Monetary Policy, Heterogeneity, and the Housing Channel

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Abstract

We investigate the role of housing and mortgage debt in the transmission of monetary policy to household consumption and the aggregate economy. In order to do so, we develop a heterogenous agents model with a frictional housing market, nominal long-term borrowing, default, and price rigidities. The model is able to capture rich heterogeneity in home ownership and leverage. Endogenous cyclical movements in house prices as well as counter-cyclical dynamics in the liquidity of housing allows us to explore the various indirect mechanisms through which monetary policy affects consumption. Nominal long-term mortgage debt implies that changes in monetary policy will result in redistribution between lenders and borrowers. Further, a contractionary monetary policy shock raises the cost of borrowing which reduces *liquidity* in the housing market, depresses house prices and feeds back into increasing the cost of borrowing. We find that this amplification channel disproportionally affects households with high leverage and high marginal propensities to consume. Finally, we investigate how booms and busts in the housing market asymmetrically affect the efficacy of monetary policy.

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1 Introduction

For a majority of US households, owner-occupied housing represents the single most important asset in the household porfolio and is tied to the single largest liability—the mortgage. Furthermore, housing is not only quite illiquid, but also the extent of the illiquidity is countercyclical. In this paper, we investigate the rich role that housing and nominal mortgage borrowing play in the transmission of monetary policy.

In addition to the direct effect of monetary policy on consumption, changes in interest rates generate several indirect effects related to housing. First, the fact that household portfolios are tilted toward a real asset financed with long-term nominal debt implies that declines in interest rates may affect disposable incomes through increased refinancing activity, resulting in significant redistribution between households that are net debtors in nominal assets and net lenders. If debtors and lenders have different propensities to consume, this redistribution through balance sheets could have large effects on aggregate consumption.

Second, changes in interest rates can generate real movements in house prices. A reduction in interest rates reduces the cost of borrowing, alleviates credit constraints and increases the demand for housing. The increase in demand for housing increases real house prices and makes the housing market more *liquid*, which further alleviates borrowing constraints. This indirect effect on house prices can translate into significant movements in household consumption as recent empirical research finds large effects of house prices changes on household consumption (for example, Mian and Sufi (2014b, 2011)).

Heterogeneity is crucial for accurately evaluating the importance of the redistribution and house price channels. The distribution of mortgage debt across agents with different consumption propensities is critical for the consumption effects through redistribution. Similarly, the distribution of liquid wealth is a key driver of the responsiveness of housing demand with respect to financing costs.

The goal of this paper is to understand and quantify the extent to which the joint distribution of housing and mortgage debt affects the transmission of monetary policy. To this end, we develop a heterogenous agents model with a frictional housing market, nominal long-term borrowing, default, and price rigidities. The model is able to capture the rich heterogeneity in home ownership and leverage and allows us to explore the various indirect mechanisms through which monetary policy affects consumption.

This paper is related to several strands of the literature. Several papers examine the role of house prices in driving aggregate fluctuations through consumption. Mian *et al.* (2013) study the response of consumption to house prices by exploiting geographical variation in the housing collapse of 2006—2009. They find a large elasticity of consumption with respect to housing net worth. Furthermore, they show that this elasticity is higher for poorer households and those with higher loan-to-value on their mortgages. Mian and Sufi (2014a) show the analogous result, that there is a strong consumption response to house price changes and that there is substantial heterogeneity in the marginal propensity to consume. In more recent work, Mian *et al.* (2016) find evidence that higher debt-to-GDP predicts lower future output growth and higher unemployment. Our model features demand effects and is quantitatively consistent with the magnitudes in these papers.

