Do Credit Conditions Move House Prices?

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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:
  - Favilukis-Ludvigson-Van Nieuwerburgh: Credit explains most (60%) of movement in prices.
  - Kaplan-Mitman-Violante: Credit had virtually no effect on prices.
- Key difference is **rental market**, where two polar assumptions used:
  - **Full segmentation**: Fixed homeownership rate. Credit $\rightarrow$ demand $\rightarrow$ prices (e.g., FLVN).
  - **No segmentation**: 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).
  - Actual economy likely somewhere between these extremes. But where?
- More generally: Extent to which **credit insensitive** agents absorb credit-driven demand.
  - Depends on degree of **segmentation** in housing markets.
  - **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 vs. homeownership to credit supply shock is key determinant of degree of segmentation.
  - **Calibrate model** to match empirical findings, then decompose boom-bust.
- **Main Findings:**
  - Price-rent ratio responds at least **4**$\times$ more to identified credit shock than homeownership.
  - Change in credit standards as in 2000s explains **32% and 53%** of price-rent rise.
  - Close to full segmentation model, much stronger than no segmentation model.
  - Findings matter for other shocks to demand for owner-occupied housing, e.g. foreclosures.

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 (2020), Justiniano Primiceri Tambalotti (2015, 2018), Kaplan Mitman Violante (2019), Kiyotaki Michaelides Nikolov (2011), Landvoigt, Piazzesi, and Schneider (2015).

  Here: Common framework/methodology to resolve disparate results.

- **Empirical Credit Elasticities:** Adelino Schoar Severino (2022), Di Maggio Kermani (2017), Favara Imbs (2015), Glaeser Gottlieb Gyourko (2012), Loutskina Strahan (2015), Mian Sufi (2019).

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

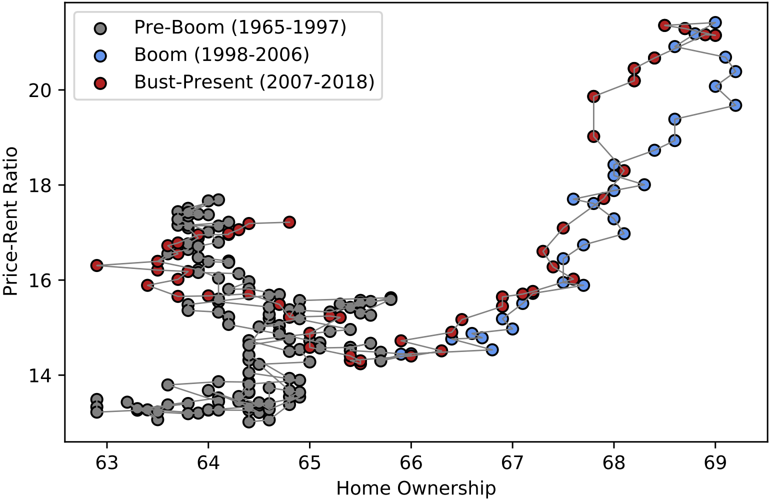
- **Housing DSGE Models:** Campbell, Hercowitz (2005), Eggertsson, Krugman (2012), Garriga, Kydland, Sustek (2015), Ghent (2012), Kiyotaki, Moore (1997), Iacoviello (2005), Iacoviello, Neri (2011), Liu, Wang, Zha (2013), Monacelli (2008), Rognlie, Shleifer, Simsek (2015).

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

Outline

- Intuition: Modified Supply and Demand
- Empirics: Estimate Sensitivity
  - Data and Empirical Approach
  - Main Instrument (Loutskina-Strahan)
  - Alternate Instruments (Di Maggio-Kermani; Mian-Sufi)
- Theory: Quantify Impact
  - Calibrated Model: Focus on Rental Markets
  - Quantitative Results
  - Model Extensions
    - Landlord Credit
    - Saver Housing Demand

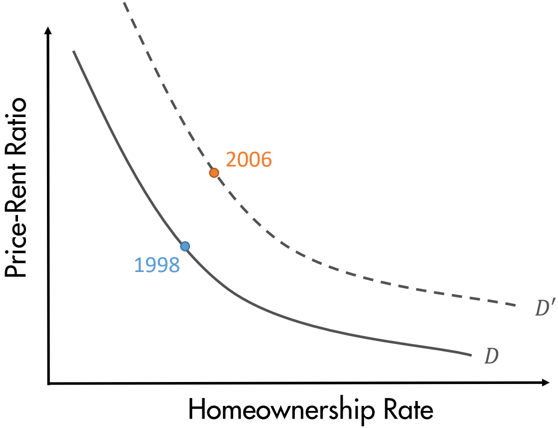
Time Series: Price-Rent Ratio vs. Home Ownership Rate



National data. Price-Rent: Flow of Funds, National Income and Product Accounts. Homeownership: Census.

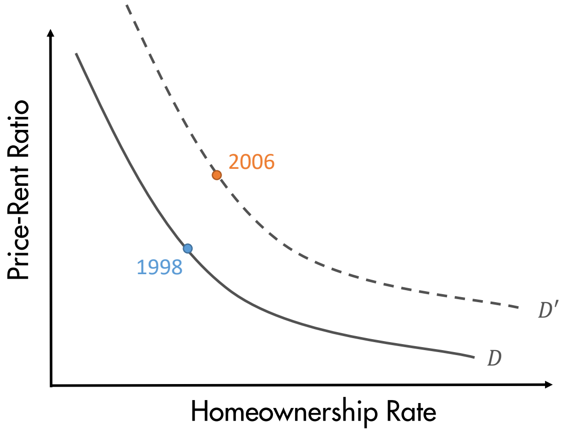
Intuition: Modified Supply and Demand

- Plot demand for owner-occupied housing. Price-rent ratio and homeownership rate robust to changes in housing stock.



