Consumption and House Prices in the Great Recession: Model Meets Evidence

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Extended Abstract

One of the distinctive features of the Great Recession is that the drop in household consumption expenditures was (i) larger, (ii) broader —i.e., all components of consumption expenditures, not just durables, dropped substantially— and (iii) more persistent than in recent recessions (Petev, Pistaferri, and Saporta-Eksten, 2011).

The leading explanation for these atypical aggregate consumption dynamics is the extraordinary destruction of US housing wealth that occurred between 2006 and 2009. For example, the S&P Case-Shiller Real House Price Index shows a decline of 30 percent in this period, and only a timid recovery since then. In an influential paper, Mian, Rao, and Sufi (2012) have cleverly used an IV technique applied to a combination of various micro data to estimate an aggregate elasticity of nondurable consumption expenditures to housing net worth of 0.4 for the recession period. They have argued that the long-lasting plunge of house prices can explain much of the recent collapse in aggregate consumption expenditure in the US.

In this paper we revisit the consumption-house price nexus both empirically and structurally, with a special focus on the Great Recession. We do so by asking three related questions.

First, we ask: how robust are the Mian, Rao and Sufi (2012) estimates? This is an important question because these estimates are at the upper bound of the range provided by most of the literature, between 0.0 and 0.02 (Case, Quigley, and Shiller, 2005; Carroll,

Otsuka, and Slacalek, 2006; Attanasio, Blow, Hamilton and Leicester, 2009). Moreover, the Mian-Rao-Sufi insight is being incorporated into dynamic equilibrium models of business cycle (Midrigan and Philippon, 2011; Justiniano, Primiceri, and Tambalotti, 2014, Huo and Rios-Rull, 2014) but, these models can be quantitatively successful only if the elasticity of consumption to housing wealth is high enough.

The first contribution of the paper is to provide an alternative set of estimates on the consumption response to the fall in house prices by exploiting a new source of nondurable consumption expenditure data, weekly store-level data from the Kilts-Nielsen Retail Scanner Dataset (KNRS). The dataset is a weekly panel of total sales (quantities and prices) at the UPC (barcode) level for around 40,000 geographically dispersed stores. From this weekly/UPC level data we construct an annual store-level panel of total sales. Since the dataset contains geographic information for each store (county, first 3 digits of zip code), we merge this sales data with county-level information on house prices, household wealth, and labor market variables. In the paper we discuss why our data source is superior to the Mastercard data used by Mian, Rao and Sufi (2012).

We study the effect of changes in these county-level variables on store-level changes in sales. Since the sales of a store in a county are indicative of the expenditure of the households who live in that county, our estimates provide a reliable measure of the effect of county-level changes in house prices and household balance sheets on county-level non-durable expenditure. Our preliminary results broadly confirm the Mian, Rao and Sufi (2012) empirical findings, when replicating their regressions on our data. We also find that about one half of the effect is due to contemporaneous changes in labor market conditions. Given the richness of the data, we are also able to explore the heterogeneity of consumption responses by age, income, leverage ratio, homeownership status, etc.

Second, we ask: can a plausibly parameterized equilibrium structural model replicate these empirical findings on the aggregate elasticity and its heterogeneity across household types? We thus solve a stochastic equilibrium overlapping-generations model where households derive utility from a nondurable consumption good and from housing. They work for a number of years and earn labor income subject to uninsurable idiosyncratic and aggregate fluctuations, then retire, and when they die they bequeath their residual (positive) net worth to their offsprings based on a warm-glow giving motive. Every period, they choose nondurable consumption, saving into a risk-free liquid asset, and their homeownership status.

Households can own or rent. Housing purchases can be financed by taking on mortgages. All mortgages are long-term and amortized over the life of the household. The mortgage price is determined in equilibrium so that banks make zero profit in expectation from a loan. Households have the option to default on their mortgages. If a household defaults on its mortgage it forfeits its house and incurs a utility penalty. We impose a maximum face value

on the loan that can be taken out by a household as a fraction of the value of the home. Households also have the option of taking on home equity lines of credit (HELOC), one-period debt contracts that must be repaid in the subsequent period. Households can also default on their HELOCs, and consistent with a second lien, the HELOC is junior to the primary mortgage in terms of disbursement of funds in default. Further, consistent with mortgage law, if the household is going to default on its debt obligations, it must default on both the HELOC and first mortgage. Households that currently have a mortgage have the option to refinance, by repaying the principal balance remaining and any HELOCs, and originating a new mortgage and possibly a new HELOC. If a household chooses to sell its home, it is also required to pay off its remaining mortgage balance and HELOC.

We close the model with a construction sector and a representative rental company. Their profit-maximizing choices, together with aggregate demand of owner-occupied and rental units, yield equilibrium prices and equilibrium rents that are connected by a no-arbitrage relation.

The economy is subject to four aggregate shocks to (i) housing supply, (ii) preferences for owner-occupied housing, (iii) credit market conditions, and (iv) income. We solve the model with a variant of the Krusell-Smith approach to solving heterogeneous-agents incomplete-market models with aggregate fluctuations. We emphasize that the endogenous price dynamics are key to address our question because different shocks that have the same impact on prices may lead to very different consumption responses. For example, a housing supply or preference shock has no other direct effect on the household budget constraint, whereas both income and credit conditions shocks do.

We parameterize the model to generate plausible lifecycle profiles for all the key endogenous variables, and a realistic consumption response to individual income shocks. We then simulate boom-bust episodes in house prices that are empirically comparable to the 2000s and look at implications for the aggregate consumption response —and its distribution across household types— homeownership, leverage ratios, etc. In preliminary (so far, partial equilibrium) results, the model has sizable elasticities, around 2/3 of the micro estimates. We note that, in the model, we allow for two groups of households facing different housing supply elasticities. This way we can exactly replicate, within the model, the Mian-Rao-Sufi identifying strategy.

Third, we ask: what accounts for these large consumption elasticities? Broadly speaking, the correlation between housing wealth and consumption may arise from three sources: (i) a wealth, or balance-sheet, effect, (ii) a tightening of credit constraints (forced deleveraging), or (iii) the response of both housing wealth and consumption to common third factors, such as expected future income. Our structural model allows us to decompose the total effect into these three components.

This decomposition also allows us to understand why estimates of the elasticity obtained with data for the Great Recession are significantly higher than other empirical estimates in the literature. Simulations from our structural model will shed some light on this issue, since different sources of house price movements, as well as different macroeconomic conditions, translate into diverse values for the average elasticity. In other words, we will be able to understand what was so special about the Great Recession to imply these unusually high consumption responses to house prices.

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House prices and consumption

- Empirical evidence suggests substantial elasticity of consumption expenditure to housing net worth
  - Case, Quigley and Shiller (2005): small, 0.1
  - Campbell and Coco (2005): larger, UK data
  - Mian, Rao and Sufi (2014): 0.4-0.6

- Commonly proposed as the story of Great Recession
  - Midrigan and Philippon (2011)
  - Mian and Sufi (2014)
  - Justiniano, Primiceri, Tambellotti (2014)
  - Huo and Rios-Rull (2014)

Three channels

1. Direct: Balance sheet effects
   - Change in housing wealth depends on:
     a. change in house prices
     b. leverage ratio
   - Expectations of future prices and housing purchases

2. Direct: Budget constraint effects
   - Forced deleveraging from short-term debt
   - Adjustable rate mortgages

3. Indirect: GE effects
   - Further demand-driven drops in employment and income
   - Collateral for new business startups, hiring and investment

Reasons for skepticism

Budget Constraint effects

- Most mortgages in the US are fixed rate
- HELOCS: typically roll over every 5 years

Balance Sheet effects

- Negative shock for households planning to downsize:
  a. One-third of households are not homeowners
  b. Younger households typically plan to upsize
  c. Leverage plus down payment constraints matter when upsizing
- Older households are least leveraged
- Foreclosure limits the downside loss in wealth
- Require very persistent (perceived) house price movements
- Largest elasticities in counties with small price declines

Outline

1. Evidence on consumption response to housing net worth shock
   - Existing methods, new consumption data
   - Sources of micro-heterogeneity in elasticity
   - Impact of macro-environment

2. Structural model of consumption and housing
   - Lifecycle
   - Long-term mortgage debt
   - Amortizing mortgages
   - HELOCS
   - Foreclosure
   - Rational expectations about house price movements

Empirical Evidence

Empirical strategy

- Mian, Rao and Sufi (2014) (MRS):
  - Housing net worth decline from 2006 to 2009 at CBSA
  - Instrument: Saiz (2010) housing supply elasticities
- New source of expenditure data:
  - Kilts-Nielsen Retail Scanner data set (KNRS)
- Extend analysis to aid model evaluation:
  - Heterogeneity in elasticity of expenditure to housing net worth
  - Contribution of changes in income and unemployment
  - Contribution of house price drop vs leverage ratio differences
  - Post-2009 recovery

