferences, homeownership only falls by 1% in the short run and returns approximately to its initial level in the long run. For the benchmark calibration, house prices also return to their initial level in the long run after falling by 8% upon initiation of the tighter down payments. The Cobb-Douglas specification yields a smaller price decline on impact but a slower and incomplete recovery, ending 1% below their starting point.

[9]The Cobb-Douglas specification exhibits an even larger homeownership decline with higher rates.

[10]As in standard models with capital, there is a background technology that allows conversion between houses of different qualities once they are being transacted. This assumption simplifies the analysis by allowing one p to clear the market instead of a separate p_h for each $h \in H$.

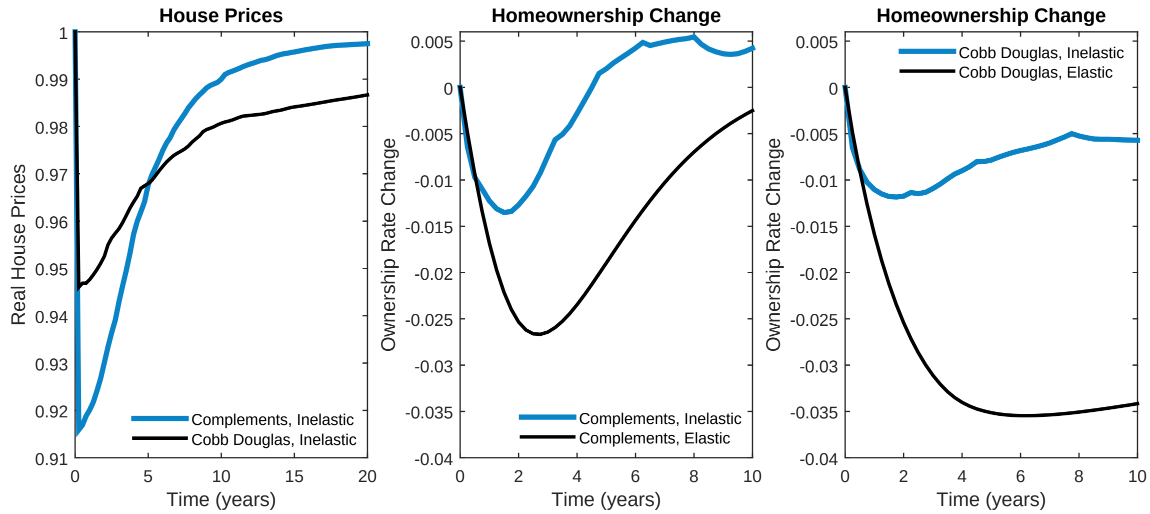

Figure 9: Comparison between the benchmark and Cobb-Douglas calibrations of the response to a 50% down payment requirement.

6.5 Homeownership, Asset Accumulation, and the Life Cycle

The decision of households to gradually build savings in the face of higher down payment requirements explains the resilience of homeownership to tighter credit. However, what if, unlike in an infinite horizon environment, households "run out of time" to accumulate assets for a home purchase? To answer this question, a stylized life cycle dimension is added to the model. Specifically, agents now face stochastic death each period with an annualized probability of $\rho = 0.975$, which corresponds to an expected life span of 40 years. Upon death, all home equity and liquid assets are expunged, and homeowners' houses are auctioned off to cover any outstanding debt. All dead households are replaced by newborn renters with zero savings starting at the lowest persistent income state. Thus, even without an age-specific deterministic wage profile, newborn households anticipate a rising income profile and greater future saving. To maximize the impact of credit constraints, households are not permitted to make bequests or inter vivos transfers.[11]

Table 3 gives the calibrations, and table 2 summarizes the behavior of

[11] Mayer and Engelhardt (1996) and Guiso and Jappelli (2002) point out that gifts from relatives are an important source of funds for down payments.

Table 2: Homeownership Response to a 20% Minimum Down Payment

Description	IH, Comp	IH, C-D	LC, Comp	LC, C-D
Short-Run Trough	−2.4pp	−3.6pp	−4.9pp	−5.2pp
Long-Run Change	+0.4pp	−2.6pp	+0.3pp	−4.7pp

Note: The abbreviations IH = Infinite Horizon, LC = Life Cycle, Comp = Complements, C-D = Cobb-Douglas.