Several empirical papers look at how household balance sheets affect the transmission of monetary policy. Di Maggio *et al.* (2014) show a significant consumption response to monetary policy, but they highlight how voluntary deleveraging attenuates the effect of rate reductions on consumption. Consistent with other work, they show that the marginal propensity to consume is higher for low income or underwater borrowers, and that the effect is larger in counties with a greater fraction of adjustable rate mortgages. In other words, debt rigidity reduces the effectiveness of monetary policy in their setting. Keys *et al.* (2014) also show that voluntary deleveraging mutes the response of consumption to lower mortgage rates. They also show that regions that were more exposed to mortgage rate declines saw faster recovery of house prices, consumption, and employment, particularly in the non-tradable sector. In short, these papers provide empirical support for the key result that the effectiveness of monetary policy crucially depends on the distribution of liquid wealth and mortgage debt.[1]

This paper is also related to Hedlund (2015), which looks at what impact higher inflation could have had in potentially mitigating the Great Recession by inflating away nominal mortgage debt. Both papers feature frictional housing and long-term debt, but Hedlund (2015) abstracts from the actual conduct of monetary policy, treats inflation as exogenous, and operates in an open-economy setting.

[1]A number of other recent papers demonstrate the importance of heterogeneity in the transmission of monetary policy. See Auclert (2015), Kaplan *et al.* (2016),Cloyne *et al.* (2015), Wong (2015), and Aladangady (2015).

2 Model

To investigate the effect of the housing channel in the transmission of monetary policy, we need a business-cycle model with the following ingredients: (1) nominal rigidities, so as to provide a role for aggregate demand in determining output; (2) a frictional housing market that allows monetary policy to affect the price and liquidity of the housing market; (3) nominal long-term mortgages to generate redistribution across households and allow monetary policy to affect credit constraints.

2.1 Households

There are two types of households in the population. The first type of households, **capitalists**, are more patient than the second type, **laborers**.

Laborer Households

- They have preferences over consumption, c, leisure, l, and housing services, s. Preferences are time-separable and the future is discounted at rate β_L. In particular, their expected lifetime utility is defined by:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_L^{t-1} \frac{\left[(1-\phi_h)\left(c+g(1-l)\right)^{1-\rho_h} + \phi_h s^{1-\rho_h}\right]^{\frac{1-\sigma_L}{1-\gamma}}}{1-\sigma_L}, \text{ with } g(1-l) = \psi z \frac{(1-l)^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}.$$

- They are subject to uninsurable idiosyncratic labor productivity risk. In particular, their labor productivity z follows an exogenous Markov process.

- They own houses, h or rent housing services from a competitive market in the form of apartment space. We assume that if a house owns a house of size h, it generates $s = h\omega_h$, where in general $\omega_h \geq 1$ to represent pride of ownership.

- Homeowners can borrow in the form of long term, fixed rate nominal mortgage contracts. Mortgage size is denoted by M and the fixed mortgage interest rate is denoted by r_m.

- They can accumulate risk free bond, b with a return $1 + r_b$.

- Each period households are faced with a positive but constant death probability, λ. Death give birth to an offspring with zero wealth, and labor productivity z equal to a random draw from its ergodic distribution.

- There is a unit measure of laborer households in the population.

- State variables for the laborer households are $z,\ b,\ h,\ M,\ r_m$.

Capitalist Households

- They have preferences over consumption, c. Preferences are time-separable and the future is discounted at rate $\beta_C > \beta_L$. In particular, their expected lifetime utility is defined by:
$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_C^{t-1} \frac{c^{1-\sigma_C}}{1-\sigma_C}.$$

- They have access to a complete set of insurance markets in which they can insure all idiosyncratic productivity risks. Then we are talking about a representative capitalist household.

- They own the shares of banks, s_B.

- They own the shares of intermediate firms, s_I.

- They trade bonds b with the laborer households and the government and they invest capital to banks k.

- Similar to the laborer households they face a positive but constant death probability, λ and upon death give birth to an offspring. Unlike the laborer households, they can leave all of their wealth to their offsprings as bequests. This implies infinite lifetime for capitalist households.

- There is a measure ν of capitalist households at each period.

- The state variables for the capitalist households are $b,\ k,\ s_I,\ s_B$.

2.2 Housing Market

- There is a fixed supply of housing in the economy and no depreciation.

- Due to the presence of trading frictions, owners cannot sell their houses directly to buyers. Instead, they search in a decentralized housing market for real estate brokers whose job it is to purchase houses to turn around and sell to buyers.