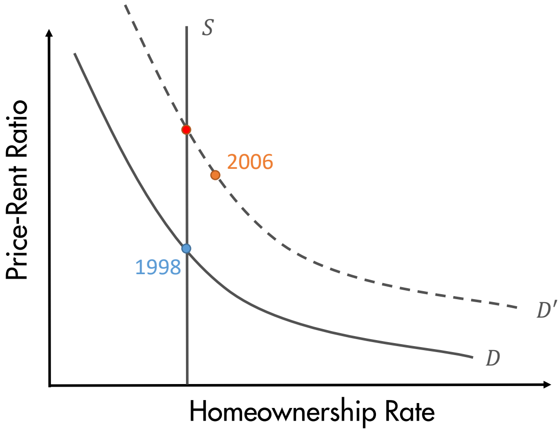
Intuition: Modified Supply and Demand

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



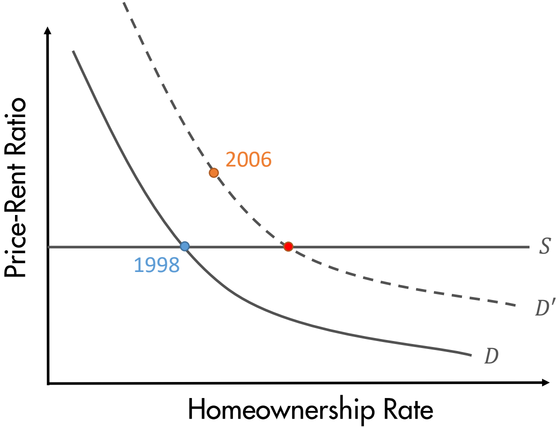
Intuition: Modified Supply and Demand

- Fixed "supply" (homeownership rate) $\implies$ all adjustment through price-rent ratio.



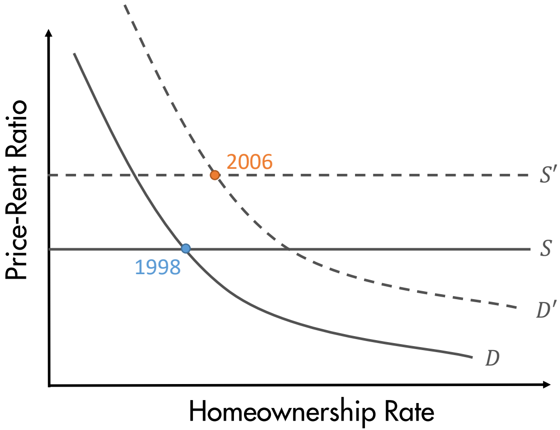
Intuition: Modified Supply and Demand

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



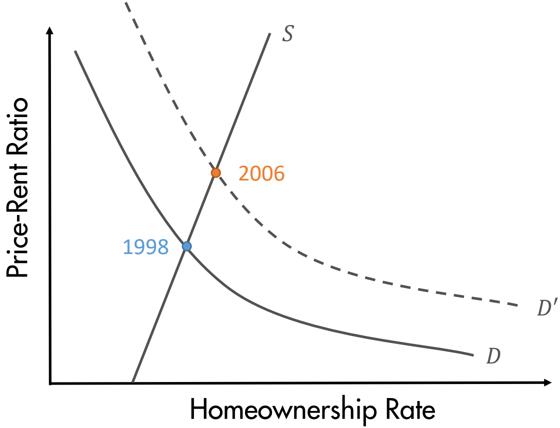
Intuition: Modified Supply and Demand

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



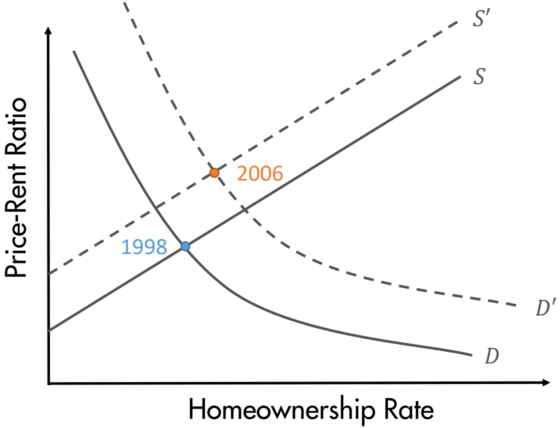
Intuition: Modified Supply and Demand

- 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.



Empirical Estimates

Empirical Overview

- Use three off-the-shelf empirical approaches to estimate causal effect of credit supply on price-rent ratio and homeownership rate.

    1. **Loutskina and Strahan (2015)**: Exploit differential city-level exposure to national changes in conforming loan limits.
    2. **Di Maggio and Kermani (2017)**: Exploit federal preemption of national banks from local anti-predatory-lending laws in 2004.
    3. **Mian and Sufi (2019)**: Exploit differential city-level exposure to private-label securitization expansion.

- Robustness to alternative methodologies assuages concerns for any one approach.
    - Each instrument has different identification assumptions.
    - Operate on prime (#1) vs. riskier (#2, #3) segments of the market.

- Results imply slope point estimates of **at least 4 and often significantly higher**. Cannot reject ∞ (full segmentation).

Data

- CBSA-Level Balanced Panel 1995-2017
- Prices: CoreLogic Repeat Sale HPI
- Rents: CBRE Economic Advisors Torto-Wheaton Index (CBSA)
  - High-quality repeat rent index for multi-family (single family index behaves similarly).
  - Measures rent commanded by newly rented unit.
- Homeownership Rate 1: Census Housing and Vacancy Survey
  - Noisy; CBSA definitions change over time. Drop affected CBSAs for balanced panel.
- Homeownership Rate 2: New measure based on microdata (Greenwald and Guren, 2023)
  - Zillow property records combined with Infutor address histories. Details
  - Covers more cities with much less noise. Benchmark to decennial census to adjust for coverage.

Empirical Approach 1: Conforming Loan Limit Exposure

- Credit shock: Loutskina and Strahan (2015)
  - CLL: Max loan size eligible for GSE subsidy, for most part changes nation-wide.
  - Idea: Change in conforming loan limit has more bite in cities with more loans near CLL.
- Instrument: **fraction of originations** within 5% of CLL at $t-1 \times$ **% change in CLL**.
  - Control for fraction, CBSA, and time FE so identification is only from interaction.
  - Identifying assumption: no non-credit shock that varies with CLL in time series and affects more exposed cities in cross section.
- Panel local projection of reduced form: for $k = 0, \ldots, 5$ and $outcome \in \{PRR, HOR\}$,

$$\log(outcome_{i,t+k}) = \xi_i + \psi_t + \beta_k Z_{i,t} + \Theta X_{i,t} + \epsilon_{i,t}$$

where X_t includes $Fraction_{i,t-1}$ as well as one lag of instrument, $Fraction$, and outcome.