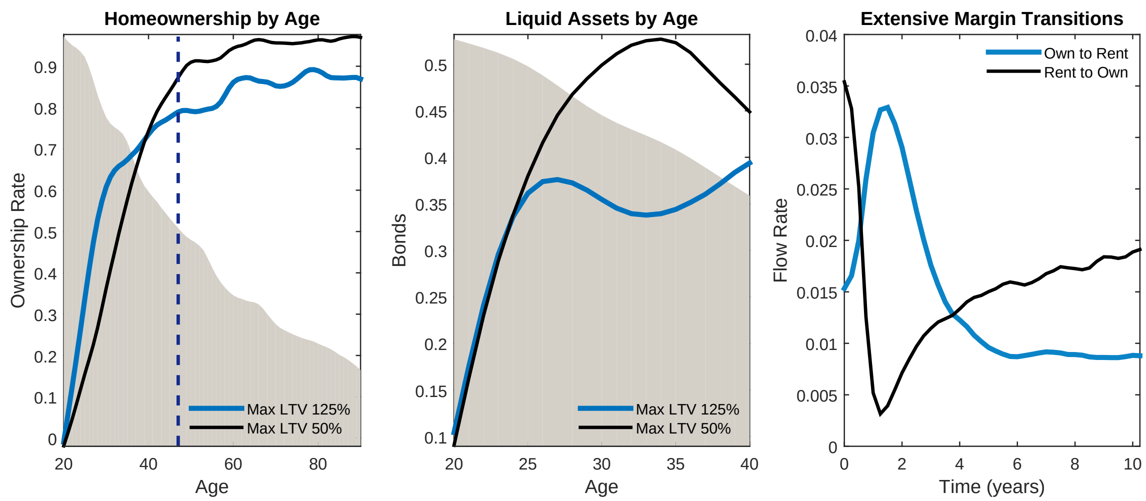

Figure 10: (Left) Housing transitions after imposing a 50% minimum down payment with complements. (Middle) Homeownership by age. (Right) Liquid assets by age. *Note:* the shaded area is the age distribution. The dashed line is the median age.

homeownership for each case. With a 20% down payment requirement, life cycle behavior magnifies the short-run homeownership decline but does nothing to alter its long-run stability when housing and consumption are complements. With Cobb-Douglas utility, the life cycle—even with its exaggerated assumption of no bequests or inter vivos transfers—only reduces long-term homeownership by 2.1%.

Even with a 50% down payment requirement, the life cycle model with complementarity between housing and consumption still only experiences a long-run homeownership decline of 2%. However, the left panel of figure 10 shows that this aggregate stability conceals significant heterogeneity by age. Homeownership among the young declines precipitously because of the added time required to accumulate assets for a larger down payment. The middle panel confirms this increased savings behavior among households at the age where they are preparing to buy. However, by around age 40, the homeownership rate in the economy with tighter down payments starts to *exceed* that of the low down payment economy. The right panel gives some clues as to the reason. Consistent with earlier intuition, higher down payments reduce rent-to-own flows by complicating the path for aspiring buyers into homeownership. However, precisely because higher down payments make transitioning from renting to owning more difficult, homeowners are more reluctant to ever transition into renting. In other words, own-to-rent flows fall as well. The result is a significant dampening of gross flows in both directions that produces little change in net flows or homeownership. Notably, Boehm and Schlottmann (2014) find cross-country empirical evidence in support of this negative relationship between down payment requirements and gross housing tenure flows.

7 Conclusions

This paper documents that during the financial crises the credit contraction made it very difficult for households to purchase housing, homeownership across most MSAs in the U.S. declined even with a sizeable price correction. To assess the dynamic patterns in the cross-section, the papers constructs an equilibrium model of tenure decisions to evaluate whether credit supply shocks generate persistent or permanent scarring effects on homeownership. The model highlights a dichotomy that emerges between the short and long-run response to a different degrees of credit tightening as prospect homeowners need to accumulate a downpayment. The effects of credit supply shocks on homeownership are adversely magnified in areas when rents increase, the return of savings decreases, or the housing supply is very inelastic by creating a rental trap. The ability to circumvent the downpayment constraint diminishes when the decision to purchase a house is driven by life-cycle motives.