- Homeowners cannot own two houses at the same time. If they want a different house, they must first sell their existing house and temporarily become renters.
- Renters (including people who just sold their house) purchase houses from the real estate brokers in a competitive market at price $p_h$per unit of housing.
- Buyers immediately move into their house and switch from apartment-dweller ("renter") status to homeowner status.
- Brokers are not permitted to carry housing inventories into future periods, but inventories *do* arise in equilibrium from the portion of the housing stock that owners put on the market but fail to sell.

2.2.1 Directed Search in the Housing Market

- Owners of house $h \in H$ looking to sell their house at a price x_s of their choice enter submarket (x_s, h) in hopes of matching with a broker.
- With probability $p_s(\theta_s(x_s, h))$, a seller successfully matches and sells the house, *provided that they have the ability to pay off any outstanding mortgage debt.* The probability that a broker finds a seller is $\alpha_s(\theta_s(x_s, h)) = \frac{p_s(\theta_s(x_s,h))}{\theta_s(x_s,h)}$.
- The function $p_s : \mathbb{R}_+ \to [0, 1]$ is continuous and strictly increasing with $p_s(0) = 0$; α_s is strictly decreasing. It is possible that $\alpha_s > 1$, in which case the same broker finds multiple sellers, from which the broker buys one house each.
- Each broker incurs an entry cost $\kappa_s h$, and owners that try and fail to sell pay a small utility cost ξ.

The profit maximization condition of the real estate brokers is

$$\kappa_s h \geq \overbrace{\alpha_s(\theta_s(x_s, h))}^{\text{prob of match}} \overbrace{(p_h h - x_s)}^{\text{broker revenue}} \tag{1}$$

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

The revenue to a seller-broker that purchases a house from a seller is $p_h h - x_s$. Therefore, brokers continue to enter submarket (x_s, h) until the cost $\kappa_s h$ exceeds the expected revenue.

2.2.2 Block Recursivity

The menu of market tightnesses does not depend directly on the distribution of household states (income, assets, and debt). Instead, $\theta_s(x_s, h)$ depends only on p_h:

$$\theta_s(x_s, h) = \alpha_s^{-1}\left(\frac{\kappa_s h}{p_h h - x_s}\right) \tag{2}$$

This *block recursivity* result greatly increases computational tractability without altering the substance of the selling problem of the households. In particular, solving for the dynamics of the market tightnesses reduces to finding the equilibrium path of p_h and then substituting into – (2). As explained later, solving for p_h amounts to equating two Walrasian-esque equations for housing supply and housing demand.

2.3 Apartments

Landlords operate a linear, reversible technology that converts one unit of the final good into A_h units of apartment space. Each period, apartment-dwellers purchase apartment space from these landlords at unit price r_h.

2.4 Banks and Mortgage Markets

- Banks issue long-term, fixed rate mortgage contracts. At origination, borrowers choose M', are assigned interest rate r_m, and receive nominal resources of $q_m^0 M'$.
- The mortgage price q_m^0 incorporates all idiosyncratic and aggregate risk to the bank from issuing contract (r_m, M)
- Mortgages have no pre-defined maturity date. Instead, borrowers choose how quickly to pay down their mortgage so long as they make at least the pre-specified minimum payment, i.e. $M' \leq (1-\chi)M$.
- Alternatively, borrowers can refinance by paying off their old mortgage and taking out a new one.
- Banks incur a proportional origination cost ζ and servicing costs ϕ over the life of each mortgage.
- Banks face default risk and inflation risk. If a borrower defaults by not making a payment, the bank forecloses on the borrower.

To summarize, a borrower with existing contract (r_m, m) that chooses a new balance of M' owes $(1+r_m)M - M'$ if $M' \leq (1-\chi)M$ or else $(1+r_m)M - q_m^0((r_m, M'), b', h, s)M'$ if $M' > (1-\chi)M$, where (r'_m, M') is the refinanced contract at the new prevailing rate r'_m.

