Do Credit Conditions Move House Prices?

Daniel Greenwald[1] Adam Guren[2]

[1]MIT Sloan

[2]Boston University

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Do Credit Conditions Move House Prices?

- What role did credit play in the housing boom and bust?
  - Key to design of macroprudential policy.
- Divergent views in literature. Two prominent examples:
  - Faviliukis-Ludvigson-Van Nieuwerburgh: Credit explains most (60%) of movement in prices.
  - Kaplan-Mitman-Violante: Credit had virtually no effect on prices.
- Key difference: Extent to which **credit insensitive** agents absorb credit-driven demand.
  - Depends on degree of **segmentation** in housing markets.
- Clearest in **rental market**, where two polar assumptions are often used:
  - **Perfectly segmented**: Fixed homeownership rate. Credit $\rightarrow$ demand $\rightarrow$ prices (e.g., FLVN).
  - **Perfectly frictionless**: Deep-pocketed landlords who do not use credit. When credit loosens, renters buy from their landlord, prices pinned down by PV of rents (e.g., KMV).
- **Unconstrained savers** can play similar role unless their housing is segmented.

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What We Do In This Paper

- **Main Question:** How sensitive are house prices to credit standards and interest rates?
- **Approach:** Tractable macro-housing framework + novel empirical estimates.
  - **Introduce model** with arbitrary degree of segmentation through heterogeneity, nesting polar cases.
  - **New empirical moment for calibration**: Relative causal elasticity of price-rent and homeownership to credit supply shock is sufficient statistic for degree of segmentation.
  - **Calibrate model** to match empirical findings, then decompose boom-bust.
- **Main Findings:**
  - Price-rent ratio responds at least $5\times$ more to identified credit shock than homeownership.
  - Change in credit standards as in 2000s explains **28% to 47%** of price-rent rise.
  - Responses closer to full segmentation (**38% to 60%**) than under frictionless market (**0% to 8%**).

Literature Review

- **Credit in the Boom-Bust:** Favilukis Ludvigson Van Nieuwerburgh (2017), Garriga Hedlund (2017, 2018), Garriga Manuelli Peralta-Alva (2019), Greenwald (2018), Guren Krishnamurthy McQuade (2018), Justiniano Primiceri Tambalotti (2015, 2018), Kaplan Mitman Violante (2019), Kiyotaki Michaelides Nikolov (2011), Landvoigt, Piazzesi, and Schneider (2015).

  Here: Common framework to resolve disparate results.

- **Empirical Credit Elasticities:** Adelino Schoar Severino (2012), Glaeser Gottlieb Gyourko (2012) Favara Imbs (2015), Di Maggio Kermani (2017).

  Here: Focus on homeownership rate as key response variable (alongside price).

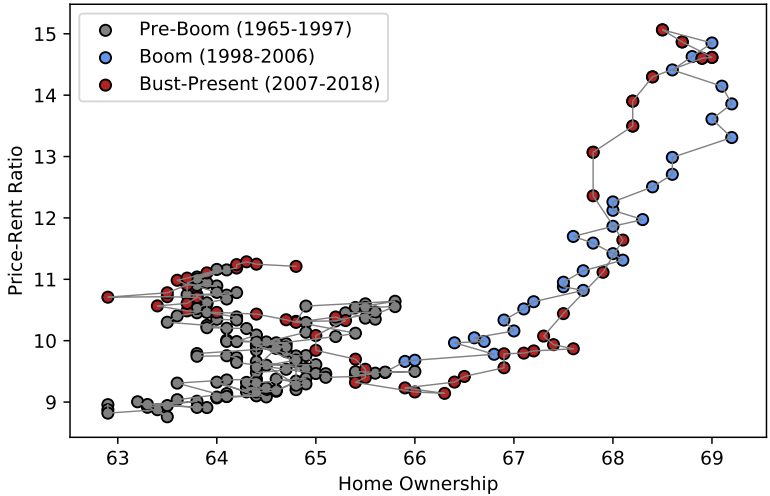
- **Housing DSGE Models:** Campbell, Hercowitz (2005), Eggertsson, Krugman (2012), Garriga, Kydland, Sustek (2015), Ghent (2012), Kiyotaki, Moore (1997), Iacoviello (2005), Iacoviello, Neri (2011), Liu, Wang, Zha (2013), Monacelli (2008), Rognlie, Shleifer, Simsek (2015).

  Here: Tractable model to capture joint dynamics of homeownership and credit.

Outline

- Intuition: Modified Supply and Demand
- Empirics: Estimate Sensitivity
  - Data and Empirical Approach
  - Estimation Results
- Theory: Quantify Impact
  - Calibrated Model: Focus on Rental Markets
  - Quantitative Results
  - Model Extensions: (i) landlord credit, (ii) saver housing demand.

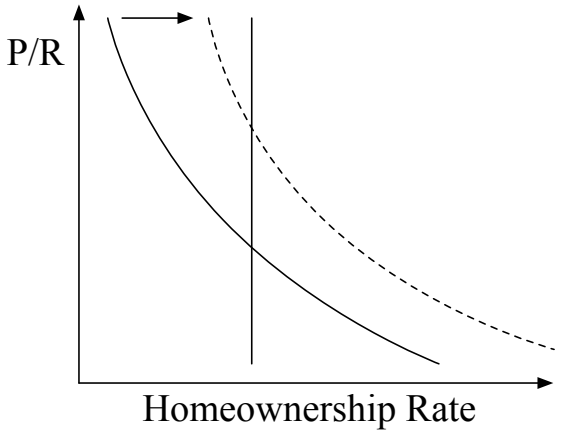
Time Series: Price-Rent Ratio vs. Home Ownership Rate



National data. Price/Rent: Flow of Funds. Homeownership: Census.

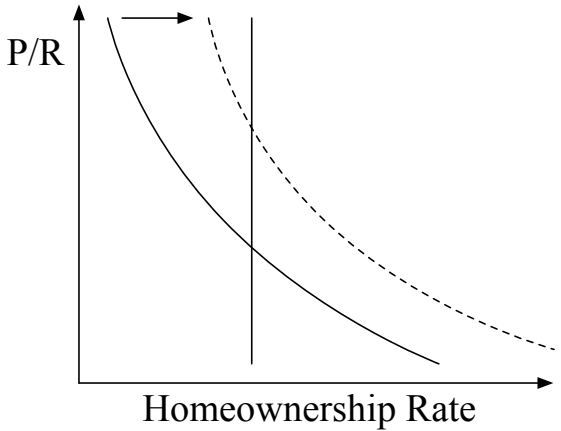
Intuition: Modified Supply and Demand

- Plot demand for owner-occupied housing against supply (willingness of landlords to sell).
  - Why price-rent ratio and homeownership rate? Robust to changes in housing stock.



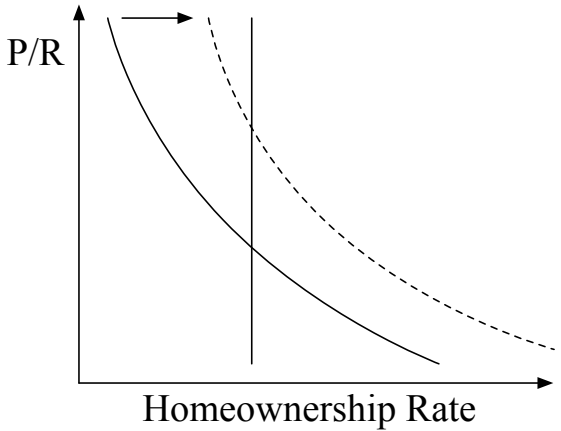
Intuition: Modified Supply and Demand

- Credit expansion: Demand for owner-occupied housing shifts right.