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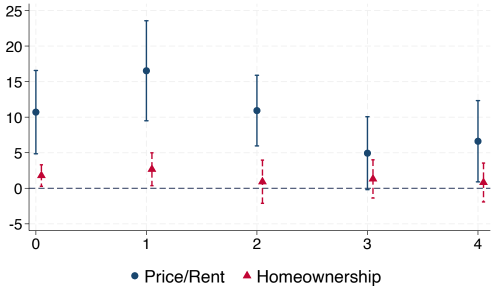
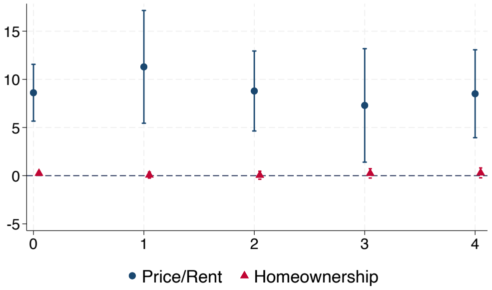
CLL Impulse Response: Credit Shock (Panel Local Projection)

- Census: PRR point estimates from **10.7-16.5** in years 0-2, **4.9-6.6** in years 3 and 4, HOR **0.9-2.7** in years 0-2, **0.8-1.3** in years 3 and 4.
- GG Microdata: PRR point estimates **8.6-11.3** in years 0-2, **7.2-8.5** in years 3 and 4, HOR **0.05-0.3** in all years. ▸ Comparison



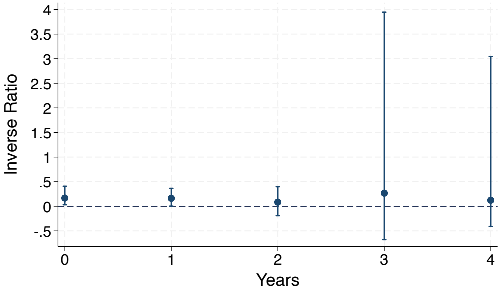
(a) Census Housing Vacancy Survey



(b) GG Microdata Homeownership Rate

CLL Impulse Response: Credit Shock (Panel Local Projection)

- Plot **inverse slope** because HOR response insignificant $\implies$ unbounded ratios.
  - Compute confidence interval using bootstrap.



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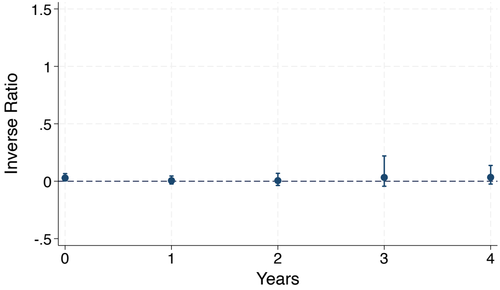
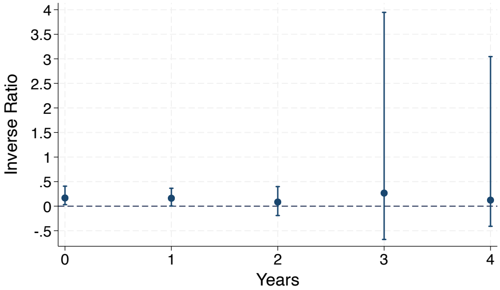


(b) GG Microdata Homeownership Rate Details

CLL Impulse Response: Credit Shock (Panel Local Projection)

- Census: Ratio estimates range from **3.8 to ∞**, **6.0-11.8** in the years 0-2.
  - 95% CI lower bound ranges from **2.5-2.8** in years 0-2, **0.3** in years 3 and 4
  - 95% CI upper bound is ∞ because cannot reject zero.



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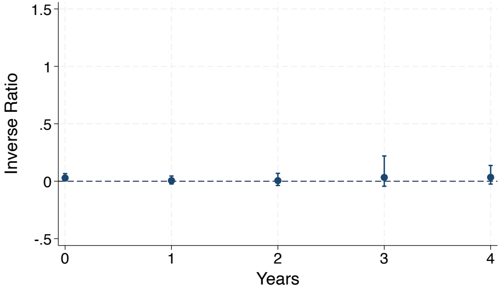
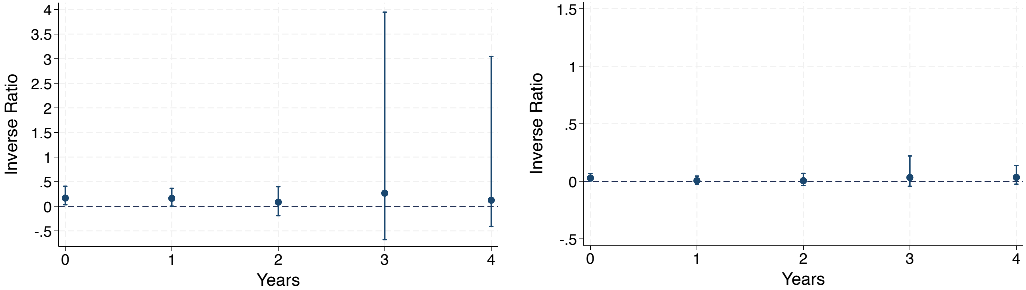


(b) GG Microdata Homeownership Rate ▸ Details

CLL Impulse Response: Credit Shock (Panel Local Projection)

- GG Microdata: Ratio estimates range from **35-190** in years 0-2, **27-30** in years 3-5.
  - 95% CI lower bound is at least **14** in years 0-2, min of **4.5** in year 3.
  - To be conservative and obtain upper bound on effect of credit, we calibrate using Census.