The fixed rate r_m set at origination satisfies $1 + r_m = \underbrace{(1+\phi)}_{\text{spread}} \underbrace{(1+r^*)(1+\pi^*)}_{\text{long-run nominal risk-free rate}}.$

- **Note (AH):** An alternative is to let households choose from a menu of r_m

Mortgage prices for contract (r_m, M') satisfy the following recursive relationship:

$$\begin{aligned}
q_m((r_m, M'), b', h, s)M' = \frac{1}{(1+r_m)}\mathbb{E}\Bigg\{ & \overbrace{p_s(\theta_s(x'_s, h))\frac{(1+r_m)}{(1+\phi)}M'}^{\text{sell + repay}} + \overbrace{[1 - p_s(\theta_s(x'_s, h))]}^{\text{no sale (do not try/fail)}} \\
& \times \Bigg[\underbrace{d' \min\left\{P' J_{REO}(h), M'\right\}}_{\text{default + repossession}} + Refi' \frac{(1+r_m)}{(1+\phi)}M' \\
& +(1 - d' - Refi')\left(\underbrace{\frac{(1+r_m)}{(1+\phi)}M' - M''}_{\text{borrower payment net of servicing costs}} + \underbrace{q_m((r_m, M''), b'', h, s')M''}_{\text{continuation value of new } M''}\right)\Bigg]\Bigg\}
\end{aligned} \tag{3}$$

where P' is the price level and x'_s, d', b'', and M'' are the policy functions for list price, mortgage default ($\in \{0,1\}$), bonds, and new mortgage balance next period, respectively. At origination, $q_m^0 = \frac{1}{(1+\zeta)} q_m$

By defining $m' = \frac{M'}{P}$ and $m'' = \frac{M''}{P'}$ and dividing through by Pm', q_m becomes

$$\begin{aligned}
q_m((r_m, m'), b', h, s) = \frac{1}{(1+r_m)}\mathbb{E}\Bigg\{ & p_s(\theta_s(x'_s, h))\frac{(1+r_m)}{(1+\phi)} + [1 - p_s(\theta_s(x'_s, h))] \\
& \times \left[d' \min\left\{\frac{(1+\pi)J_{REO}(h)}{m'}, 1\right\} + Refi' \frac{(1+r_m)}{(1+\phi)}\right. \\
& \left. +(1 - d' - Refi')\left(\frac{(1+r_m)}{(1+\phi)} - \left[1 - q_m((r_m, m''), b'', h, s')\right] \frac{(1+\pi)m''}{m'}\right)\right]\Bigg\}
\end{aligned} \tag{4}$$

If the borrower never sells or defaults, mortgage prices in the steady state reduce to $q_m((r_m, m'), b', h, s) = \frac{1}{(1+r_m)}$. We can see that higher inflation π reduces mortgage prices. Intuitively, for a given promised sequence of nominal repayments, banks reduce lending as expected inflation increases.

2.4.1 Foreclosure Process

In the event of foreclosure, borrowers lose their house, have their debt erased, and incur a utility cost ξ_f[2].

Banks sell repossessed houses (REO properties) in the decentralized housing market. Banks lose a proportion γ of sales revenue to the various costs of selling foreclosed houses. The bank absorbs all 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

$$\begin{aligned} J_{REO}(h) &= R_{REO}(h) - \eta h + \frac{1-\delta_h}{1+r} J_{REO}(h) \\ R_{REO}(h) &= \max\left\{0, \max_{x_s \geq 0} p_s(\theta_s(x_s,h)) \left[(1-\gamma)x_s - \left(-\eta h + \frac{1-\delta_h}{1+r} J_{REO}(h)\right)\right]\right\} \end{aligned} \tag{5}$$

where η 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.