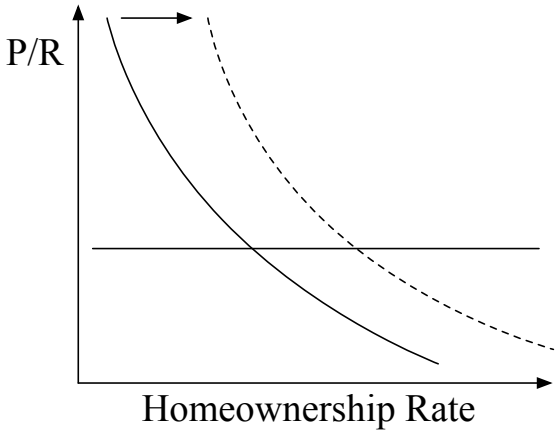
Intuition: Modified Supply and Demand

- Fixed supply $\Longrightarrow$ all adjustment through increase in price-rent ratio.



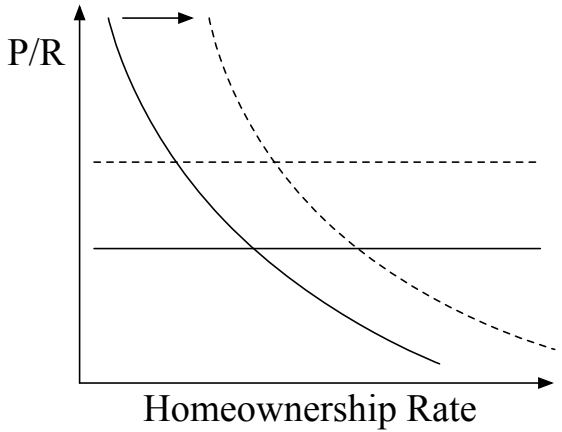
Intuition: Modified Supply and Demand

- Perfect rental market $\Longrightarrow$ all adjustment through homeownership rate.



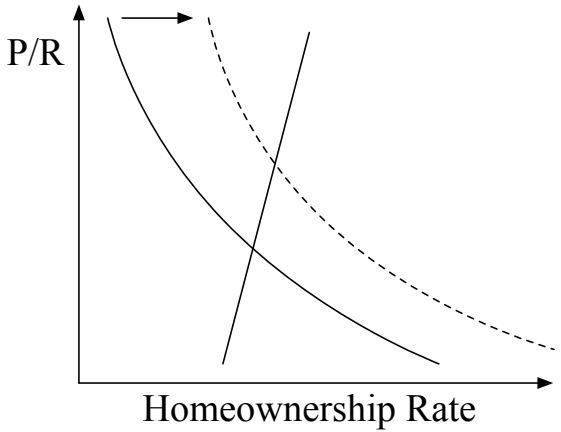
Intuition: Modified Supply and Demand

- In this world, increase in price-rent requires **separate** shock to supply.
  - E.g., Change in expectations about future price/rent.



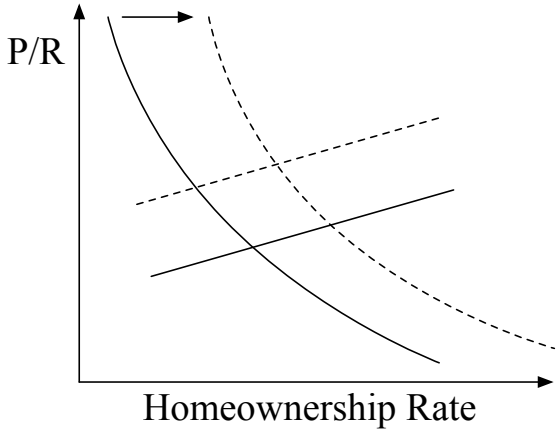
Intuition: Modified Supply and Demand

- Alternative view: credit expansion + **upward sloping supply** (imperfect rental market).



Intuition: Modified Supply and Demand

- Any intermediate combination of upward sloping supply and supply shift also possible.
  - To separate role of credit from other shocks, need a way to **identify slope** of supply curve.



Data

- CBSA-Level Panel 1990-2017
- Prices: CoreLogic Repeat Sale HPI
- Rents: CBRE Economic Advisors Torto-Wheaton Index (CBSA)
  - High-quality repeat sale rent index for multi-family (single family index behaves similarly).
  - Measures rent commanded by newly rented unit.
- Homeownership Rate: Census Housing and Vacancy Survey
  - CBSA definitions change over time. Drop periods where definitions change.
  - Use state data with fixed definitions as robustness check.
- Credit: HMDA
  - Following Favara-Imbs, use no. of loans, dollar volume of loans, loan/income ratio (IRS).

Empirical Approach

- Credit shock: Loutskina and Strahan (2015)
  - CLL: Max value loan that receives GSE subsidy, for most part changes nation-wide.
  - Idea: Change in conforming loan limit has more bite in cities with more homes near CLL.
  - Instrument: Interaction of frac. originations within 5% of CLL at $t-1$ with % change in CLL.
  - Bartik-Style Identifying Assumption: No non-credit shock that varies with CLL in time series and affects more exposed cities in cross section.

- Specification:

$$\log(outcome_{i,t+k}) = \xi_i + \psi_t + \beta_k \Delta \log(\widehat{credit}_{i,t}) + \theta X_{i,t} + \epsilon_{i,t}$$

$$\Delta \log(credit_{i,t}) = \phi_i + \chi_t + \gamma Fraction_{i,t-1} \times \%\Delta CLL_t + \omega X_{i,t} + e_{i,t}$$

where common controls X_t include $Fraction_{i,t-1}$ and its interaction with Saiz elasticity, lags of instrument and credit variable.

Regression Results: Price-Rent Ratio

- Significant response of PRR, insignificant response of HOR.
- Point estimate: PRR responds $5\times$ as much

	$\Delta \log$(Price/Rent)			$\Delta \log$(Homeownership Rate)		
$\Delta \log$(# Loans)	0.152*			0.032		
	(0.086)			(0.068)		
$\Delta \log$(Vol. Loans)		0.116*			0.027	
		(0.071)			(0.058)	
$\Delta \log$(Loan/Income)			0.142*			0.027
			(0.075)			(0.065)
N	1404	1404	6940	1404	1404	1346

Impulse Response: Credit Shock (Panel Local Projection IV)

$$\log(outcome_{i,t+k}) = \xi_i + \psi_t + \beta_k \Delta \log(credit_{i,t}) + \theta X_{i,t} + \epsilon_{i,t}$$