(a) Census Housing Vacancy Survey

(b) GG Microdata Homeownership Rate ▸ Details

Alternate Empirical Approaches

DK Details MS Details Infutor Data

- **Di Maggio and Kermani (2017)**: Preemption of state anti-predatory-lending laws (APLs).
  - 2004 OCC preemption allows national banks to expand credit to risky borrowers.
  - Compare across states based on presence of APL and across cities within states based on OCC-regulated-bank market share.
- **Mian and Sufi (2019)**: City-level exposure to expansion in private-label securitization.
  - Variation across cities based on funding structure (non-core liabilities) of local banks.
- Despite different identification assumptions and variation that expands credit to riskier borrowers and only price data, **both approaches yield similar slope estimates**.
  - Di Maggio and Kermani: "naive" slope estimates of **over 20** using GG microdata HOR, **0.9-3** but very imprecise for Census data.
  - Mian and Sufi: "naive" slope estimates of **at least 15** using GG microdata HOR, **2** but very imprecise for Census data.
  - Complementary empirical approaches reinforce confidence in this moment.

Structural Model

Modeling Credit and House Prices

- Three factors generate strong house price response to credit in models:
  1. Frictions on trade with unconstrained owners of rental properties (landlords).
  2. Frictions on trade with unconstrained savers.
  3. Latent demand for credit.
- Items 1. and 2. relate to supply slope, identified by our empirical moment.
  - Single moment does not pin down relative frictions across margins.
  - We fully shut down saver margin, which occurs (unrealistically) along intensive margin.
  - Relaxing this assumption doesn't overturn results (see paper).
- Item 3. relates to gap between mortgage rate and borrower's reservation rate.
  - Influences size of demand shift following credit shock, rather than slope of supply.
- Credit strongly affects house prices only if **all three** factors are present.

Model Overview

- Adaptation of Greenwald (2018) to allow endogenous rental market.
- Endowment economy, endogenous investment in housing stock.
- Credit + rental market $\implies$ borrowers (B), landlords (L), savers (S).
- Realistic mortgages $\implies$ long term, fixed-rate, prepayable.
  - Loan-to-value (LTV) and payment-to-income (PTI) limits at origination only.
- Main modeling contribution: **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.

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 (extension: landlord mortgages too).
  - Savers: finance borrower mortgages, own **fixed housing stock** H_S (extension: trade housing).
- Preferences:

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

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

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

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

Mortgage Technology

Details Laws of Motion Timing

- 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 of borrowers move each period, prepay their loans.
  - Fraction η of moving households become active, eligible to buy housing.
- Active buyers choose loan size $M_{i,t}^*$ and house size $H_{i,t}^*$ subject to loan-to-value and payment-to-income constraints:

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

- Aggregate as in Greenwald (2018): Endogenous frac. F_t^{LTV} LTV-constrained in equilibrium.

Housing Technology

- Housing asset: Divisible, requires maintenance cost, owned by borrowers or landlords.
- Produced by construction firms using investment of the nondurable good (Z_t) and land (L_t), where a fixed amount of land permits $\bar{L}$ are issued each period.
- Construction firm's problem:

$$\max_{L_t, Z_t} p_t L_t^{\varphi} Z_t^{1-\varphi} - p_{L,t} L_t - Z_t$$

- Housing priced at marginal cost, but land prices rise as construction rises to create upward-sloping supply curve.
- Implies elasticity of investment to prices of $\varphi/(1-\varphi)$.

Heterogeneity

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

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:

$$
\begin{aligned}
c_{B,t} \leq \underbrace{(1-\tau)y_{B,t}}_{\text{after-tax income}} + \underbrace{\rho\eta\left(M^*_{B,t} - \pi^{-1}(1-\nu_B)M_{B,t-1}\right)}_{\text{net mortgage iss.}} - \underbrace{\pi^{-1}(1-\tau)X_{B,t-1}}_{\text{interest payment}} - \underbrace{\nu_B\pi^{-1}M_{B,t-1}}_{\text{principal payment}} \\
- \underbrace{\rho\eta p_t\left(H^*_{B,t} - H_{B,t-1}\right)}_{\text{net housing purchases}} - \underbrace{\delta p_t H_{B,t-1}}_{\text{maintenance}} - \underbrace{\text{rent}_t\left(h_{B,t} - H_{B,t-1}\right)}_{\text{rent}} \\
+ \underbrace{\left(\int_{\bar{\omega}_{B,t-1}} \omega \, d\Gamma_{\omega,B}\right)\bar{H}_{t-1}}_{\text{owner surplus}} + \underbrace{T_{B,t}}_{\text{other rebates}}
\end{aligned}
$$

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

▸ Equilibrium Definition ▸ Landlord's Problem ▸ Saver's Problem

Asset Pricing

- Key optimality conditions ($\mathcal{C}_t = \mu_{B,t} F_t^{LTV} \theta_t^{LTV}$): ▸ Details

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

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

- In 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 parameter is dispersion of Γ_ω^L distribution (more dispersed $\Longrightarrow$ more inelastic supply).

Calibration Strategy

Parameter Values | Parameterization of Heterogeneity

- Most parameters: Match external calibration targets or standard parameters.
  - Borrower pop and income shares, utility, construction, depreciation, taxes, etc.
- Key parameter is landlord heterogeneity ($\sigma_{\omega,L}$) which we match to regressions.
- Borrower heterogeneity ($\sigma_{\omega,B}$): match uptake of First Time Homebuyer Credit estimated in Berger, Turner, Zwick (2020).
- 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.
- Sensitivity analysis shows other parameters not important once we recalibrate to match our key empirical moment.

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- Borrower heterogeneity ($\sigma_{\omega,B}$): match uptake of First Time Homebuyer Credit estimated in Berger, Turner, Zwick (2020).
- 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.
- Sensitivity analysis shows other parameters not important once we recalibrate to match our key empirical moment.

Calibration Strategy

Parameter Values   Parameterization of Heterogeneity

- Most parameters: Match external calibration targets or standard parameters.
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Calibration Strategy

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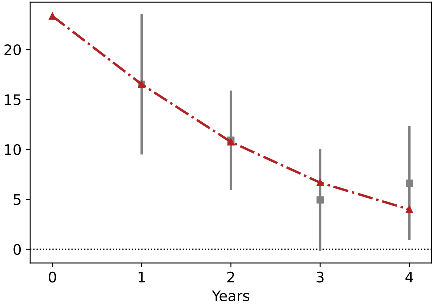
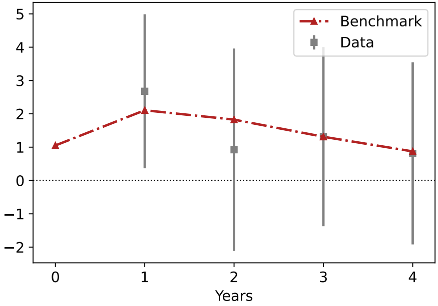
Calibration: Supply Elasticity

▸ Identification

- Model change in CLL as shock to real mortgage spreads for borrowers.
- Choose $\sigma_{\omega,L}$, along with size and persistence of shock, to minimize distance from empirical Loutskina-Strahan price-rent and homeownership IRFs.
- Fit in years 1-4.