The bottom line that emerges from this analysis is one of a highly time-dependent relationship between credit constraints and homeownership. In the short-run, credit supply shocks that tighter down payments depress homeownership as in the static model of section 2. However, with moderate down payment requirements on the order of 20%, the relationship largely disappears in the long run. A significant long-run link between down payments and homeownership only emerges after an implausibly severe contraction in borrowing limits, and even then, only if preferences feature a substantial degree of substitutability between housing and consumption. Explicitly modeling the life cycle, even with exaggerated assumptions limiting bequests and inter vivos transfers, mostly just alters short-run dynamics. The long-run trends in homeownership appear to be affected by other fundamental factors. However, the scarring effects of credit supply contractions generate different degrees of suppress homeownership in the short-run. This is important for policymakers and researchers interested in debt-reducing macroprudential policies should be mindful of the transitional dynamics associated with such interventions.

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A Definitions and Proofs

Proof of Theorem 1. Proof by contradiction. Suppose that tightening borrowing constraints actually *increases* homeownership, i.e. $\Gamma(\vartheta) \subset \Gamma(\widetilde{\vartheta})$. Then $\exists e \in \Gamma(\widetilde{\vartheta})$ such that $e \notin \Gamma(\vartheta)$. The first statement is equivalent to $U_{own}(e;\widetilde{\vartheta}) \geq U_{rent}(e)$, while the second is equivalent to $U_{rent}(e) > U_{own}(e;\vartheta)$. By transitivity, it must be the case that $U_{own}(e;\widetilde{\vartheta}) > U_{own}(e;\vartheta)$. However, the budget set in the homeowner optimization problem is *larger* with ϑ than with $\widetilde{\vartheta}$, which necessary implies $U_{own}(e;\vartheta) \geq U_{own}(e;\widetilde{\vartheta})$. Thus, we arrive at a contradiction. ■

Definition 1 (Housing Market Clearing) *For given trading probability functions $\eta_s(x_s;p)$ and $\eta_b(x_b;p)$, the shadow price p adjusts to equate the flow of houses from successful sellers to successful buyers,*

$$\underbrace{\int h^* \eta_b(x_b^*, h^*; p) d\Phi_{rent}}_{\textit{successful purchases}} = \underbrace{\overbrace{S_{REO}(p)}^{\textit{REO sales}} + \overbrace{\int h\eta_s(x_s^*, h; p) d\Phi_{own}}^{\textit{sold by owner}}}_{\textit{successful sales}}, \tag{14}$$

where Φ_{rent} and Φ_{own} are the distributions of renters and owners, respectively, and $S_{REO}(h)$ is the REO stock. The mappings from p to $\eta_s(\cdot;p)$ and $\eta_b(\cdot;p)$ satisfy

$$\kappa_b h \geq \overbrace{\alpha_b(\theta_b(x_b, h))}^{\textit{prob of match}} \overbrace{(x_b - ph)}^{\textit{broker revenue}} \tag{15}$$

$$\kappa_s h \geq \underbrace{\alpha_s(\theta_s(x_s, h))}_{\textit{prob of match}} \underbrace{(ph - x_s)}_{\textit{broker revenue}}, \tag{16}$$

which represent free-entry conditions for a third class of agents—brokers—who passively facilitate the flow of houses from sellers to buyers, where κ is the broker entry cost, θ_j $(j = b, s)$ is the tightness in submarket (x_j, h), $\alpha_j(\theta_j) = \widetilde{\eta}_j(\theta_j)/\theta_j$, and $\eta_j(x_j, h) \equiv \widetilde{\eta}_j(\theta_j(x_j, h))$. Brokers do not alter the decision problems of buyers or sellers and are purely for computational tractability, as in Hedlund (2016).

B Supplementary Tables and Figures

Table 3: Model Specifications

Description	IH, Comp	IH, C-D	LC, Comp	LC, C-D
	Re-Calibrated Parameters			
Largest Apartment $\overline{a}$	2.300	1.650	1.520	1.000
Search Cost ξ	0.0014	0.0135	0.0010	0.0085
Discount Factor β	0.9737	0.9767	0.9898	0.9918
Utility Parameter ω	0.8389	0.6809	0.8279	0.6829
	Select Model Moments			
Homeownership Rate	69.1%	68.1%	68.9%	68.0%
Owner Housing Wealth	3.99	3.95	3.94	3.99
Median LTV	56.4%	60.3%	54.5%	57.5%
Share with $LTV \geq 80\%$	20.4%	26.8%	21.6%	24.4%
Share with $LTV \geq 90\%$	9.5%	9.9%	9.5%	12.9%
Share with $LTV \geq 95\%$	4.8%	4.8%	4.4%	8.4%
Med Owner Liq Assets	0.34	0.33	0.33	0.29
Months of Supply	4.86	5.04	4.91	4.98
Foreclosure Rate	0.67%	0.68%	0.56%	0.43%

Notes: IH = Infinite Horizon; LC = Life Cycle; Comp = Complements; C-D = Cobb-Douglas. The elasticity of substitution and annual survival probability take on values $(0.13, 1)$, $(1, 1)$, $(0.13, 0.975)$, and $(1, 0.975)$, respectively. The probability 0.975 reflects a 40-year expected life span.