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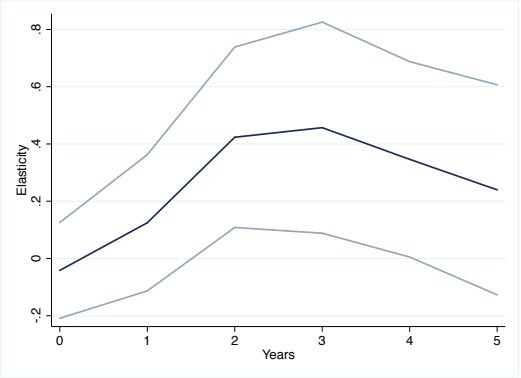
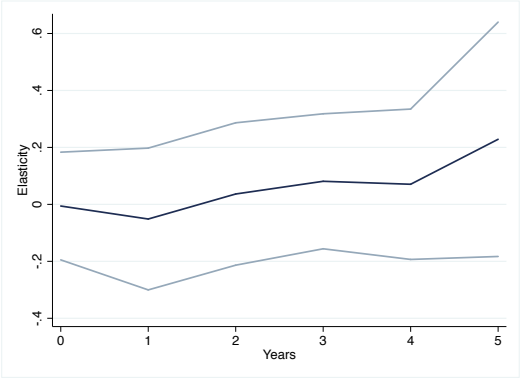


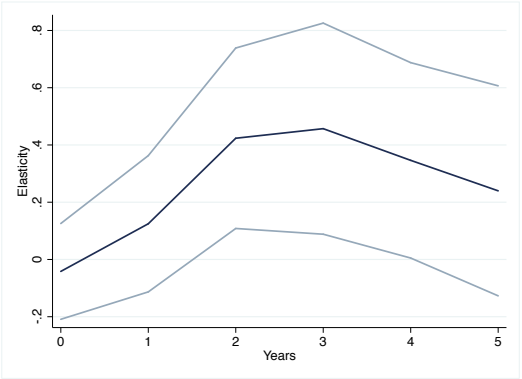
(a) Price/Rent



(b) Homeownership Rate

Impulse Response: Credit Shock (Panel Local Projection IV)

- Price-rent ratio hits 0.46 after three years, compared to 0.07 for HOR.
- PR ratio combination of price increase ($\sim$ 70% peak) and rent increase ($\sim$ 20% peak).



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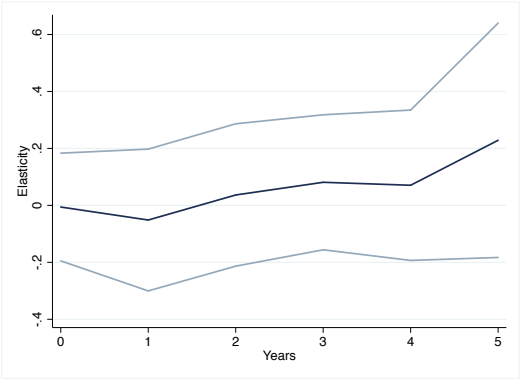
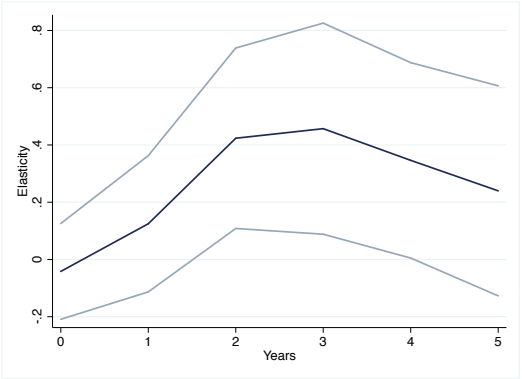


(b) Homeownership Rate

Impulse Response: Credit Shock (Panel Local Projection IV)

- Use 5× **ratio** as calibration target to pin down supply elasticity (slope).
- Alt. instrument based on Non-Core Liabilities (Mian + Sufi, 2019) yields similar ratio. Results



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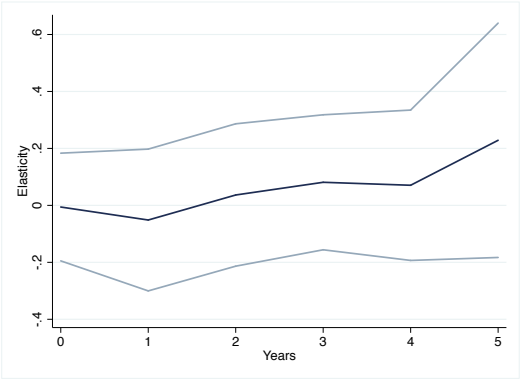

(b) Homeownership Rate

Model Overview

- Adaptation of Greenwald (2018) to allow endogenous rental market.
- Endowment economy, endogenous construction, divisible housing.
- Credit + rental market $\Longrightarrow$ borrowers (B), landlords (L), savers (S).
- Realistic mortgages $\Longrightarrow$ long term, fixed-rate, prepay at exogenous rate.
- Main modeling innovation: **borrower and landlord heterogeneity**.

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Agents and Prefs | Mortgage Technology | Borrower Problem

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  - Complete intratype insurance $\implies$ rep agent for each type.
  - Borrowers own or rent from landlord, borrow from saver.
  - Savers only own, have fixed housing demand (segmented saver market).
  - Landlords risk neutral and deep-pocketed.
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- Realistic mortgages $\implies$ long term, fixed-rate, prepay at exogenous rate.
  - Loan-to-value (LTV) and payment-to-income (PTI) limits at origination only.
- Main modeling innovation: **borrower and landlord heterogeneity**.

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- Endowment economy, endogenous construction, divisible housing.
- Credit + rental market $\implies$ borrowers (B), landlords (L), savers (S).
- Realistic mortgages $\implies$ long term, fixed-rate, prepay at exogenous rate.
- Main modeling innovation: **borrower and landlord heterogeneity**.
  - Without any heterogeneity, 0% or 100% home ownership.
  - How heterogeneity falls on borrowers vs. landlords determines slope of demand vs. supply.

Heterogeneity

- Implementation of borrower and landlord heterogeneity:
  - Borrower i gets additional benefit $\omega^B_{i,t} H_{i,t}$ from ownership, where $\omega^B_{i,t} \overset{iid}{\sim} \Gamma_{\omega,B}$.
  - Landlords get additional benefit $\omega^L_{j,t} H_{j,t}$ from ownership for property j, where $\omega^L_{j,t} \overset{iid}{\sim} \Gamma_{\omega,L}$.
  - Implicit assumption: New construction has same dist of "rentability" as existing stock.
- Borrower interpretation: Variation in life cycle, preferences, ability to come up with down payment, etc.
- Landlord interpretation: Variation in rental suitability by property/geography.
- Owned housing is reallocated to best suited agents: Own if $\omega^j_{i,t} \geq \bar{\omega}^j_t$.

Model Solution

▸ Landlord's Problem ▸ Saver's Problem

- Key optimality conditions from borrower and landlord housing FOC ($\mathcal{C}_t = \mu_t F_t^{LTV} \theta_t^{LTV}$):

$$p_t^{\text{Demand}} = \underbrace{\Big(1 - \mathcal{C}_t\Big)^{-1}}_{\text{credit conditions}} E_t\Bigg\{\Lambda_{t+1}^B\Bigg[\underbrace{\bar{\omega}_t^B + \text{rent}_{t+1}}_{\text{housing services}} + \underbrace{\Big(1 - \delta - (1-\rho_{t+1})\mathcal{C}_{t+1}\Big)p_{t+1}}_{\text{continuation value}}\Bigg]\Bigg\}$$

$$p_t^{\text{Supply}} = E_t\Bigg\{\Lambda_{t+1}^L\Bigg[\underbrace{\bar{\omega}_t^L + \text{rent}_{t+1}}_{\text{housing services}} + \underbrace{\Big(1-\delta\Big)p_{t+1}}_{\text{continuation value}}\Bigg]\Bigg\}$$

- At equilibrium, $(\bar{\omega}_t^B, \bar{\omega}_t^L)$ ensure $p_t^{\text{Demand}} = p_t^{\text{Supply}}$ and $H_t^B + H_t^L = \bar{H}_t$, where

$$H_t^B = \Big(1 - \Gamma_\omega^B(\bar{\omega}_t^B)\Big)\bar{H}_t, \qquad H_t^L = \Big(1 - \Gamma_\omega^L(\bar{\omega}_t^L)\Big)\bar{H}_t$$

- Key param: dispersion of Γ_ω^L distribution (more dispersed $\implies$ more inelastic supply).