(a) Price-Rent Ratio

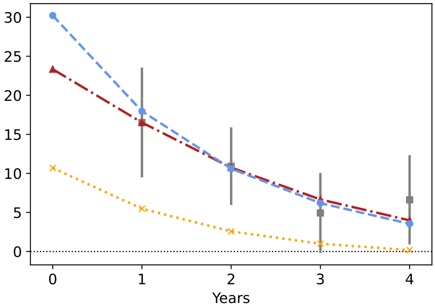


(b) Homeownership Rate

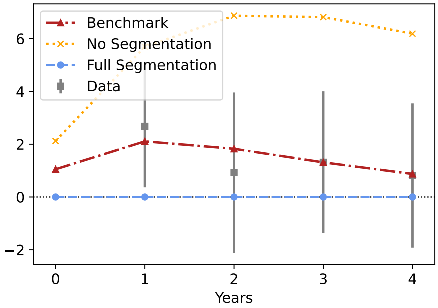
Calibration: Supply Elasticity

▸ Identification

- Requires substantial deviation from perfect rental markets.
- Benchmark has price response close to Full Segmentation model, but larger homeownership response.



(a) Price-Rent Ratio

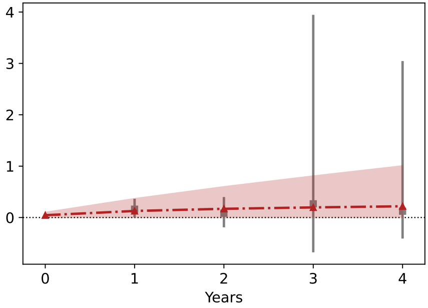


(b) Homeownership Rate

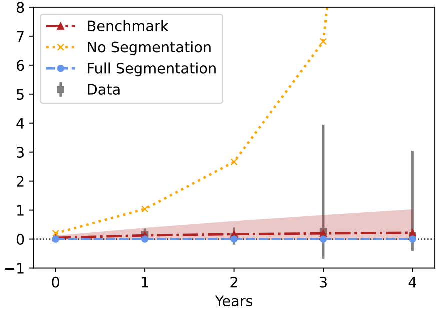
Calibration: Supply Elasticity

▸ Identification

- For confidence bands, turn to inverse slope estimates.
  - Characterize joint uncertainty, drops nuisance parameter of shock size.
  - Fit upper and lower confidence interval bounds.



(a) Inverse Ratio (Bands)

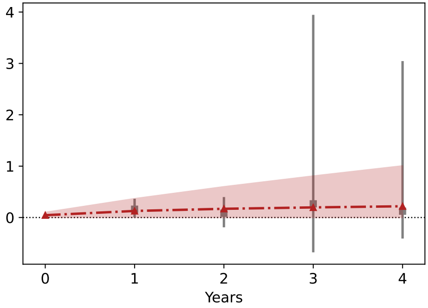


(b) Inverse Ratio (Model Comparison)

Calibration: Supply Elasticity

▸ Identification

- Cannot reject Full Segmentation, but can reject No Segmentation model.
- Directly estimating $\sigma_{\omega,L}$ to match ratio point estimates would yield steeper slope.



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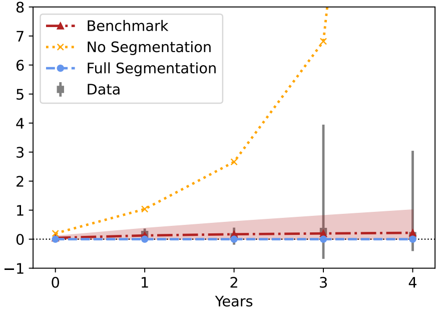
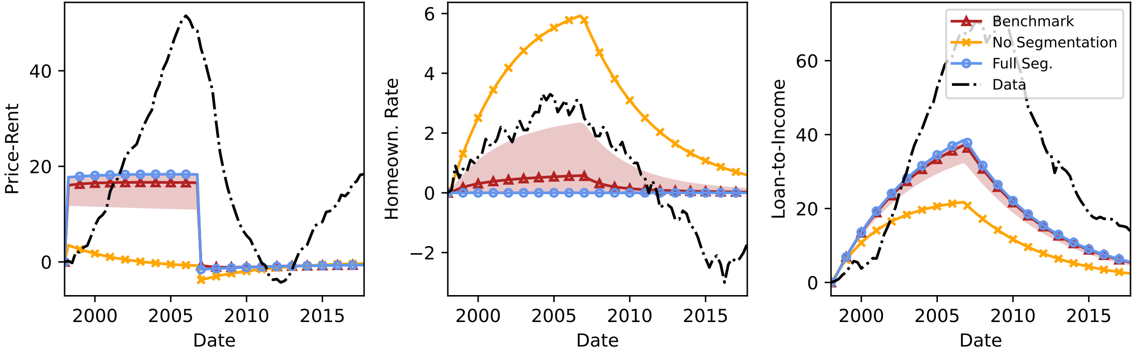


(b) Inverse Ratio (Model Comparison)