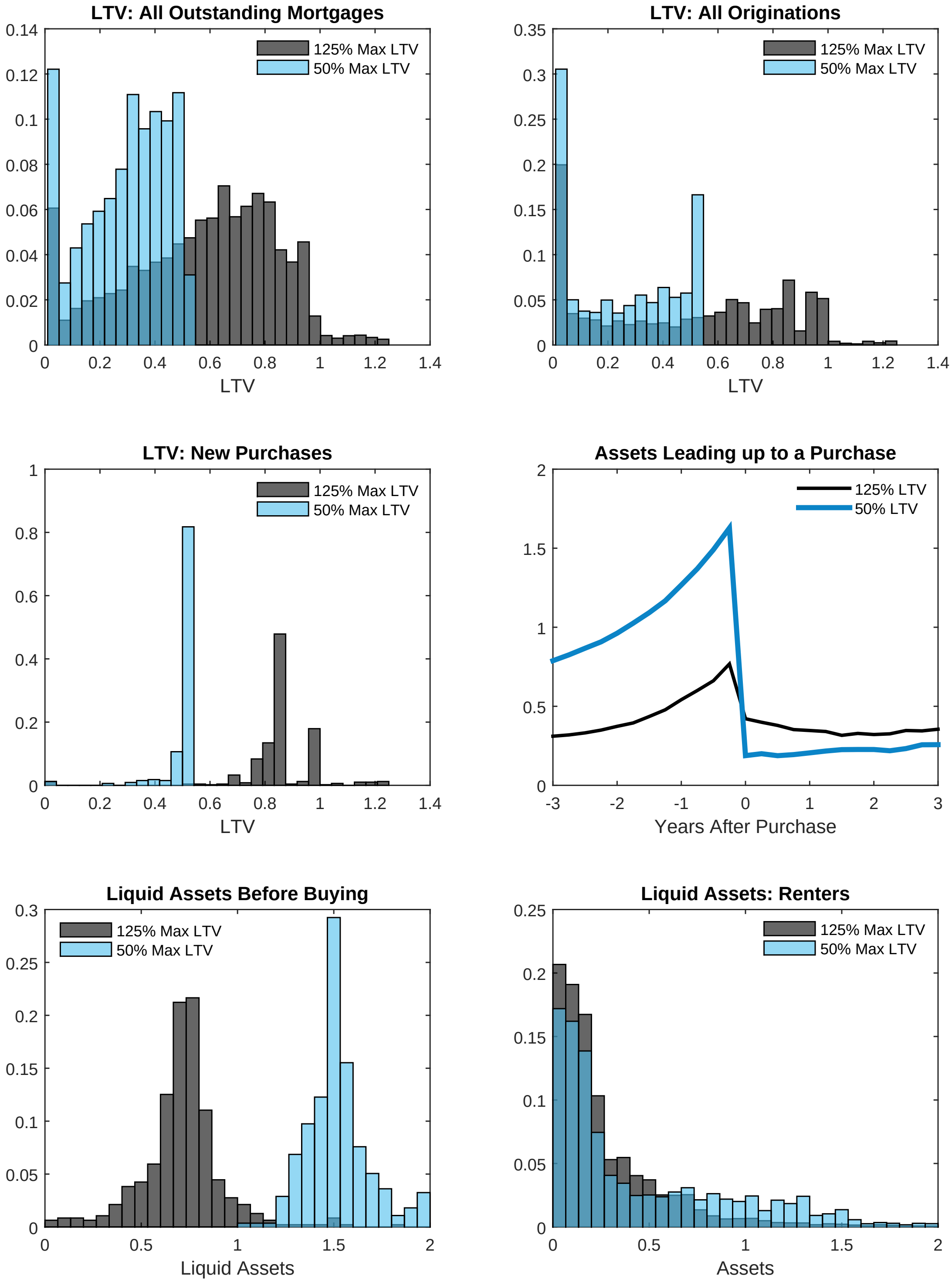

Figure 11: Assets and debt after increasing the minimum down payment to 50%. Tighter down payments prolong the build-up of savings leading up to purchase.