Calibration Strategy

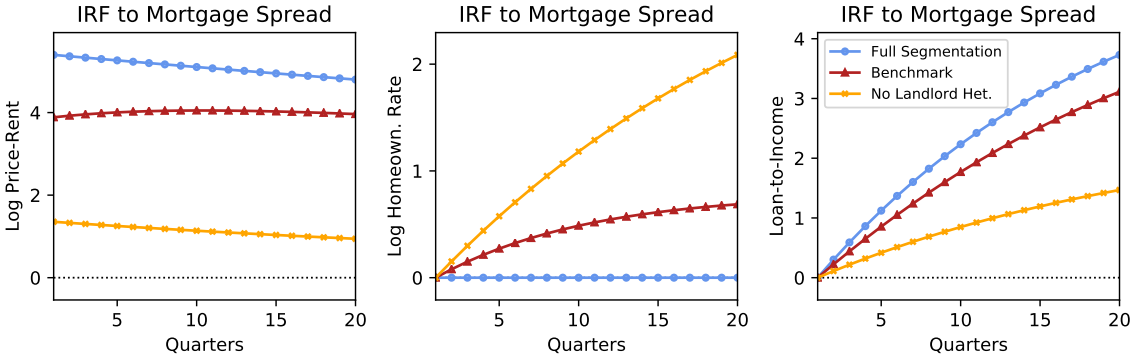
▸ Parameter Values

- Most parameters: Match external calibration targets or standard parameters.
  - Borrower pop and income shares, utility, construction, depreciation, taxes, etc.
- Landlord heterogeneity: Match relative causal effect of credit on price-rent and homeownership.
- Borrower patience controls extent to which demand shifts when credit changes.
  - Intuition: More impatience, more latent demand for credit.
  - Calibrate β_B using private mortgage insurance pricing: indifferent between receiving 80% LTV loan and paying for FHA insurance at 95% LTV.
- Landlord patience equal to borrower (agnostic on effect of expectations on homeownership).
- Sensitivity analysis shows other parameters not important once we recalibrate rest of model.

Calibration: Supply Elasticity

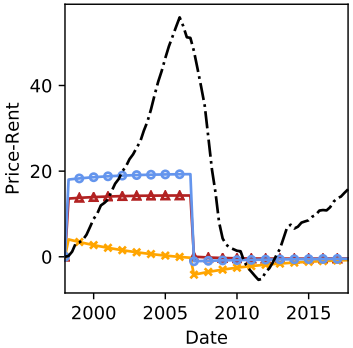
Identification

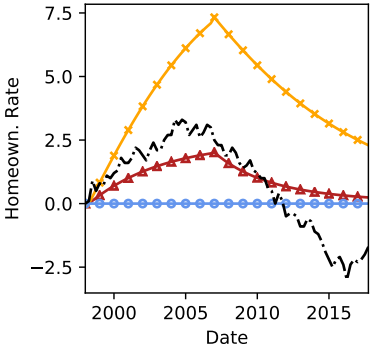
- Model change in CLL as shock (↓ 100bp) to real mortgage spreads for borrowers.
- Choose dispersion of Γ_ω^L to ensure 5x larger price-rent vs. homeownership response.
  - Requires substantial deviation from frictionless rental markets (no landlord heterogeneity).

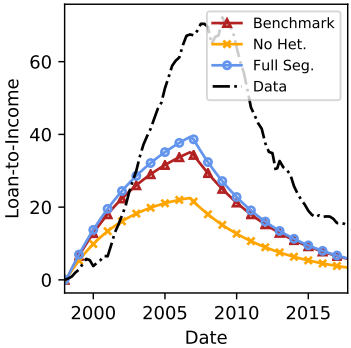


Credit Expansion Experiment

- Credit expansion: Increase max LTV from 85% to 99%, max PTI from 36% to 65%.
- Start in 1998 Q1, surprise reversal in 2007 Q1, compute nonlinear perfect foresight paths.

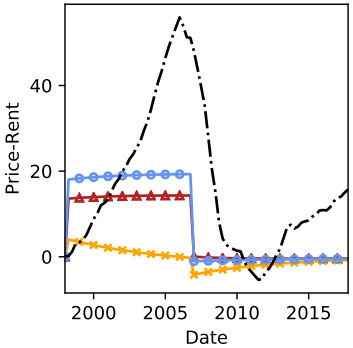


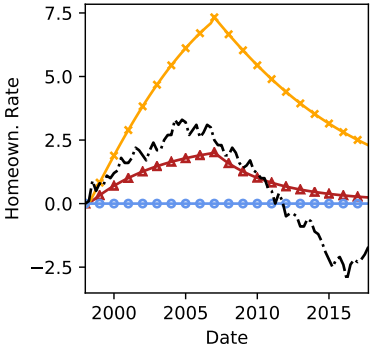


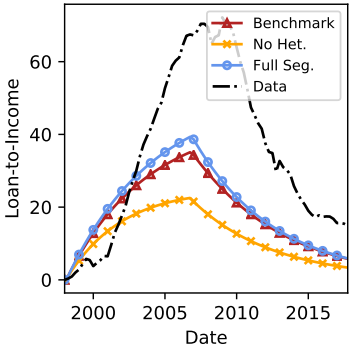


Credit Expansion Experiment

- Benchmark: Credit explains **28%** of peak price-rent increase, **52%** of peak LTI increase.
- No het. (frictionless): Credit explains **0%** of price-rent, only **33%** of peak LTI increase.

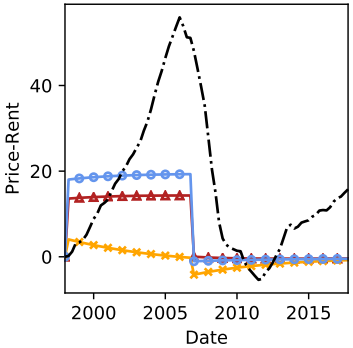


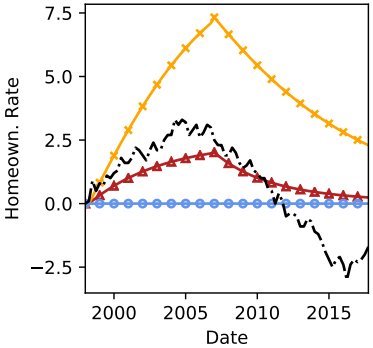


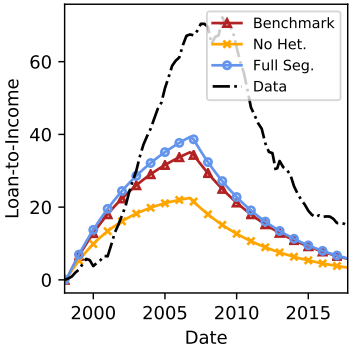


Credit Expansion Experiment

- Benchmark closer to complete segmentation: **38%** of price-rent, **58%** of peak LTI increase.
- But Benchmark allows for nontrivial movement in homeownership.