Banks finance themselves by issuing one-period mortgage-backed securities. A form of the law of large numbers is assumed to hold, such that the bank can perfectly diversify the idiosyncratic mortgage risk. In terms of the aggregate risk, the government offers actuarially fair insurance against aggregate risk in both interest rate and default risk through Government Sponsered Enterprises. As such the return on mortgage backed securties will equal that of government bonds (See Jeske *et al.* (2013) for a discussion of the pass through of the government subsidy to the GSEs). Thus, any ex-post profits of losses by the banks are completely absored into the government budget. This assumption, importantly, does not preclude the state of the housing market and monetary policy from affecting contemporaneous pricing of mortgages. The assumption alleviates having to price the mortgage-backed securities when there are ex-post profits and losses which depend on the aggregate state and the complete distribution of mortgages held on the bank balance sheet.

[2] The utility cost is meant to represent, among other things, the stigma associated with foreclosure and non-monetary moving costs.

2.5 Final Good Producer

A competitive representative final goods producer aggregates a continuum of intermediate goods indexed by $j \in [0,1]$ and with prices p_j:

$$Y = \left(\int_0^1 y_j^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}.$$

where ϵ is the elasticity of substitution across goods. Given a level of aggregate demand Y, cost minimization for the final goods producer implies that the demand for the intermediate good j is given by

$$y_j(p_j) = \left(\frac{p_j}{P} \right)^{-\epsilon},$$

where P is the (equilibrium) price of the final good and can be expressed as

$$P = \left(\int_0^1 p_j^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}.$$

2.6 Intermediate Good Producers

Each intermediate good j is produced by a monopolistically competitive producer using labor input n_j.

$$y_j = Z n_j^{\alpha}$$

where Z is aggregate productivity. Intermediate producers hire labor at wage w_t in a competitive labor market.

Each intermediate producer chooses its price to maximize profits subject to price adjustment costs as in Rotemberg (1982). These adjustment costs are quadratic in the rate of price change $\frac{p_{t+1}-p_t}{p_t}$ and expressed as a fraction of produced output, Y_t

$$\Theta\left(\frac{p_j^{'} - p_j}{p_j} \right) = \frac{\theta}{2} \left(\frac{p_j^{'} - p_j}{p_j} \right)^2 Y$$

where $\theta > 0$. The price adjustment cost makes the intermediate producer's problem dynamic. Given current price p_j, the firm solves the following problem:

$$V\left(p_j\right)=\left[\left(\frac{p_j}{P}-mc_j\right)\left(\frac{p_j}{P}\right)^{-\epsilon}-\frac{\theta}{2}\left(\frac{p_j^{'}-p_j}{p_j}\right)^2\right]Y+\frac{1}{1+r}V\left(p_j'\right),$$

where mc_j is the marginal cost for j. Note that I omitted all the aggregate state variables that would potentially be part of the firm's problem. The key here is that the level of aggregate demand is not important for the firm's first-order condition, since adjustment costs and revenues both scale linearly with Y.

2.7 Government

The government levies a progressive tax on household labor income y that consists of a lump-sum transfer T_t and a proportional tax τ:

$$\tilde{T}(y)=-T+\tau y.$$

The government issues bonds denoted by B^g, with negative values denoting government debt. The government finances exogenous goverment expenditures, G and interest payments on bonds.

Furthermore, there is a monetary authority that sets the nominal interest rate on bonds according to a Taylor rule.

3 Recursive Equilibrium without Aggregate Shocks

For now I assume we are in a Aiyagari world and I ignore the aggregate state variables in households' dynamic programming problems.