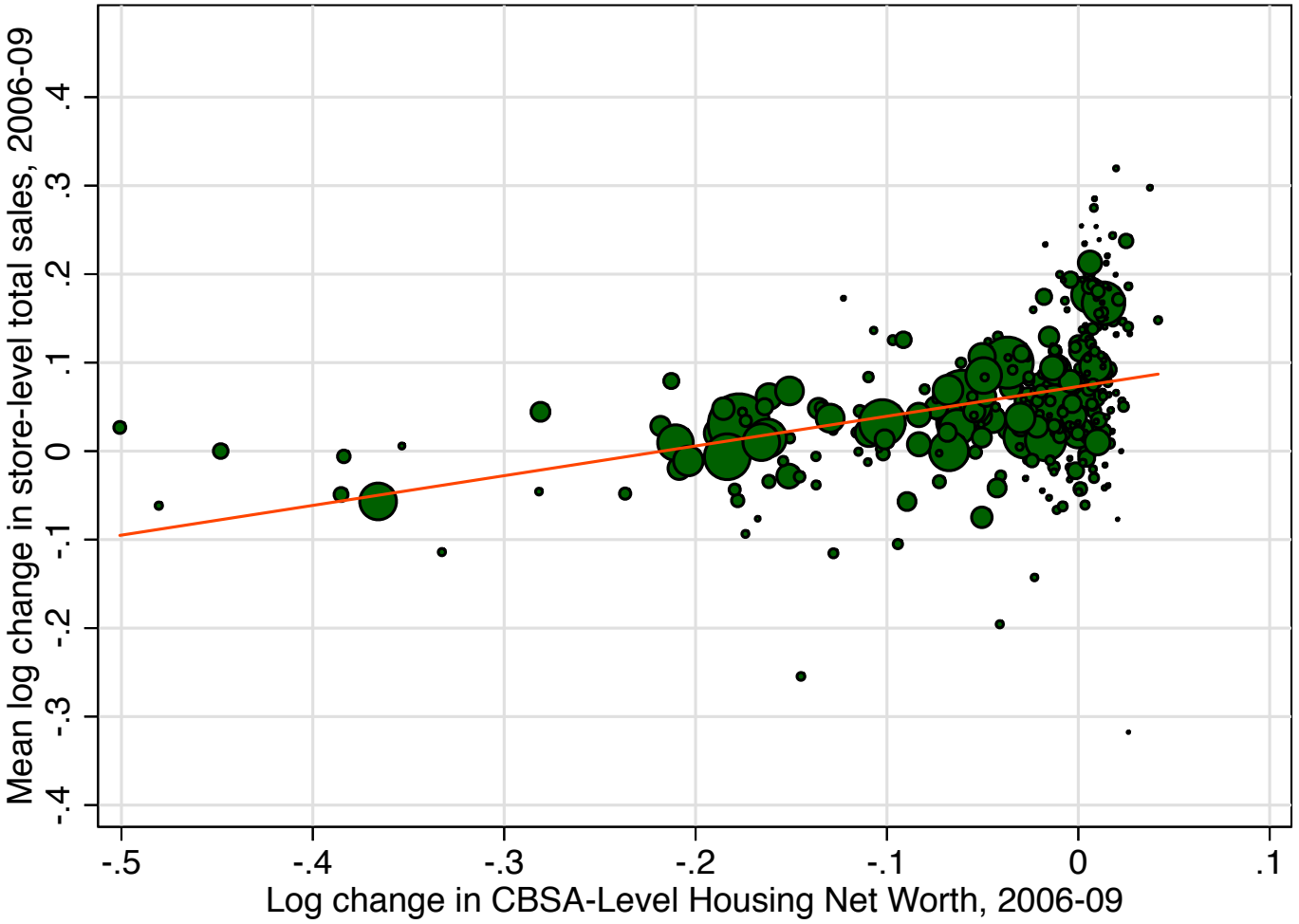
Kilts-Nielsen Retail Scanner Data (KNRS)

- Weekly store-level data on prices and quantity at UPC (barcode) level
- Aggregate to store-level changes in total sales from 2006 to 2009

- Merge with
  - CBSA-level data on housing net worth from MRS
  - CBSA-level data on housing supply elasticity from Saiz
  - County-level characteristics

- Selection
  - All stores that reported sales in every quarter of 2006 and 2009, with a 3-year log change in annual sales $\in$ (-1,1)
  - 21,892 stores in 647 of 944 counties analyzed by MRS
    18,593 stores in 519 of 540 counties covered by Saiz (2010)

Mean store-level sales growth vs change in housing net worth at CBSA level, 2006-09



Elasticity of consumption to housing net worth: Replicating Mian, Rao and Sufi (2014)

Dependent variable: log change in store-level total sales, 2006-09				
	OLS	IV	OLS (IV sample)	IV (exclude AZ,CA,FL,NV)
Log change in housing	0.326**	0.326**	0.307**	0.580*
net worth, 2006-09	(0.068)	(0.068)	(0.048)	(0.261)
N stores	21,892	18,593	18,593	14,237
N counties	647	519	519	259
R^2	0.026	0.025	0.025	0.012

Elasticity of consumption to housing net worth
Heterogeneity by size of housing net worth change

Dependent variable: log change in store-level total sales, 2006-09				
	OLS <-10%	OLS >-10%	OLS (-10%,0%)	OLS >0%
Log change in housing net worth, 2006-09	0.217*	0.582**	0.241	3.10
	(0.091)	(0.129)	(0.167)	(1.06)
N stores	5,196	16,696	11,929	4,767
N counties	85	562	359	203
R^2	0.009	0.010	0.001	0.011

Elasticity of consumption to housing net worth: Heterogeneity by average age of county

Dependent variable: log change in store-level total sales, 2006-09				
	OLS Age<=44	OLS Age>44	OLS Age>45	OLS Age>46
Log change in housing	0.318**	0.392**	0.459**	0.614**
net worth, 2006-09	(0.051)	(0.073)	(0.086)	(0.117)
N stores	12,290	9,602	6,057	2,987
N counties	308	339	213	116
R^2	0.033	0.016	0.021	0.042

Elasticity of consumption to housing net worth: Effect of unemployment rate

Dependent variables: (1) change in county-level unemployment rate, 2006-09
(2) log change in store-level total sales, 2006-09

	(1) OLS	(1) IV	(2) OLS	(2) IV
Log change in housing net worth, 2006-09	-11.2**	-10.8**	0.182**	0.208
	(0.959)	(1.89)	(0.045)	(0.151)
Change in unemployment rate, 2006-09			-0.012**	-0.011**
			(0.002)	(0.006)
N stores	21,892	18,593	21,892	18,593
N counties	647	519	647	519
R^2	0.407	0.441	0.033	0.032

Summary of key empirical findings

1. Large average elasticity during great recession
2. Not driven by regions with very big house price declines
3. Bigger elasticity with older population
4. About one half of the effect due to contemporaneous changes in labor market

Model

Demographics

- Continuum of finitely lived households
- Work for first J^w periods
- Retired for final J^r periods
- Age dependent moving shock: θ_j

Preferences

- Lifetime utility of household:

$$u(c_i, h_i) = \mathbb{E}_0 \sum_{j=1}^{J} \left\{ \beta^{j-1} U_j(c_{ij}, h_{ij}, \mathcal{Z}_t) \right\} + \beta^J V(b_J)$$

- β : discount factor
- c_{ij} : non-durable consumption
- h_{ij}: consumption of housing services
- U_j: allow for housing and consumption preferences to vary with age and aggregate state $\mathcal{Z}_t$
- V : bequest function
- b_J: bequest

Endowments

- Households receive idiosyncratic income y_{ijt}

$$\log y_{ijt} = w_t + \chi_j + z_{ij} + \nu_{ij}$$

- w_t . aggregate component of income
- χ_j . deterministic common age profile
- z_{ij} : stochastic Markov process that depends on aggregate and idiosyncratic states
- ν_{ij} : idiosyncratic IID shock

Housing

- Households can own or rent
- Finite number of house sizes: $\mathcal{H} = \{h_0, h_1, ..., h_N\}$
- Rented house of size *h* generates housing services of *h*
- Owner-occupied housing generates services $(1+D_t)h$
- Per-unit price of housing p_t^h is stochastic
- Transaction cost for selling a house
- Rental price of housing ρ_t is stochastic

Long-term mortgages

- Mortgages are amortized over remaining life of the household
- Amortized at real interest rate $r_m = r_f + r_w$
- Maximum allowed mortgage: $m \leq \lambda^{LTV} \times p_t^h h$
- Price of mortgage: $q_m(j, b, h, m, l, z; Z)$
- Fixer origination cost: t
- Down payment required is $P_h h - q_m m$
- Household makes $J\text{-}j\text{-}1$ equal payments of size

$$p_m = \frac{r_m m (1 + r_m)^{J-j}}{(1 + r_m)^{(J-j)} - 1}$$

- Remaining principle evolves as $m' = m(1+r_m) - p_m$

Foreclosure and mortgage pricing

- Households can default on their mortgages:
  1. Live in the house that period
  2. Forfeit the house
  3. Incur utility penalty
  4. Excluded from mortgage market for one year