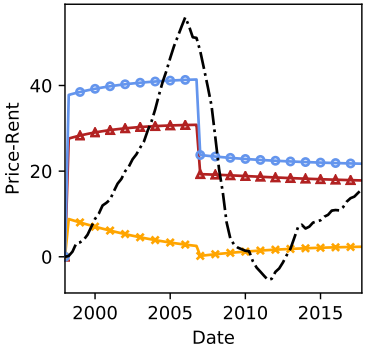


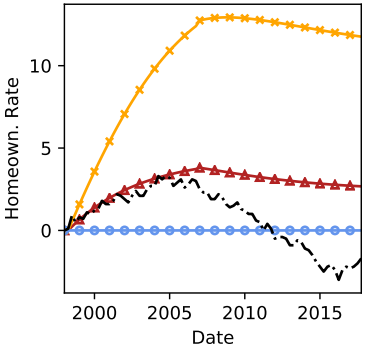


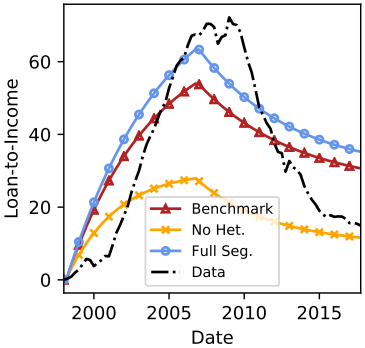


Credit Expansion Experiment

- Adding 2ppt drop in mortgage rates, we can explain **60%** of the rise in price-to-rent ratios and **80%** of the rise in loan-to-income ratios.
- Contrast to **5%** of rise in price-rent ratios and **41%** of rise in LTI under no landlord heterog.



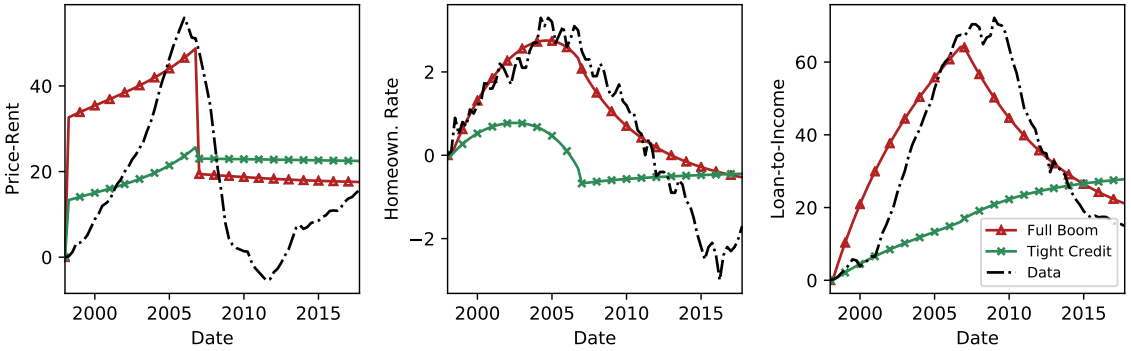




Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ Low β_L

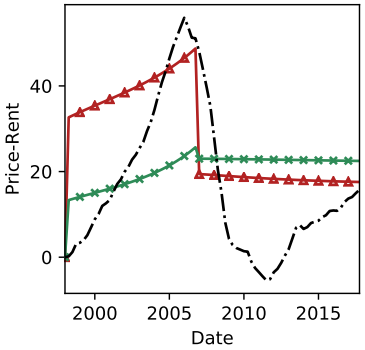
- Add observed fall in interest rates, then set house price expectations (expected rental growth) to explain entire boom in price-rent ratio and credit growth (expect $\xi \uparrow 30\%$).
- To capture bust, return credit limits to baseline, apply (i) 3% fall in mortgage rates and landlord discount rates; (ii) exclude 10% of borrowers from credit market.

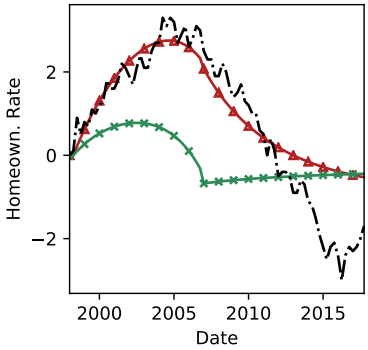


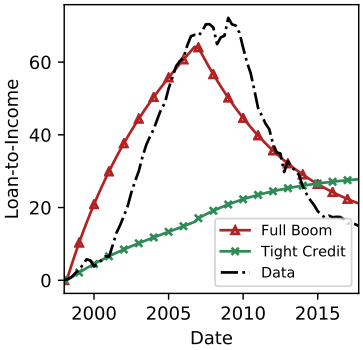
Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ Low β_L

- Now **removing** credit expansion kills **47%** of boom in price-rent, **75%** of boom in LTI.
- Implies macroprudential, monetary policy can be effective at limiting house price booms.



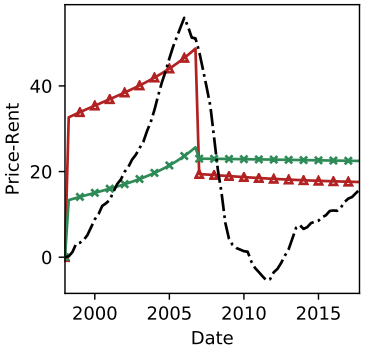


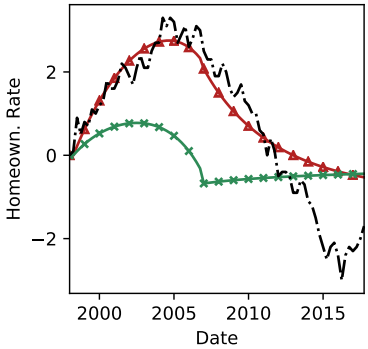


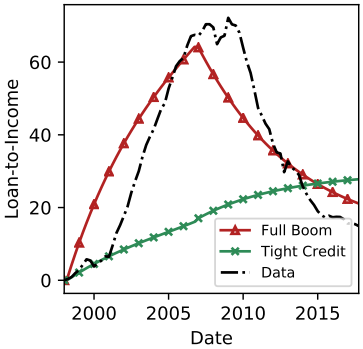
Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ Low β_L

- Why does order credit is added/removed matter?
  - Loose credit amplifies low rate + expectation effects on demand.
  - PTI limits especially effective at dampening overoptimism.