3.1 Households' Dynamic Problem

3.1.1 Capitalist's Recursive Problem

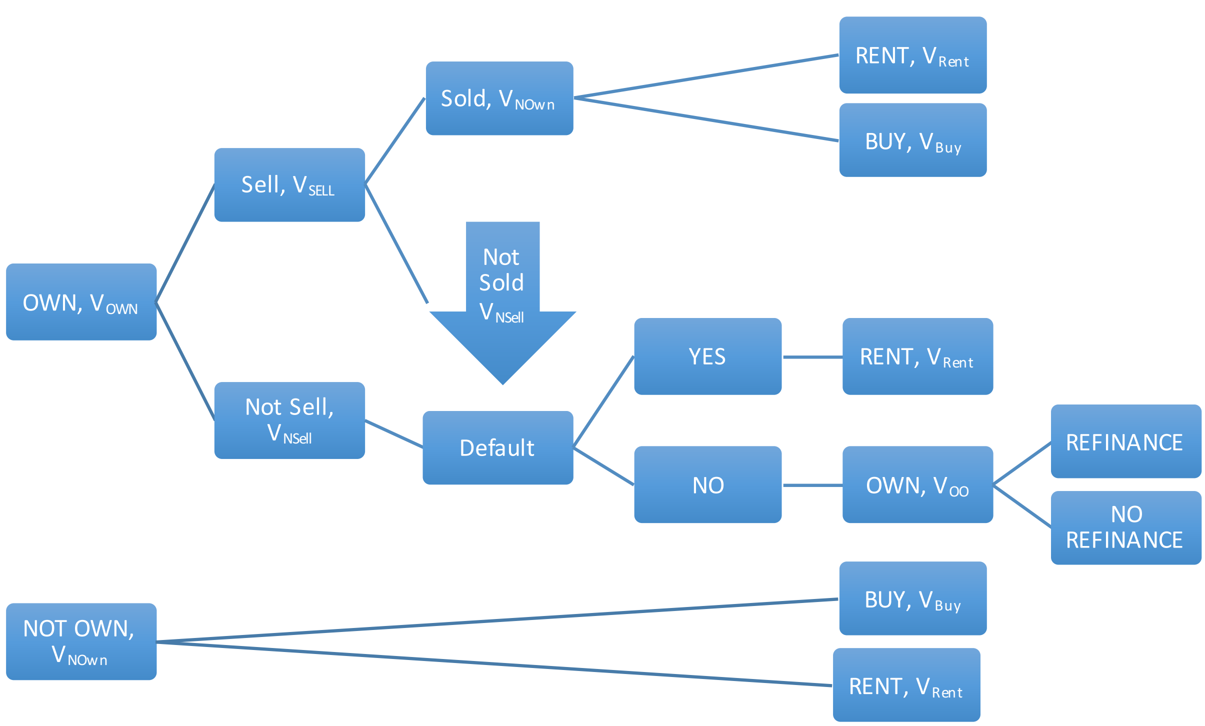
For given steady state equilibrium prices and dividends, $\{w, q^B, p^B, p^F, d^B, d^F\}$, the dynamic programming problem of the capitalist can be expressed as:

$$\begin{aligned} V(x) &= \max_{c,b',s'_B,s'_F} u^C(c) + \beta^C V(x') \\ x + wz^C &\geq c + q^B b' + p^B s'_B + p^F s'_F \\ x' &= b' + (d^B + p^B)s'_B + (d^F + p^F)s'_F \\ b' &\geq \underline{\mathrm{B}} \\ s'_B, s'_F &\in [0,1] \end{aligned}$$

3.1.2 Laborer's Recursive Problem

Laborers take the prices as given: w, q^B, p^H. Laborers dynamic problem can be summarized by the following timeline:

FIGURE 1 – Timeline



Value function of a household who owns a house in the beginning of the period and keeps the same house at the portfolio and refinance choice stage.

$$\begin{aligned}
V_{OO}(a,(r_m,m),h,z) &= \max_{m',b',c,l\geq 0} u(c,h,l)+\beta_L\mathbb{E}\left[V_{own}(a',(r'_m,m'),h,z')\right] \\
\text{subject to} & \\
c+q^Bb'+\frac{m(1+r_m)}{1+\pi} &\leq a+m' \text{ if } m'\leq \frac{(1-\chi)}{1+\pi}m \\
c+q^Bb'+\frac{m(1+r_m)}{1+\pi} &\leq a+q_m^0((r'_m,m'),b',h,z')m' \text{ if } m' > \frac{(1-\chi)}{1+\pi}m \\
r'_m &= \begin{cases} r_m & \text{if } m'\leq \frac{(1-\chi)}{1+\pi}m \\ r'_m & \text{o/w} \end{cases} \\
a' &= wz'+b'
\end{aligned}$$