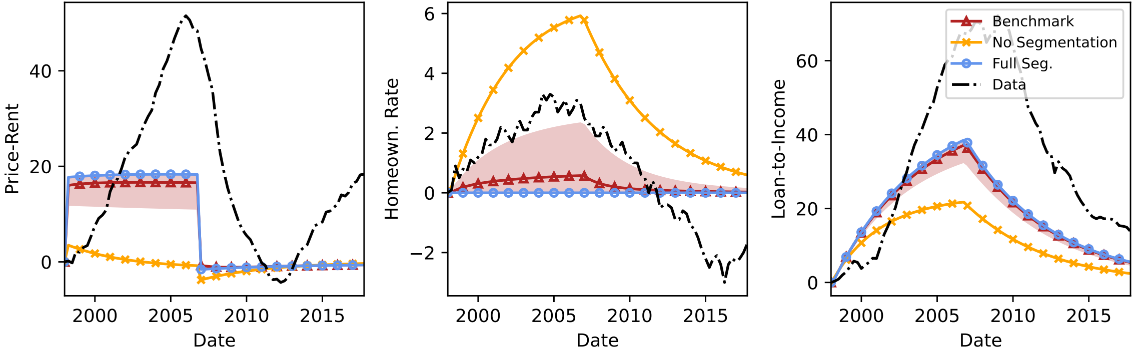
Credit Expansion Experiment

- Credit expansion: Increase max LTV from 85% to 99%, max PTI from 36% to 65%.
- Surprise arrival of policy in 1998 Q1, surprise reversal in 2007 Q1.
- Compute nonlinear perfect foresight paths.



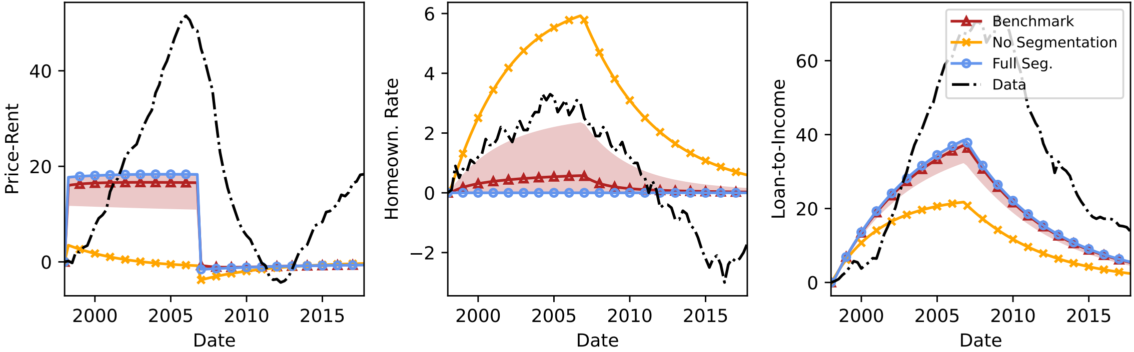
Credit Expansion Experiment

- Benchmark: Credit explains **32%** of peak price-rent increase, **51%** of peak LTI increase.
  - Using lower bound for slope, explains **22%** of rise in price-rent, **45%** of rise in LTI.
- Perfect rental markets: Credit explains **-2%** of price-rent, only **30%** of peak LTI increase.



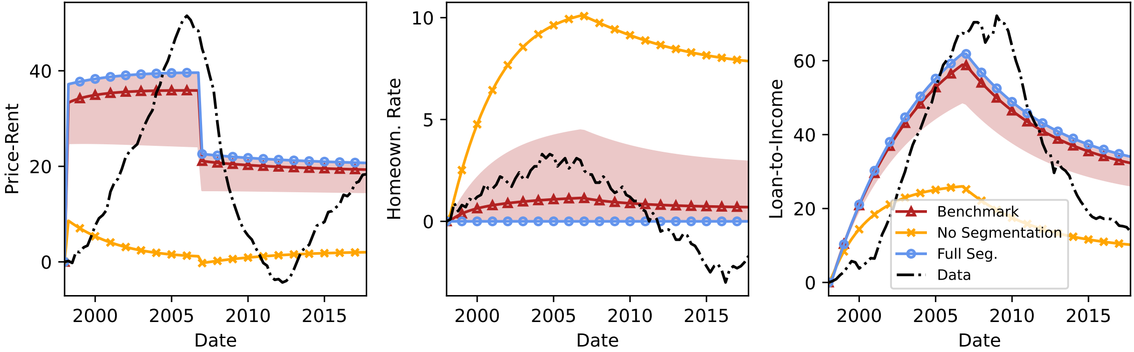
Credit Expansion Experiment

- Benchmark closer to complete segmentation: **36%** of price-rent, **53%** of peak LTI increase.
- But Benchmark allows for nonzero movement in homeownership.



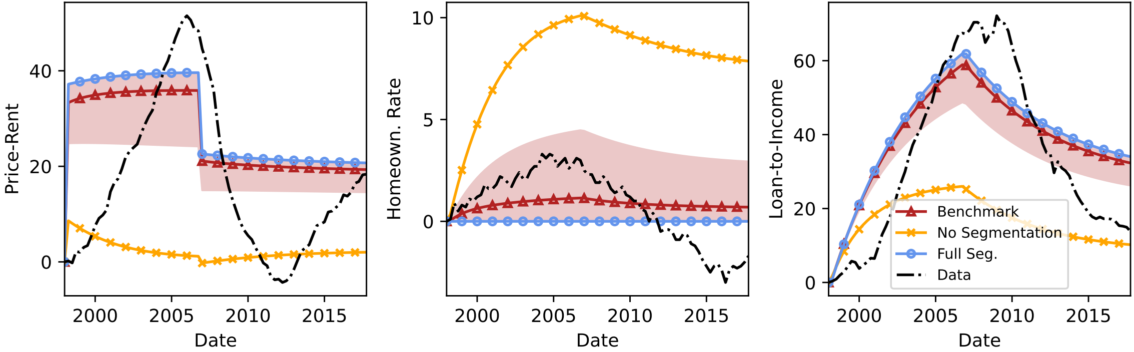
Credit Expansion Experiment

- Adding 2ppt drop in mortgage rates, we can explain **70%** of the rise in price-to-rent ratios and **82%** of the rise in loan-to-income ratios, and **35%** of the rise in homeownership.
  - Lower bound slope explains **47%** of rise in price-rent, **68%** of rise in LTI, **136%** of rise in HOR.
  - Upper bound (Full Seg) explains **77%** of rise in price-rent, **86%** of rise in LTI, **0%** of rise in HOR.