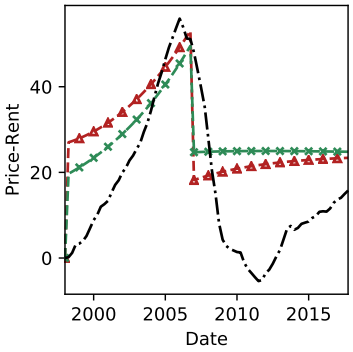


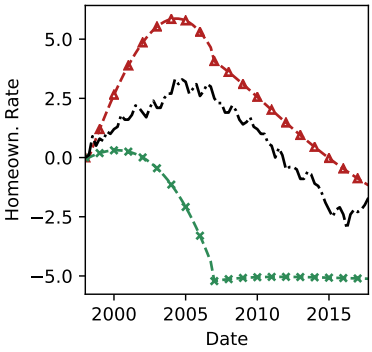


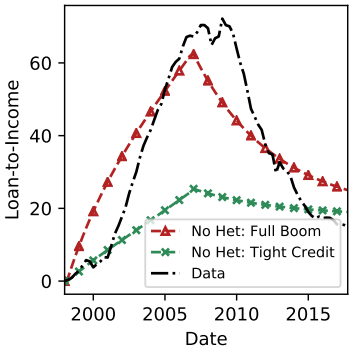


Boom Counterfactuals: No Heterogeneity

- Similar experiment under frictionless "No Heterogeneity" model also fits boom well.
- But in this world, tight credit (macroprudential policy) has no effect on prices.
  - Monetary policy would be similarly ineffective. Plots

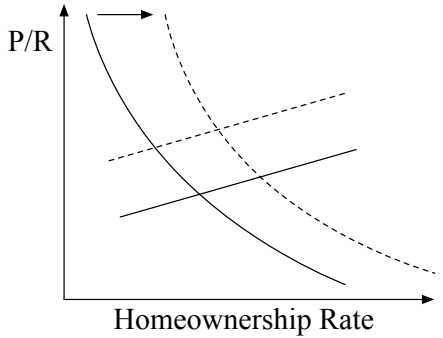






Model Extensions: Landlord Credit

- So far, have assumed landlords don't use credit.
- If landlords used credit, expansion would cause shift in the supply curve.
  - Alternative explanation for concurrent rise in price-rent and homeownership.



Model Extensions: Landlord Credit

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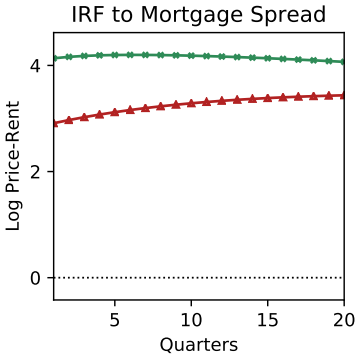
- If landlords used credit, expansion would cause shift in the supply curve.
  - Alternative explanation for concurrent rise in price-rent and homeownership.
- Implementation: landlords can borrow with mortgage tech., 65% LTV limit at origination.
- New equilibrium condition ($\mathcal{C}_{L,t} = \mu_{L,t}\theta^L$)

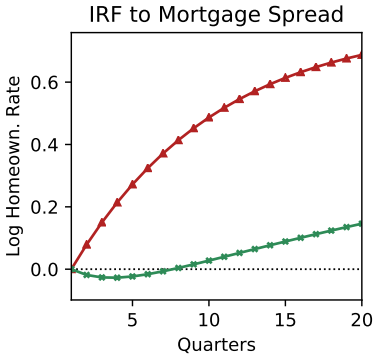
$$p_t^{\text{Supply}} = \underbrace{\left(1 - \mathcal{C}_{L,t}\right)^{-1}}_{\text{credit conditions}} E_t\left\{\Lambda_{t+1}^L\left[\underbrace{\bar{\omega}_t^L + \text{rent}_{t+1}}_{\text{housing services}} + \underbrace{\left(1 - \delta - (1-\rho_{t+1})\mathcal{C}_{L,t+1}\right)p_{t+1}}_{\text{continuation value}}\right]\right\}$$

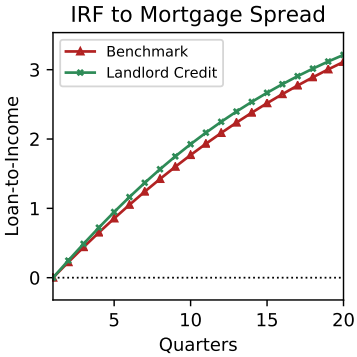
allows credit to directly influence supply.

Model Extensions: Landlord Credit

- Impose same mortgage spread shock, this time on both borrower and landlord mortgages.
- For same parameterization, strengthens movements in price-rent relative to homeownership.
  - Would generate strong effect of credit even with weaker segmentation.







Model Extensions: Saver Credit

- Next extension: relax assumption of fixed (segmented) saver demand.
- New equilibrium condition:

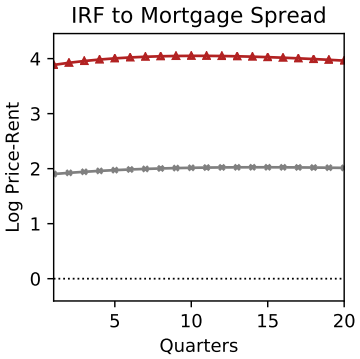
$$p_t^{\text{Saver}} = E_t\left\{\Lambda_{t+1}^S\left[\underbrace{u_{h,t}^S/u_{c,t}^S}_{\text{housing services}} + \underbrace{\left(1-\delta\right)p_{t+1}}_{\text{continuation value}}\right]\right\}$$

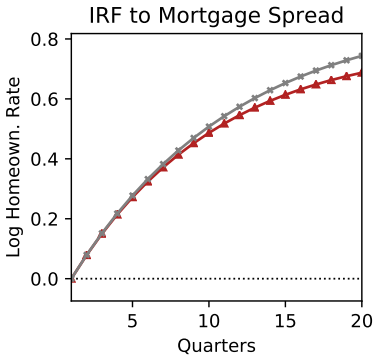
  where saver housing $H_{S,t}$ must equalize saver and borrower/landlord prices.

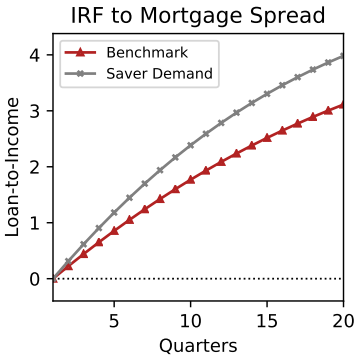
- Because saver demand not directly influenced by credit, saver housing margin can also absorb effect of credit on house prices.
  - Same mechanism highlighted in Landvoigt, Piazzesi, and Schneider (2015).
- Adjustment occurs (unrealistically) along intensive margin due to divisible housing.
  - Typically true even in models with different housing sizes/types.

Model Extensions: Saver Credit

- Flexible saver demand would cut price-rent impact of mortgage spread shock in half.
- Recovering estimated elasticities $\Longrightarrow$ strong frictions dampening saver margin.
  - Takeaway: models need saver/borrower segmentation frictions to get realistic credit sensitivities.







Conclusion

- What role did credit play in the housing boom and bust?
- Empirical results:
  - 5x or larger elasticity for price-rent ratio than homeownership rate along supply curve.
- Quantitative model calibrated to match empirical findings (landlord supply elasticity):
  - Allows us to consider cases between fixed homeownership rate and perfect arbitrage.
  - Main finding: Credit conditions explain 28% – 47% of price-rent growth during boom.
  - Frictions key to ability of macroprudential or monetary policy to dampen price booms.
  - Extensions: landlord credit (alternative comovement) and saver demand (need segmentation).
- Next steps: More instruments, improved data.