Value function of a household who buys a house:

$$\begin{aligned}
V_{Buy}(a,z) &= \max_{m',b',h',c,l\geq 0} u(c,h',l)+\beta_L\mathbb{E}\left[V_{OWN}(a',(r'_m,m'),h',z')\right] \\
\text{subject to} & \\
c+q^Bb'+p_hh' &\leq a+q_m^0((r'_m,m'),b',h',z')m' \\
h &\in H=\{h_0,h_1,h_2\} \\
a' &= wz'+b'
\end{aligned}$$

Value function of a household who rents:

$$\begin{aligned}
V_{Rent}(a,z) &= \max_{b',s,c,l\geq 0} u(c,s,l)+\beta_L\mathbb{E}\left[V_{NOwn}(a',z')\right] \\
\text{subject to} & \\
c+q^Bb'+r_ss &\leq a \\
s &\leq \bar{s} \\
a' &= wz'+b'
\end{aligned}$$

Default decision (when household defaults it is always foreclosed and banks do not come after liquid assets of the household):

$$V_{NSell}(a,(r_m,m),h,z) = \max_{d\in\{0,1\}} d(V_{Rent}(a,z)-\chi_f)+(1-d)V_{OO}(a,(r_m,m),h,z)$$

Buying decision a household who doesn't own a house (either recently sold or never owned):

$$V_{NOwn}(a,z,f) = \max_{Buy\in\{0,1\}} BuyV_{Buy}(a,z) + (1-Buy)V_{Rent}(a,z)$$

Choosing a list price x_s for a household who wants to sell her house:

$$\begin{aligned} V_{SELL}(a,(r_m,m),h,z,f) &= \max_{x_s} -\xi + p(\theta(x_s,h))V_{NOwn}(a+x_s-(1+r_m)m,z) \\ &+ (1-p(\theta(x_s,h)))V_{NSell}(a,(r_m,m),h,z) \end{aligned}$$

Selling decision of a household which defines V_{OWN}:

$$V_{OWN}(a,(r_m,m),h,z) = \max_{\varsigma\in\{0,1\}} \varsigma V_{SELL}(a,(r_m,m),h,z) + (1-\varsigma)V_{NSell}(a,(r_m,m),h,z)$$

3.2 Equilibrium

3.2.1 Housing Market Clearing

Housing supply $S_h(p_h)$ equals the sum of owner-occupied and foreclosed properties that are successfully sold to real estate brokers:

$$S_h(p_h) = S_{REO}(p_h) + \int hp_s(\theta_s(x_s^*,h;p_h))\Phi(da,d(\overline{q_m},m),dh,dz)$$

where

$$S_{REO}(p_h) = \sum_h hp_s(\theta_s(x_s^{REO},h;p_h))\left\{H_{REO}(h) + \int\left[1-p_s(\theta_s(x_s^*,h;p_h))\right]d^*\Phi(da,d(r_m,m),h,dz)\right\}$$

is the supply of foreclosed properties (existing inventories + new repossessions).

Housing demand $D_h(p_h)$ equals housing purchased by buyers,

$$D_h(p_h) = \int h^* \Phi(da, dz)$$

Equating these two Walrasian-esque expressions gives p_h:

$$D_h(p_h) = S_h(p_h)$$

The market for mortgages clears:

$$\begin{aligned}
\int b_m^{'} &= \int q_m^0((r_m^{'}, M'), b', h, s) M' \Phi(da, d(r_m, m), dh, dz) Refi(a, (r_m, m), h, dz) \\
&+ \int q_m^0((r_m^{'}, M'), b', h', s) M' \Phi(da, d(r_m, m), dh, dz) Sell(a, (r_m, m), h, dz, df) Buy_O(a, (r_m, m), \\
&+ \int q_m^0((r_m^{'}, M'), b', h', s) M' \Phi(da, dz) Buy_R(a, dz)
\end{aligned}$$

The government budget constraint (need to add in all of the aggregate gains/losses from the mortgage sector):

$$w\tau \int z + [Insert] = T + \int b_m + (1+r)B^g + G$$

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