Credit Expansion Experiment

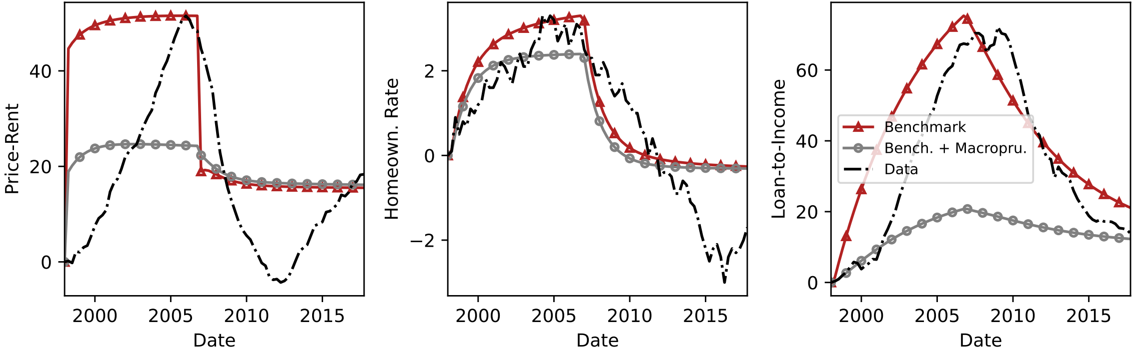
- Contrast to **2%** of rise in price-rent ratios and **36%** of rise in LTI under No Segmentation.
- Extremely favorable credit terms without price appreciation leads to rise in homeownership **306%** that of the data.



Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ No Heterog.

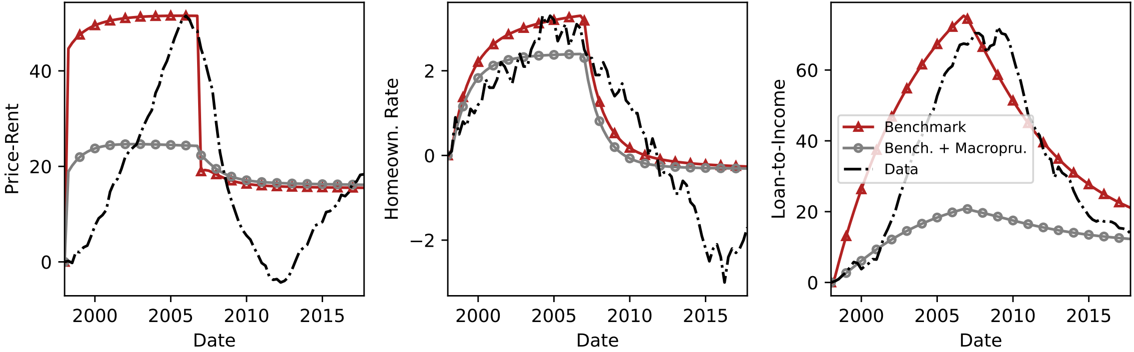
- Add observed fall in interest rates, then use demand and supply shocks (shifts in means of $\Gamma_{\omega,B}, \Gamma_{\omega,L}$ to exactly explain rise in price-rent and homeownership).
- To capture bust, return credit limits to baseline, apply (i) 3% fall in mortgage rates and landlord discount rates; (ii) exclude 10% of borrowers from credit market.



Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ No Heterog.

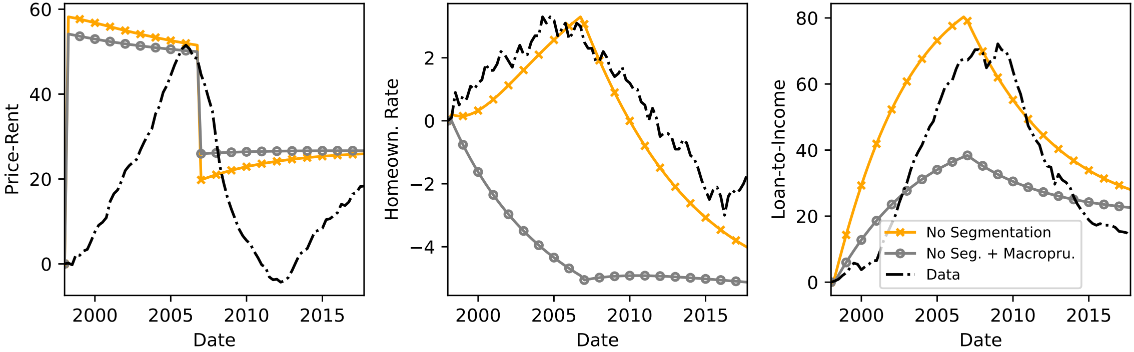
- Now **removing** credit expansion kills 53% of boom in price-rent, 71% of boom in LTI.
- Larger because of nonlinear interactions between credit and other shocks boosting house prices (Greenwald, 2018).
- Implies macroprudential, monetary policy can be effective at limiting house price booms.



Boom Counterfactuals: Benchmark Model

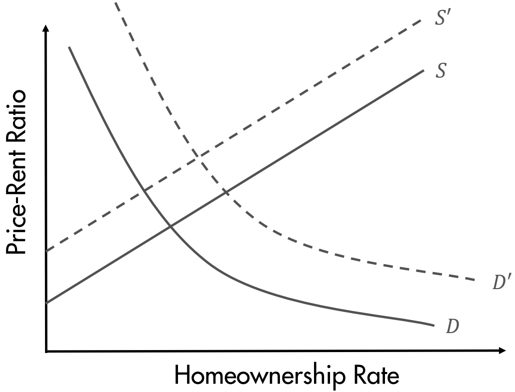
▸ Beliefs Only ▸ No Heterog.

- Under No Segmentation, removing credit relaxation would remove **3%** of boom in price-rent, **47%** of boom in LTI.
- Difficult to distinguish using macro data alone, need IV estimates to tell whether macroprudential policy works.