Empirical Approach 2: PLS Expansion Exposure

Back

- Credit shock: Mian and Sufi (2019)
  - In late summer 2003, sudden and large surge in private label securitization market that lasts until 2007 and then reverts (Justinano et al., 2017).
  - Mian-Sufi: Expansion in PLS larger for non-deposit-financed lenders.
  - Lender-Level Proxy: NCL = 1 - Core Deposits / Total Liabilities.
  - Create MSA-level exposure as average of national bank NCLs weighted by 2002 originations.
  - Mian and Sufi test exclusion restriction, argue valid credit supply instrument.

- Specification (Reduced Form):

$$\log(outcome_{i,t}) = \alpha_i + \gamma_t + \sum_{k \neq 2002} 1_{t=k} \beta_k NCLShare_{i,2002} + \epsilon_{i,t}$$

- Issue: We do not have 2002 data for homeownership rate to use 2002 as pre-period.
  - Solution: Use 2013 (when prices return to 2002 level) as base year. Peak-to-trough alternative.

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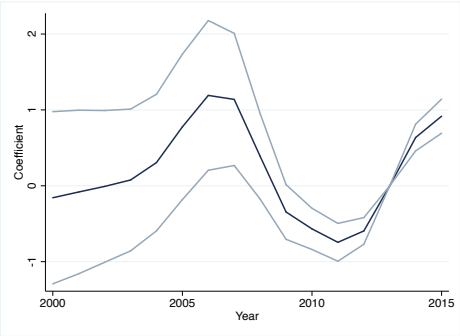
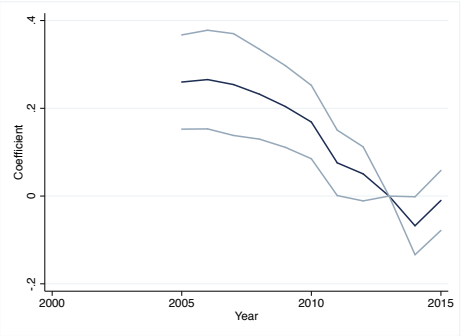
PLS Expansion: Impulse Response

Back

- Find roughly 5× **ratio**: House prices have 4.5× larger response than homeownership with 2013 base, 5.8× peak-to-trough.
  - Price-to-rent similar because ACS rents are very sticky.



(a) House Prices



(b) Homeownership Rate

Demographics and Preferences

- Three types: borrowers (B), landlords (L), savers (S).
  - Borrowers: Consume owned and rented housing, borrow in mortgages ($\beta_B < \beta_S$).
  - Landlords: Risk-neutral, own housing to rent to borrowers (think: foreign firm).
  - Savers: Finance borrower mortgages.

- Preferences:

$$V_{i,t}^B = \log\left(c_{B,t}^{1-\xi} h_{B,t}^{\xi}\right) + \beta_B E_t V_{i,t+1}^B$$

$$V_{i,t}^L = c_{i,t}^L + \beta_L E_t V_{i,t+1}^L$$

$$V_{i,t}^S = \log\left(c_{S,t}^{1-\xi} h_{S,t}^{\xi}\right) + \beta_S E_t V_{i,t+1}^S$$

- Perfect risk sharing within each type $\implies$ aggregation.

Back

Mortgage Technology

- Geometrically decaying perpetuities with fixed interest rate.
  - Pay interest r_t^* on start-of-period principal balance (tax deductible).
  - Pay fraction ν of principal balance, carry remaining $(1-\nu)$ fraction into next period.
- Fraction ρ_B of borrowers prepay loans and replace with new ones (see paper for endogenous prepayment).
- New borrowers choose loan size $M_{i,t}^*$ and house size $H_{i,t}^*$ subject to loan-to-value and payment-to-income constraints:

$$M_{i,t}^* \leq \theta_t^{LTV} p_t H_{i,t}^*, \qquad M_{i,t}^* \leq \frac{\left(\theta_t^{PTI} - \omega\right) \text{income}_{i,t}}{r_t^* + \nu + \alpha}.$$

- Aggregate as in Greenwald (2018): Endogenous fraction F_t^{LTV} constrained by LTV at equilibrium. Details Laws of Motion

Back

Borrower's Problem

- Representative borrower chooses nondurable consumption $c_{B,t}$, size of new loans $M^*_{B,t}$, size of new housing purchases $H^*_{B,t}$ and total rental services $h_{B,t}$ subject to the budget constraint

$$c_{B,t} \leq \underbrace{(1-\tau)y_{B,t}}_{\text{after-tax income}} + \underbrace{\rho_B\left(M^*_{B,t} - \pi^{-1}(1-\nu_B)M_{B,t-1}\right)}_{\text{net mortgage iss.}} - \underbrace{\pi^{-1}(1-\tau)X_{B,t-1}}_{\text{interest payment}} - \underbrace{\nu_B\pi^{-1}M_{B,t-1}}_{\text{principal payment}}$$

$$- \underbrace{\rho_B p_t\left(H^*_{B,t} - H_{B,t-1}\right)}_{\text{net housing purchases}} - \underbrace{\delta p_t H_{B,t-1}}_{\text{maintenance}} - \underbrace{\text{rent}_t\left(h_{B,t} - H_{B,t-1}\right)}_{\text{rent}}$$

$$+ \underbrace{\left(\int_{\bar{\omega}_{B,t-1}} \omega\, d\Gamma_{\omega,B}\right)\bar{H}_{t-1}}_{\text{owner surplus}} + \underbrace{T_{B,t}}_{\text{other rebates}}$$

and the borrowing (LTV + PTI) limit, applied at origination only.

Back

Mortgage Aggregation

- Want heterogeneity so that endogenous fraction are constrained by PTI.
- Idiosyncratic labor efficiency shocks $e_{i,t} \overset{iid}{\sim} \Gamma_e$, so individual borrower's income is

$$\text{income}_{i,t} = w_t n_{b,t} e_{i,t}.$$

- Shocks affect only credit limits, not consumption or labor supply (due to insurance, timing).
  - Equivalent to any shock causing variation in house price/income ratios.
- PTI binds for

$$e_{i,t} \leq \bar{e}_t \equiv \frac{\theta^{LTV} p_t^h h_t}{(\theta^{PTI} - \omega) w_t n_{b,t} / (q_t^* + \alpha)}.$$

- Fraction constrained by LTV:

$$F_t^{LTV} = 1 - \Gamma_e(\bar{e}_t).$$

Back

Laws of Motion

- Laws of motion for principal ($M_{B,t}$) and interest ($X_{B,t}$):

$$M_{B,t} = \underbrace{\rho_B M^*_{B,t}}_{\text{new loans}} + \underbrace{(1-\rho_B)(1-\nu_B)\pi^{-1}M_{B,t-1}}_{\text{old loans}}$$

$$X_{B,t} = \underbrace{\rho_B r^*_{B,t} M^*_{B,t}}_{\text{new loans}} + \underbrace{(1-\rho_B)(1-\nu_B)\pi^{-1}X_{B,t-1}}_{\text{old loans}}$$

$$H_{B,t} = \underbrace{\rho_{B,t} H^*_{B,t}}_{\text{new housing}} + \underbrace{(1-\rho_{B,t})H_{B,t-1}}_{\text{old housing}}.$$