- Mortgage price function $q_m(.)$ determined in equilibrium so that banks make zero expected profit from a loan

- q_m determines the minimum down-payment required in the economy in equilibrium as:

$$\max_m p_t^h h - q_m(b, h, m, z_{ijt}; \mathcal{Z}_t) \times m$$

Home equity lines of credit (HELOC)

- HELOCS are one-period collateralized borrowing:
  1. Price of HELOC: $q_l(j, b, h, m, l, z; Z)$
  2. Maximum allowed HELOC: $l \leq \max\{\lambda^{HELOC}(p_t^h h - m), 0\}$

- HELOCS are defaultable through foreclosure

- HELOC debt is junior to the primary mortgage

- If household defaults, it must default on both HELOC and mortgage

- HELOC rates determined in equilibrium so banks make zero profits

Refinancing

- Households can refinance long-term mortgage at any time, subject to paying origination cost μ_m
- But they are never forced to refinance long-term mortgage
- No requirement that $p_t^h h > m$
- No origination cost for HELOC, but they must repaid each period

Assets

- Households have access to a liquid asset *b*
- Gross return on liquid asset is $R^f = 1/q_f$
- There is no unsecured borrowing in the liquid asset

Production: Consumption Goods

- The final good sector operates a CRS production technology:

$$C_t = Y_t = z_t^c N_t^c$$

- z_t^c : productivity
- N_t^c : labor services

- Competitive sector, implies the wage is given by:

$$w_t = z_t^c$$

Production: Houses

- Housing construction sector has DRS technology:

$$I_t^h = z_t^h \left(N_t^h \right)^{\alpha}, \alpha < 1$$

- Competitive construction firm solves

$$\max_{N_t^h} p_t^h z_t^h \left(N_t^h \right)^{\alpha} - w_t N_t^h$$

Production: Housing

- This implies that investment follows:

$$I^h\left(p_t^h; z_t^h, z_t^c\right) = \left(p_t^h\right)^{\frac{1}{1-\alpha}} \left(z_t^h\right)^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{z_t^c}\right)^{\frac{\alpha}{1-\alpha}}$$

- The housing stocks evolves as:

$$H_t = \left(1-\delta^h\right) H_{t-1} + I^h\left(p_t^h; z_t^h, z_t^c\right)$$

Production: Rental Housing Units

- Rental company can buy and sell houses at price p_t to adjust rental stock H_t^S

- Competitive rental firm solves:

$$\begin{aligned} V\left(H_{t-1}^S\right) &= \max_{x_t} \rho_t H_t^S - p_t x_t - \phi\left(x_t\right) + \beta E\left[V\left(H_t^S\right)\right] \\ & s.t. \\ H_t^S &= \left(1-\delta\right) H_{t-1}^S + x_t \end{aligned}$$

- ρ_t : rental price
- $\phi\left(x_t\right)$: adjustment cost

Aggregate shocks

- Exogenous aggregate state vector: $\mathcal{Z}_t = \{z_t^c, z_t^h, \mathcal{D}_t, \mathcal{K}_t\}$
  - Productivity/income shock: z_t^c
  - Housing supply shock: z_t^h
  - Housing demand shock: D_t
  - Credit shock: K_t

- log Z_t follows a VAR process: $\log \mathcal{Z}_t = A \log \mathcal{Z}_{t-1} + B\eta_t$

- $\eta_t \sim N(0,I)$

- Aggregate state also depends on distribution across households, which determines the house and rental prices

Credit Supply Shock

- Credit supply shock mimics observed features of US mortgage market in late 1990s – early 2000s:
  - Increase in the maximum loan to value ratio allowed
  - Mortgage subsidy for low income households

Government

- Government expenditure *G* are not valued by households
- Retirees receive social security benefits mimicking US system
- Government levies a progressive income tax on households
- Mortgage interest payments are tax deductible

Equilibrium

- Given prices, firms and households maximize

- House and rental prices clear housing and rental markets:

$$(1-\delta^h)H_t + I^h = \int h^O\left(z_t^h, z_t^c, \kappa_t, \phi_t, p_t; s_t\right) d\mu_t + \int h^R\left(z_t^h, z_t^c, \kappa_t, \phi_t, p_t; s_t\right) d\mu_t$$

$$H_t^O + H_t^R = \left(1-\delta^h\right)\left[H_{t-1}^O + H_{t-1}^R\right] + I^h\left(\tilde{p}_t^h; z_t^h, z_t^c\right)$$

- Rent/price relationship satisfies:

$$p_t = \rho_t - \phi\left[1-\beta\left(1-\delta\right)\right] + \beta\left(1-\delta\right)E\left[p_{t+1}\right]$$

Computation

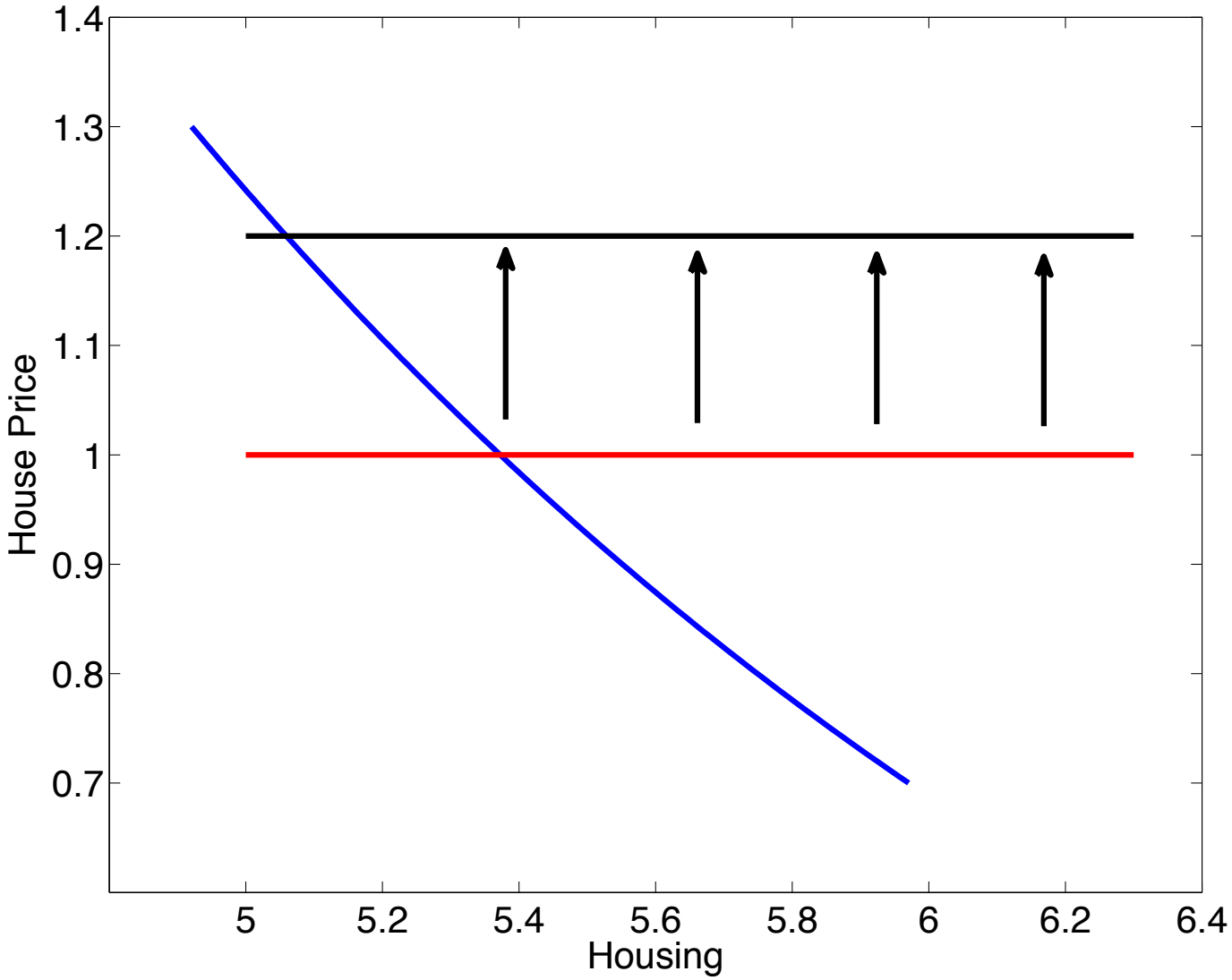
- We approximate the true aggregate state by $(\mathcal{Z}_t, p_t)$

- We conjecture a low of motion for the price:

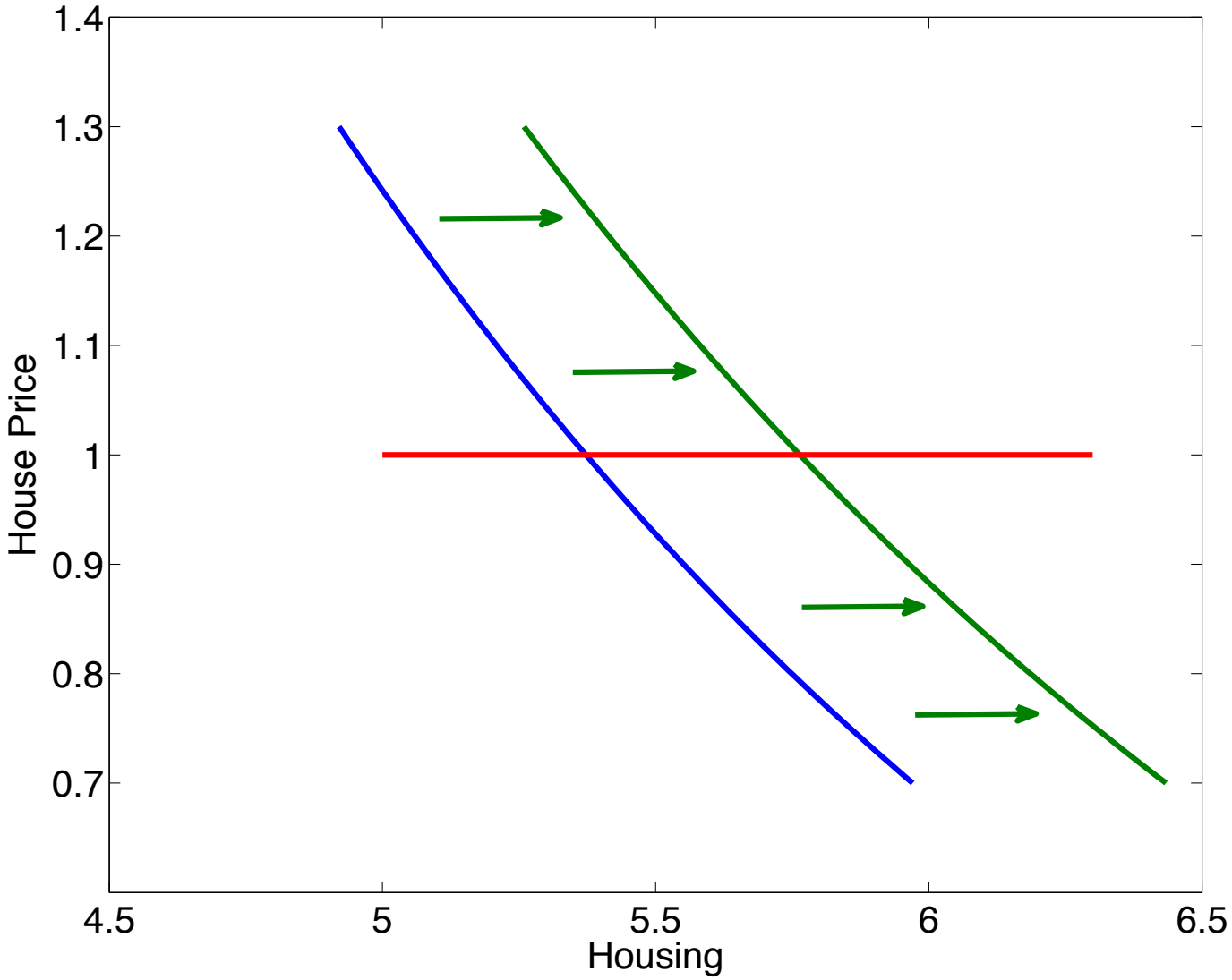
$$\log p^h_{t+1}(p^h_t, \mathcal{Z}_t, \mathcal{Z}_{t+1}) = a_0(\mathcal{Z}_t, \mathcal{Z}_{t+1}) + a_1(\mathcal{Z}_t, \mathcal{Z}_{t+1}) \log p^h_t$$

- Solve HH problem taking price and LOM as given
- Simulate the economy
- Compute excess demand functions period by period and solve for market clearing prices
- Check accuracy of forecast

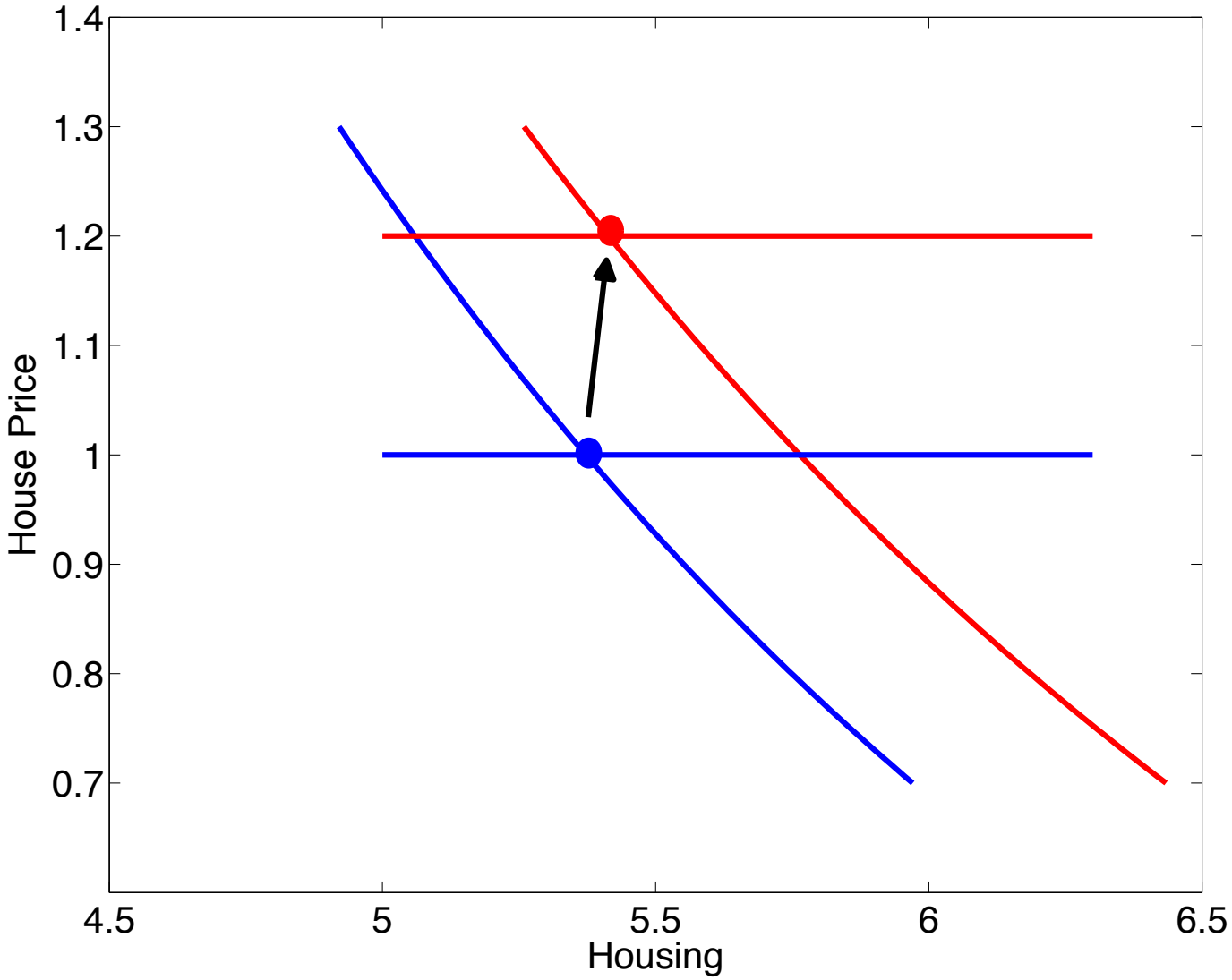
Housing supply shock



Housing demand shock



Correlated supply and demand shocks



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Parameterization

Functional forms

- Utility function is CRRA with CES aggregator over consumption and housing services:

$$U_j(c,h) = \frac{\left(\frac{\alpha c^{\nu} + (1-\alpha)h^{\nu}}{\varphi_j}\right)^{\frac{1-\sigma}{\nu}} - 1}{1-\sigma}$$

- Bequests are luxury goods: DeNardi, French and Jones (2010)

$$v(b) = \psi \frac{(b+\underline{b})^{1-\sigma} - 1}{1-\sigma}$$

- z_{ij} is AR(1)

Aggregate shocks

- Aggregate state follows a random walk with perfectly correlated shocks

- Relative magnitudes:
  - Demand shock set so that a 10% increase in house prices leads to a 3% increase in share of expenditure on housing
  - Income shock set so that a 5% increase in house prices leads to a 1% increase in aggregate income

Parameter values

- Exogenously calibrated:

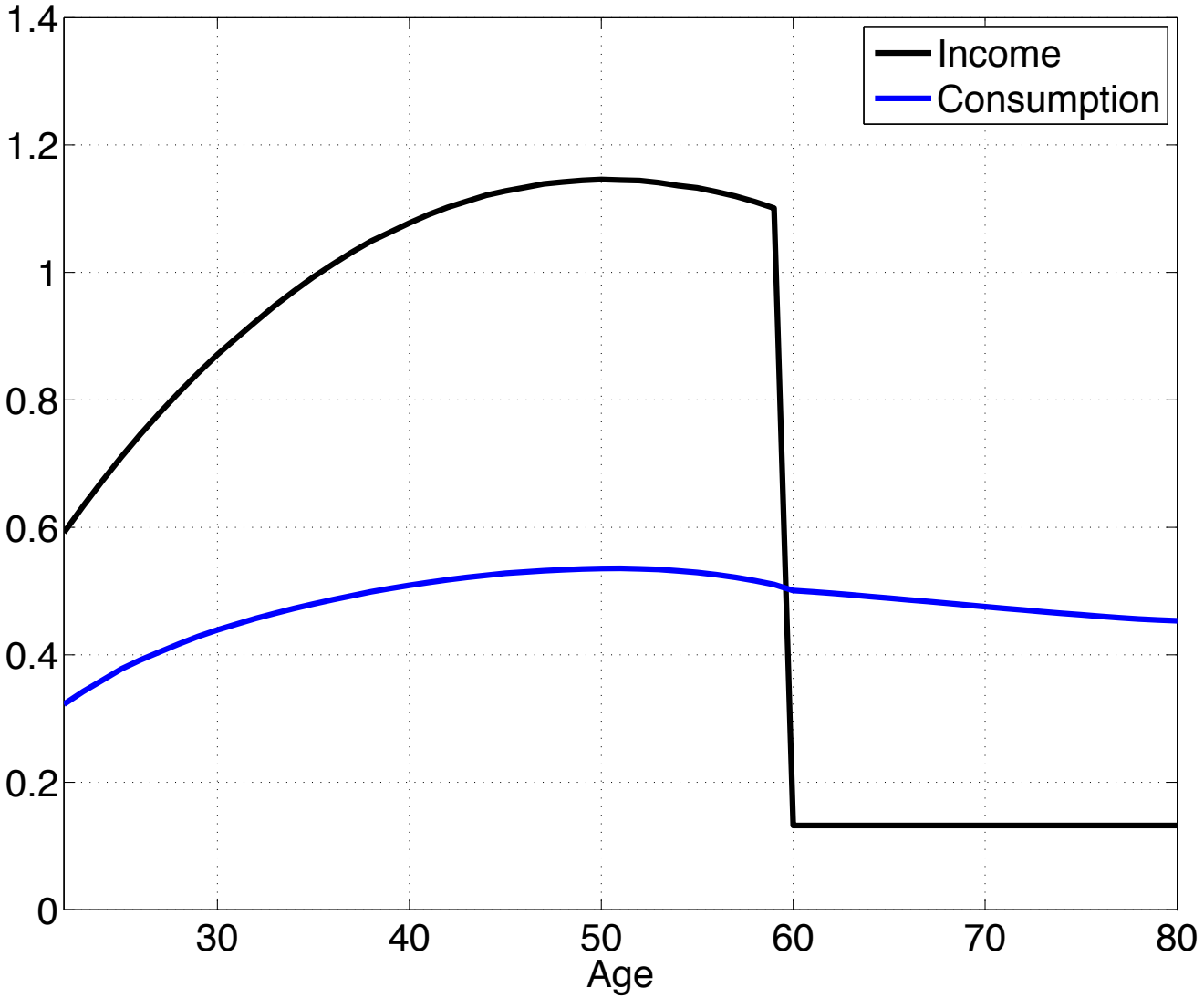
Parameter	Interpretation	Target	Values
σ	Risk aversion	Standard	2
α, ν	CES parameters	Housing share	0.16, 0
θ_j	Age Dependent Moving	Turnover 6%	0.01
φ_j	Household Size	Demographics	$(A+C)^{1/2}$
γ	Foreclosure sale loss	OFHEO	22%
r_f	Risk-free rate	Returns from KV14	3%
$r_m - r_f$	Mortgage wedge	30-yr Mort-10-yr Note	2%
χ, ψ, z, ν	Income process	KV14/PSID	AR(1)
λ^{LTV}	LTV Limit	Conforming-loan limit	0.8
λ^{HELOC}	HELOC Limit		0.95

- Calibrated in the model:

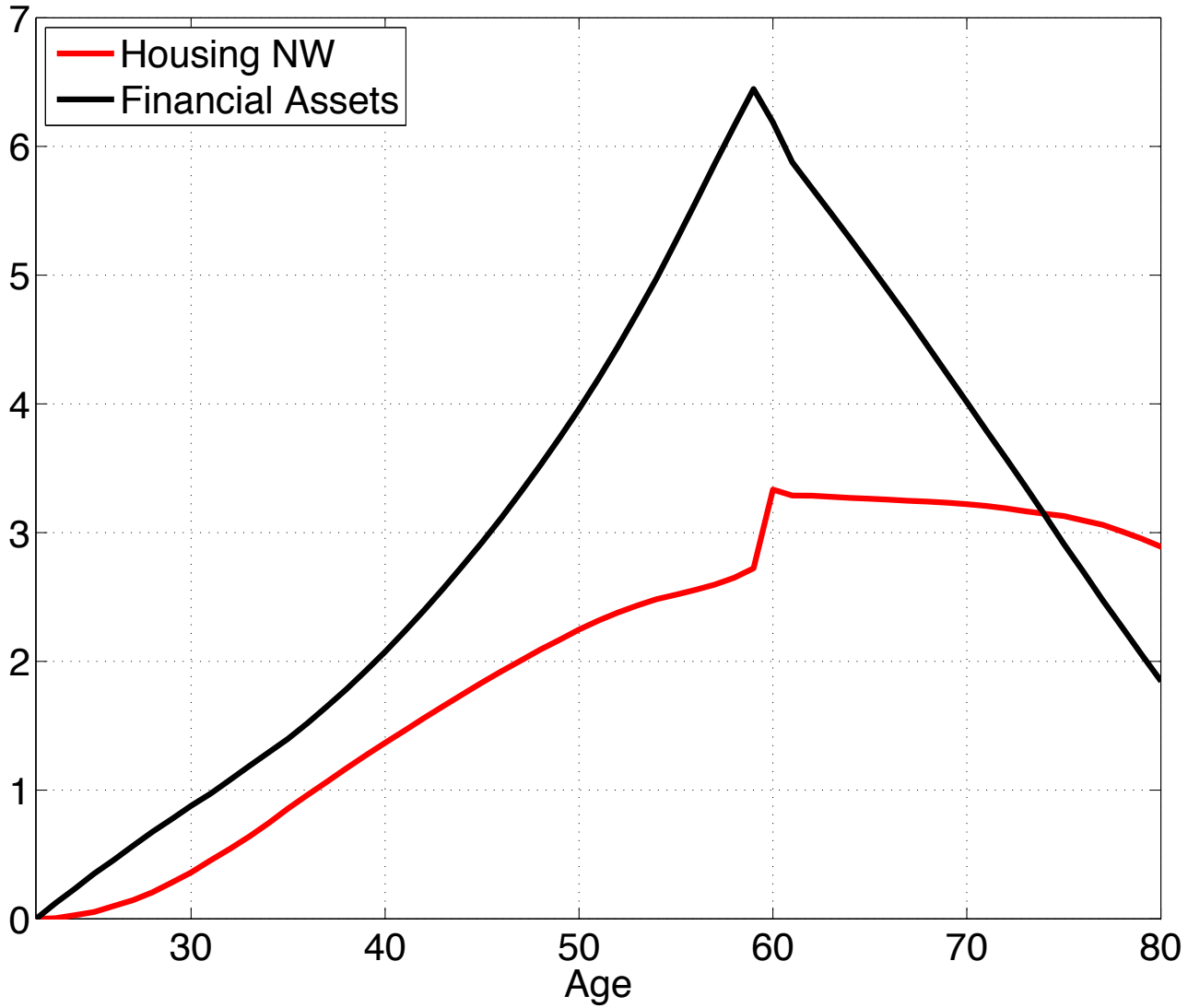
β	Discount factor	Financial assets/income	0.96
ξ	Utility cost of foreclosure	Fore rate 0.5%	3
$\omega(\cdot)$	Utility of ownership	Ownership rate	1.05
$\psi, \underline{b}$	Bequest parameters	Bequest size, fraction	236, \$273K