Back

Landlord's Problem

- Representative landlord chooses nondurable consumption $c_{L,t}$, size of new housing purchases $H^*_{L,t}$ subject to the budget constraint

$$c_{L,t} \leq \underbrace{(1-\tau)y_{L,t}}_{\text{after-tax income}} - \underbrace{\rho_{L,t}p_t\left(H^*_{L,t} - H_{L,t-1}\right)}_{\text{net housing purchases}} - \underbrace{\delta p_t H_{L,t-1}}_{\text{maintenance}} + \underbrace{q_t H_{L,t-1}}_{\text{rent}}$$
$$+ \underbrace{\left(\int_{\bar{\omega}_{L,t-1}} \omega \, d\Gamma_{\omega,L}\right)\bar{H}_{t-1}}_{\text{owner surplus}} + \underbrace{T_{L,t}}_{\text{other rebates}},$$

Back

Saver's Problem

- Saver chooses nondurable consumption $c_{S,t}$, one-period bonds B_t, new mortgage issuance M_t^*, subject to the budget constraint

$$c_{S,t} \leq \underbrace{(1-\tau)y_{S,t}}_{\text{after-tax income}} - \underbrace{(B_t - R_{t-1}B_{t-1})}_{\text{net bond purchases}} - \underbrace{p_t\left(H_{S,t}^* - H_{S,t-1}\right)}_{\text{net housing purchases}} - \underbrace{\delta p_t H_{S,t-1}}_{\text{maintenance}} + \underbrace{T_{S,t}}_{\text{rebates}}$$
$$+ \underbrace{\pi^{-1}X_{B,t-1}}_{\text{interest payment}} - \underbrace{\nu_B\pi^{-1}M_{B,t-1}}_{\text{principal payment}} - \underbrace{\rho_{B,t}\left(\exp(\Delta_{B,t})M_t^* - \pi^{-1}(1-\nu_B)M_{B,t-1}\right)}_{\text{net mortgage iss.}}$$

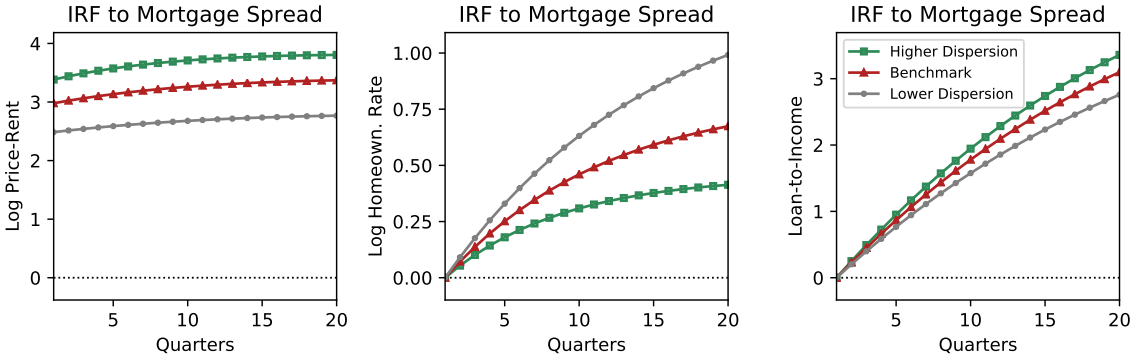
and the fixed demand constraint $H_{S,t} = \bar{H}_S$.

Back

Calibration: Supply Elasticity

Back

- 'Higher Dispersion" series doubles the dispersion to $\sigma_{\omega,L} = 0.030$, ratio of 9.3.
- ''Lower Dispersion" series halves the dispersion to $\sigma_{\omega,L} = 0.007$, ratio of 2.8.



Calibration: Parameter Values

Back

Parameter	Name	Value	Internal	Target/Source
		Demographics and Preferences		
Borrower pop. share	χ_B	0.626	N	1998 SCF
Borrower inc. share	s_B	0.525	N	1998 SCF
Landlord pop. share	χ_L	0.000	N	Normalization
Borr. discount factor	β_B	0.974	Y	PMI Rate (see text)
Saver discount factor	β_S	0.992	Y	Nom. interest rate = 6.46%
Landlord discount factor	β_L	0.974	Y	Equal to β_B
Housing utility weight	ξ	0.200	N	Davis and Ortalo-Magne (2011)
Saver housing demand	$\bar{H}_S$	5.299	Y	Steady state optimum
		Ownership Benefit Heterogeneity		
Landlord het. (location)	$\mu_{\omega,L}$	-0.002	Y	Avg. homeownership rate
Landlord het. (scale)	$\sigma_{\omega,L}$	0.020	Y	Empirical elasticities
Borr. het. (location)	$\mu_{\omega,B}$	0.004	Y	Borr. VTI (1998 SCF)
Borr. het. (scale)	$\sigma_{\omega,B}$	0.008	Y	Implied subsidy (see text)

Calibration: Parameter Values

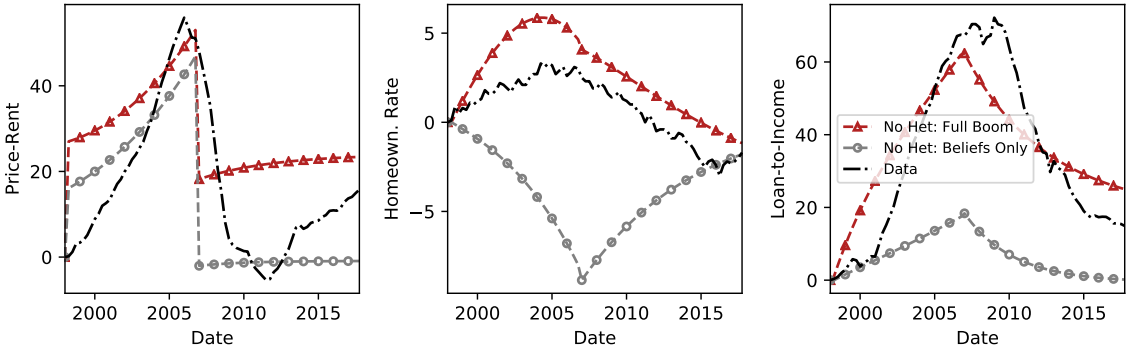
Back

Parameter	Name	Value	Internal	Target/Source
		Technology and Government		
New land per period	$\bar{L}$	0.109	Y	Residential inv = 5% of GDP
Land share of construction	φ	0.371	N	Res inv. elasticity in boom
Housing depreciation	δ	0.005	N	Standard
Inflation	$\bar{\pi}$	1.008	N	3.22% Annualized
Tax rate	τ	0.204	N	Standard
		Mortgage Contracts		
Refinancing rate	$\bar{\rho}$	0.034	N	Greenwald (2018)
Loan amortization	ν	0.004	N	Greenwald (2018)
LTV Limit	θ^{LTV}	0.850	N	Greenwald (2018)
PTI Limit	θ^{PTI}	0.360	N	Greenwald (2018)
PTI offset (taxes etc.)	α	0.001	N	Greenwald (2018)

Boom Counterfactuals: No Heterogeneity

Back

- Even removing interest rate drop (leaving beliefs only) has no effect on price-rent-ratio.



Boom Counterfactuals: Beliefs Only

Back

- Removing credit expansion + interest rates (leaving beliefs only) reduces rise in price-rent ratios by 70%, rise in LTI by 93%.