Lifecycle

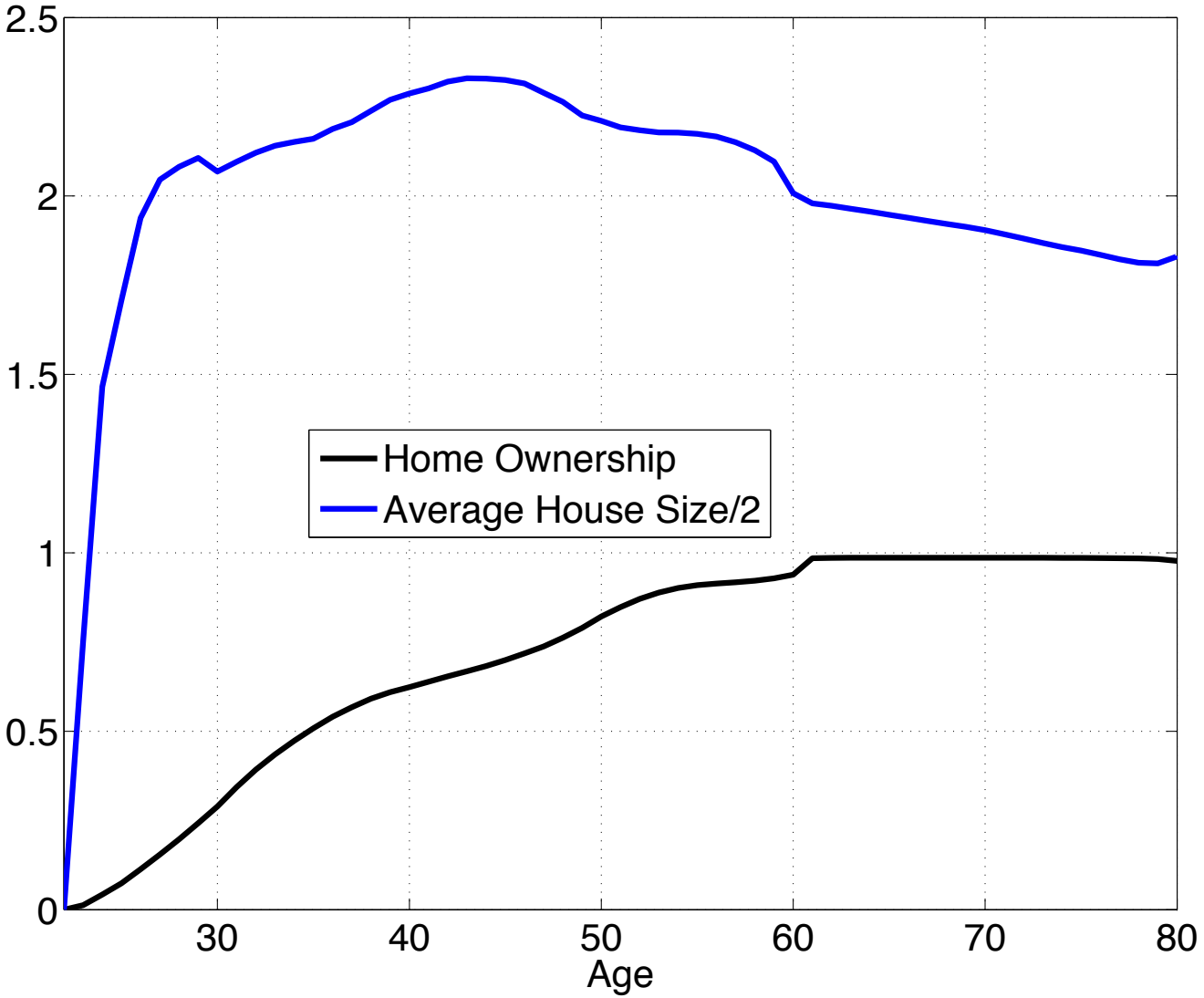
Income and consumption



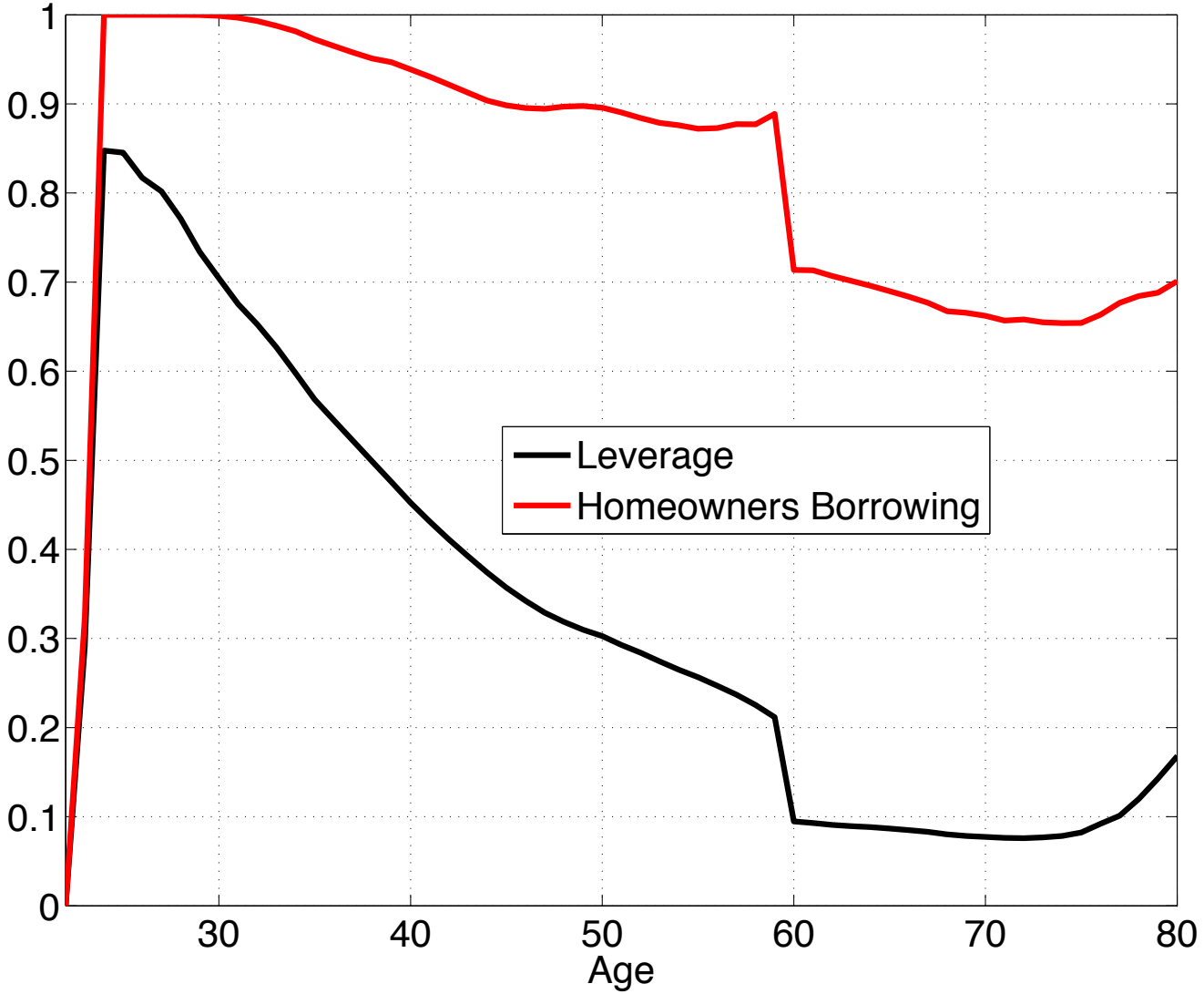
Housing wealth and financial wealth



Housing: intensive and extensive margins



Leverage ratio



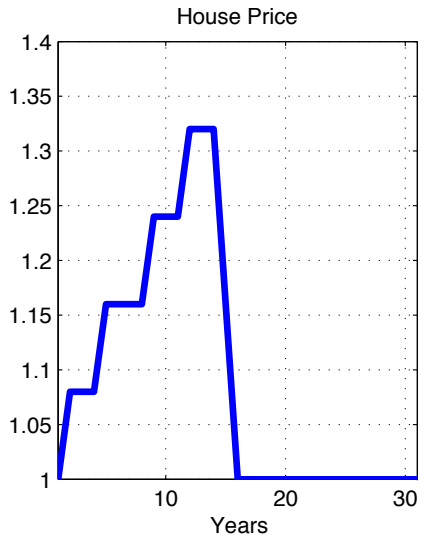
Experiments

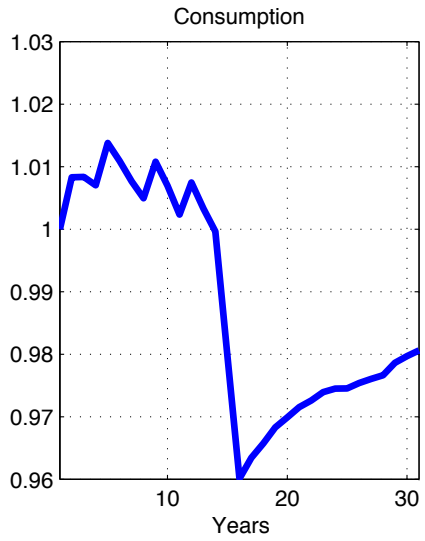
Experiments

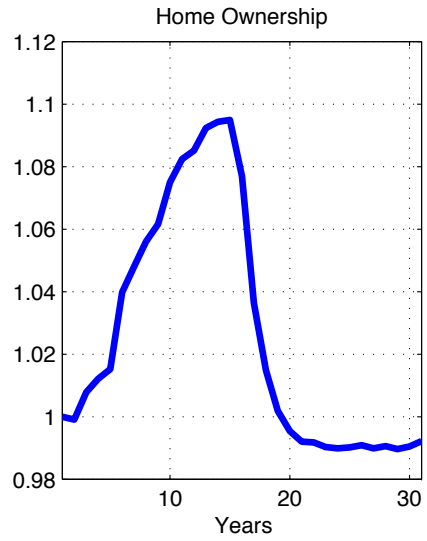
- Engineer a boom bust episode corresponding to 2000's in US
- Target 30% increase in prices over 15 years, collapse over 2 years
- Target 10% increase in home ownership during boom

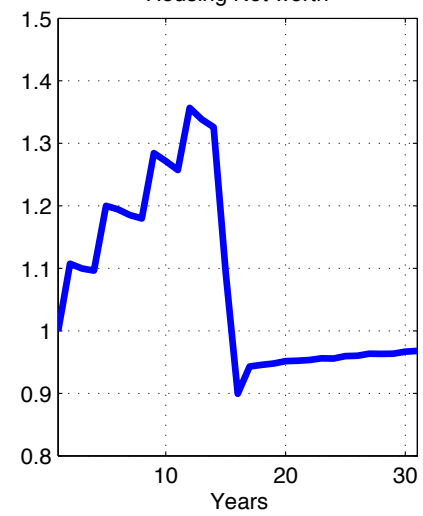
- Examine:
  1. Aggregate dynamics: consumption, leverage, housing demand
  2. Heterogeneity by age and initial leverage
  3. Cross-sectional differences
     (requires different exposure to supply shock)

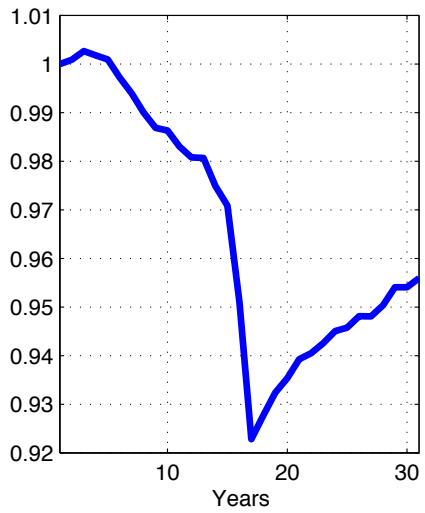
Boom-bust episode

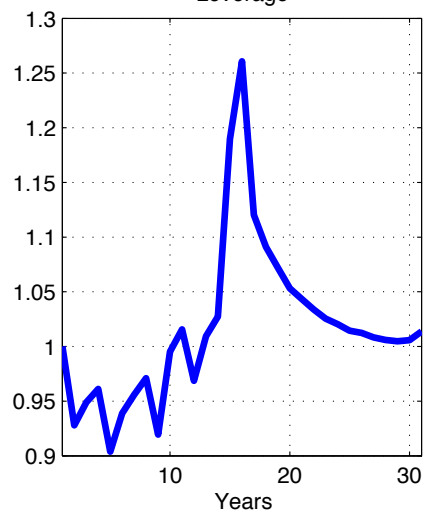








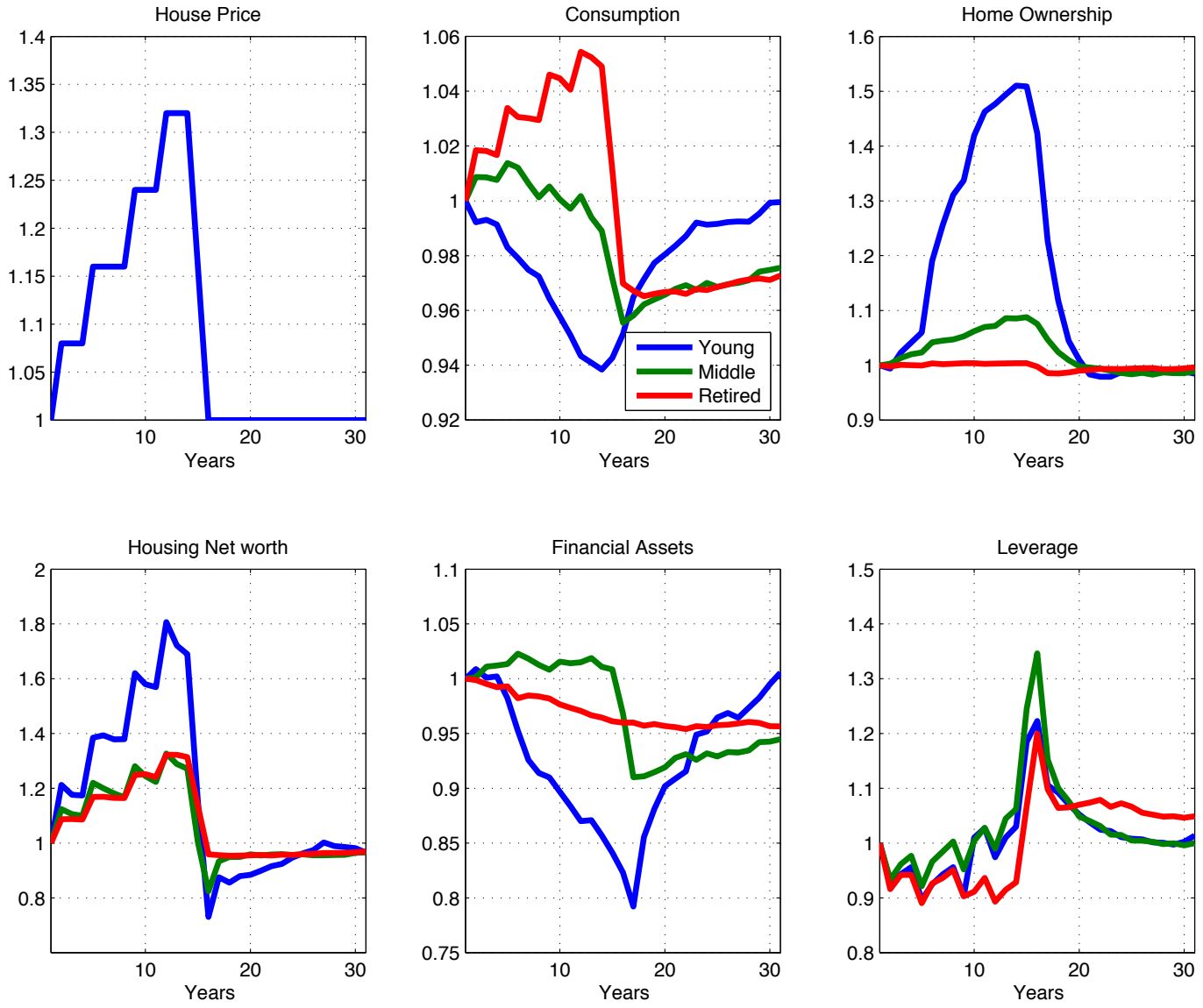




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Consumption and House Prices in the Great Recession
Kaplan, Mitman and Violante (2014)

Boom-bust episode



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Home ownership rates by age

Year	1995	2000	2005	2010
Total	64.7	67.4	68.9	66.9
18 to 25	15.9	21.7	25.7	22.8
25 to 29	34.4	38.1	40.9	36.8
30 to 34	53.1	54.6	56.8	51.6
35 to 39	62.1	65.0	66.6	61.9
40 to 44	68.6	70.6	71.7	67.9
45 to 49	73.7	74.7	75.0	72.0
50 to 54	77.0	78.5	78.3	75.0
55 to 59	78.8	80.4	80.6	77.7
60 to 64	80.3	80.3	81.9	80.4
65 to 69	81.0	83.0	82.8	81.6
70 to 74	80.9	82.6	82.9	82.4
75 years	74.6	77.7	78.4	78.9

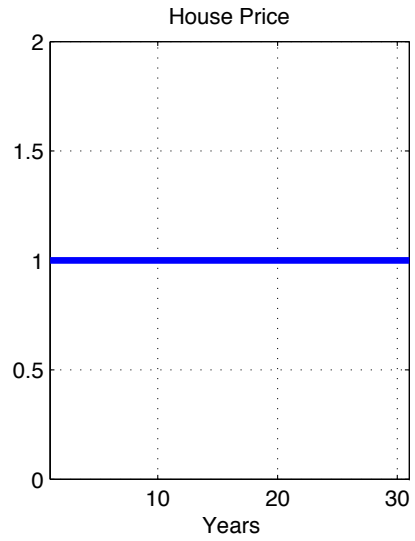
Next steps

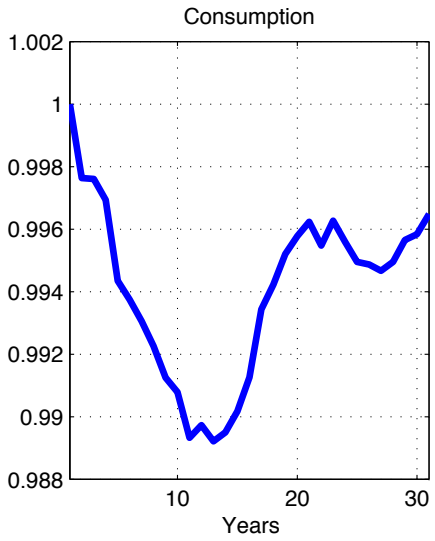
1. Extend empirical analysis
   - Further explore heterogeneity and role of labor market
   - Annual elasticities and elasticity during run-up and recovery

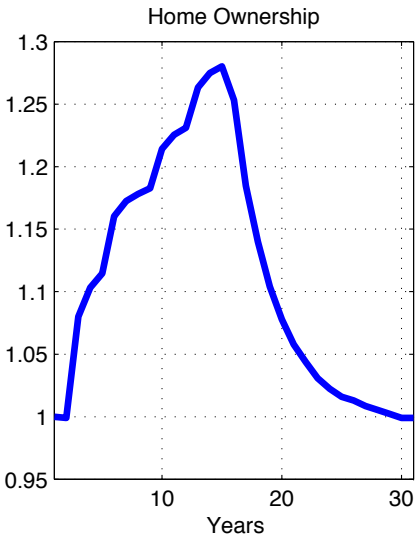
2. Improve model of lifecycle and house price dynamics
   - Too much financial wealth in current calibration
   - Calibrate joint process for house prices and income

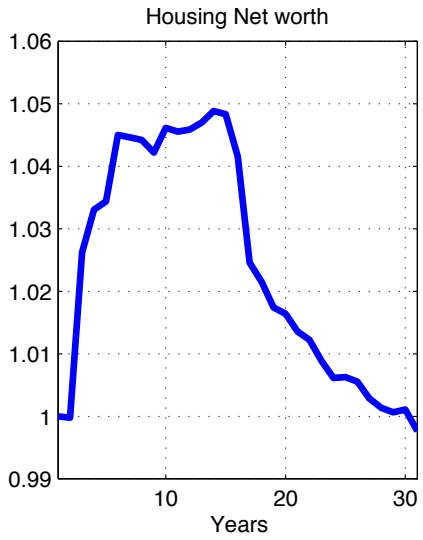
3. Currently all variation in housing net worth shocks comes from leverage and home ownership
   - Introduce heterogeneity in house price response to supply shock
   - Exploit cross-sectional variation to estimate elasticity

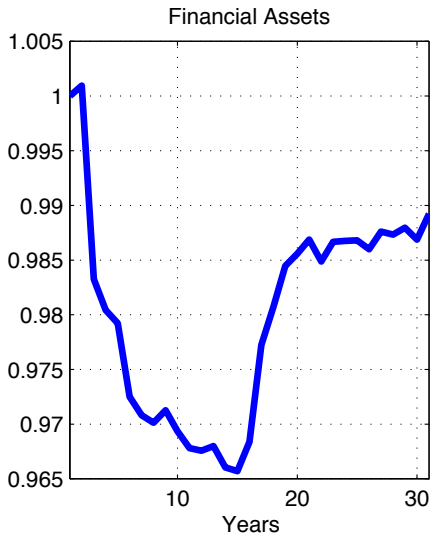
Housing demand shock, no change in prices

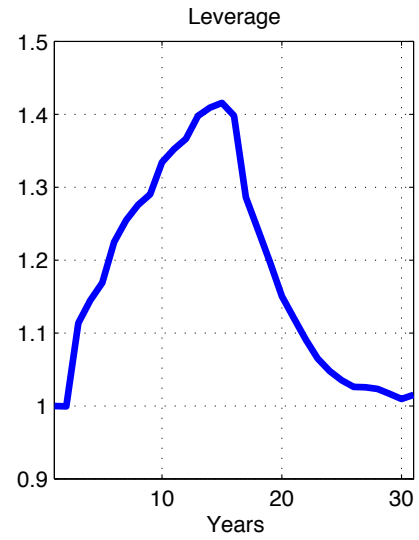








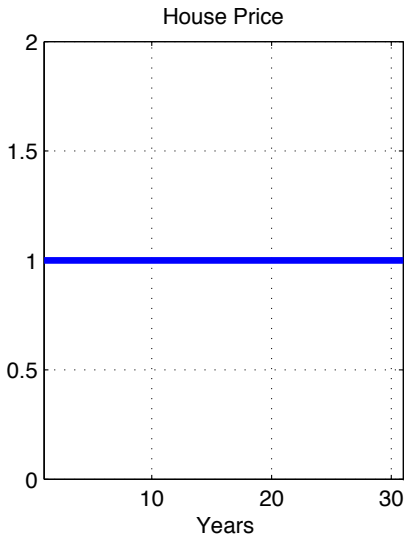


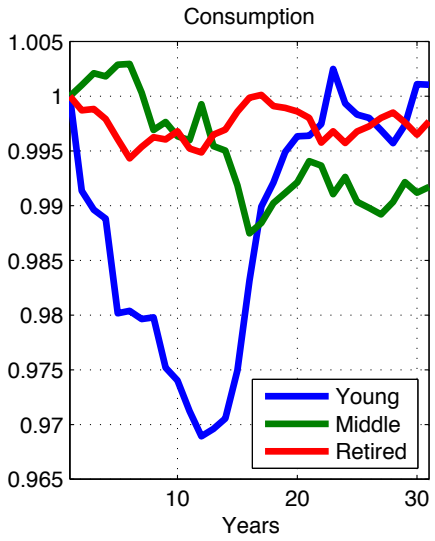


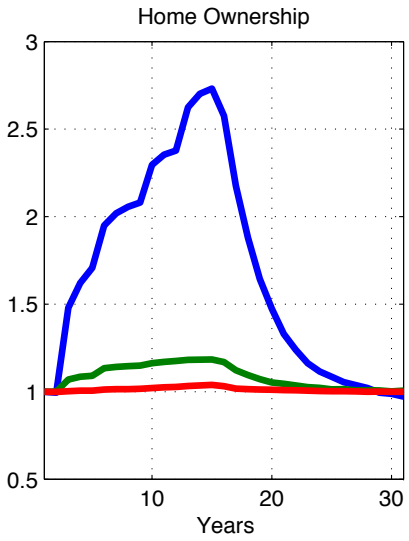
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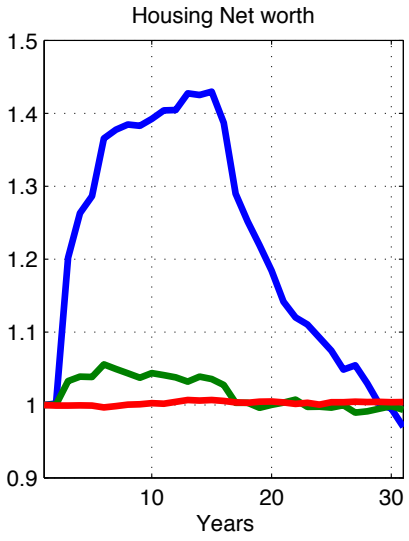
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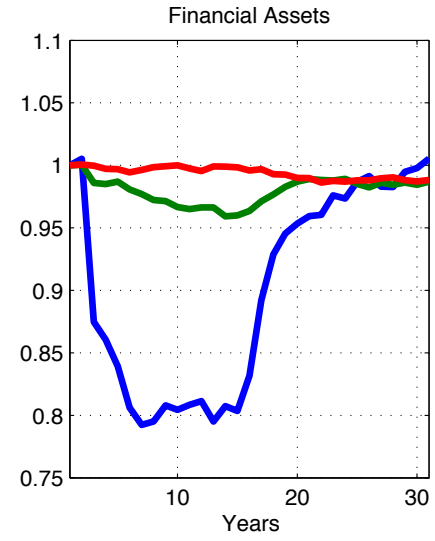
Housing demand shock, no change in prices

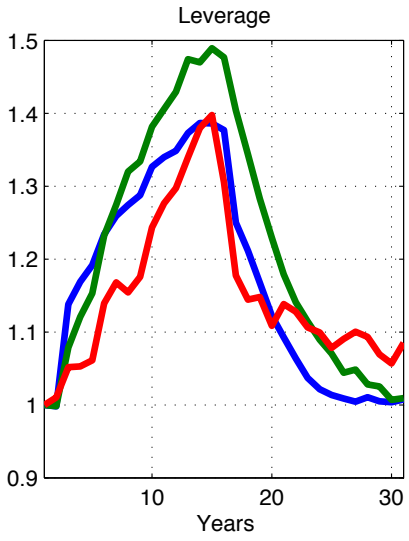












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Consumption and House Prices in the Great Recession
Kaplan, Mitman and Violante (2014)

Related models

- Quantitative models of housing with long-term mortgages:
  - Closest in terms of modelling model:

    Attanasio, Botazzi, Low, Nesheim and Wakefield (2012)

  - Chen, Michau and Roussanov (2013) (not lifecycle)
  - Hatchondo, Martinez and Sanchez (2014)

- Innovation in mortgage market and how it relates to foreclusre
  - Corbae and Quintin (2014)
  - Burcu and Chatterjee (2014)