Model Extensions: Landlord Credit

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



Model Extensions: Landlord Credit

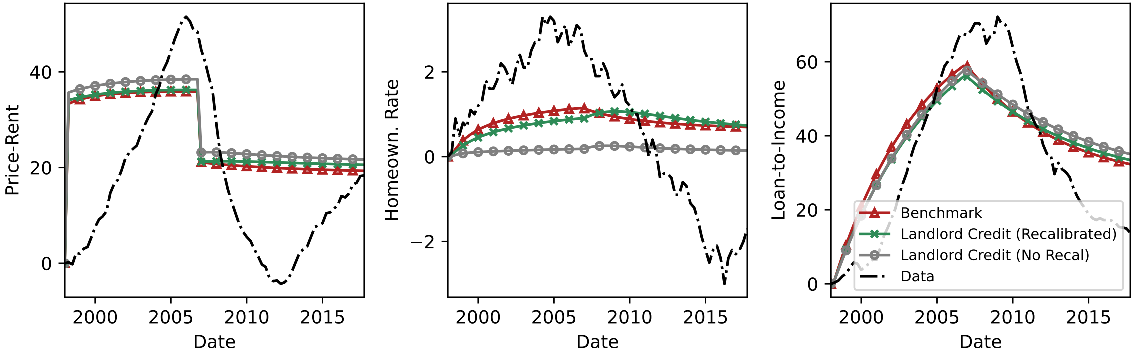
- So far, have assumed landlords don't use credit.
- If landlords used credit, expansion would also cause shift in the supply curve.
  - Alternative explanation for concurrent rise in price-rent and homeownership.
- Implementation: landlords can borrow with mortgage tech., 65% LTV limit at origination.
- 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.

Landlord Credit

- Below: credit standards + falling rates experiment.
- Compare Benchmark to model with landlord credit with same $\sigma_{\omega,L}$ ("No Recal") and landlord credit with recalibrated $\sigma_{\omega,L}$ ("Recalibrated").
- Result: Adding landlord credit strengthens effect on PRR, weakens effect on HOR even after recalibration.



Model Extensions: Flexible Saver Demand

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

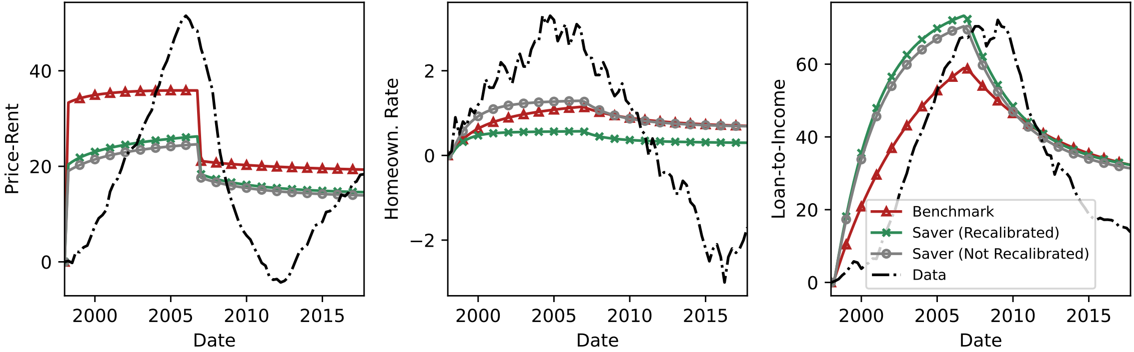
$$p_t^{\text{Saver}} = E_t\left\{\Lambda_{t+1}^S\left[\underbrace{u_{h,t}^S/u_{c,t}^S}_{\text{housing services}} + \underbrace{\left(1-\delta\right)p_{t+1}}_{\text{continuation value}}\right]\right\}$$

  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 discussed 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.

Saver Demand

- Below: Credit standards + falling rates experiment. Compare Benchmark to models with unrestricted saver housing demand, with and without recalibrating $\sigma_{\omega,L}$.
- Nontrivially dampens price-rent impact even after recalibration, but doesn't overturn main result that credit significantly affects prices.



Conclusion

Landlord Credit Saver Demand

- What role did credit play in the housing boom and bust?
- Empirical results:
  - Larger, significant response of price-rent ratio to identified credit shocks
  - Smaller, insignificant response for homeownership.
  - Ratio (tenure supply slope) at least 4.
- 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 32% – 53% of price-rent growth during boom.
  - Frictions key to effectiveness of macroprudential/monetary policy in dampening price booms.

Appendix

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 ($X_{B,t}$):

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

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

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

Back

Timing

Timing and risk sharing create representative agent of each type with meaningful within-period heterogeneity:

1. Fraction ρ of borrowers are selected to participate in the housing and mortgage markets.
2. Active borrowers select whether to own or rent.
3. Active borrowers choosing to own decide how much housing to buy.
4. Active borrowers choosing to own draw an income shock. This determines their PTI limit, which combined with the economy LTV limit sets their debt limit.
5. Complete markets contracts pay out, and all borrowers choose their consumption of nondurables and housing services.

Back

Equilibrium Definition

A competitive equilibrium consists of:

- States $H_{B,t-1}$, $M_{B,t-1}$, interest payment $X_{B,t-1}$, $\bar{H}_{t-1}$.
- Borrower controls $c_{B,t}$, $h_{B,t}$, $M^*_{B,t}$, $H^*_{B,t}$; Landlord controls $c_{L,t}$, $H_{L,t}$; Saver controls $c_{S,t}$, $M^*_{S,t}$; Construction firm controls L_t, Z_t. Aggregates pin down cutoffs $\bar{\omega}^B_t$ and $\bar{\omega}^L_t$.
- Prices p_t, rental rate q_t, interest rate r^*_t.

such that:

1. Borrowers, landlords, savers, and construction firms all optimize.
2. Laws of motion for M, X, and H hold.
3. Housing, permits, and mortgage markets clear.
4. Aggregate resource constraint holds.

Borrower's Problem

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

$\mathcal{C}_t$ Details

- $\mathcal{C}_t = \mu_{B,t} F_t^{LTV} \theta_t^{LTV}$ represents the shadow value of additional credit that can be collateralized by an additional dollar of housing.
  - Extra dollar of housing can collateralize θ_t^{LTV} of new debt for an LTV-constrained borrower.
  - Fraction of LTV-constrained borrowers is F_t^{LTV}.
  - Lagrange multiplier $\mu_{B,t}$ on borrowing constraint converts quantity of new credit to value of credit from borrower's perspective.

Back

Parameterization: Heterogeneity

- Parameterize Γ_{ω}^{j} distributions as logistic:

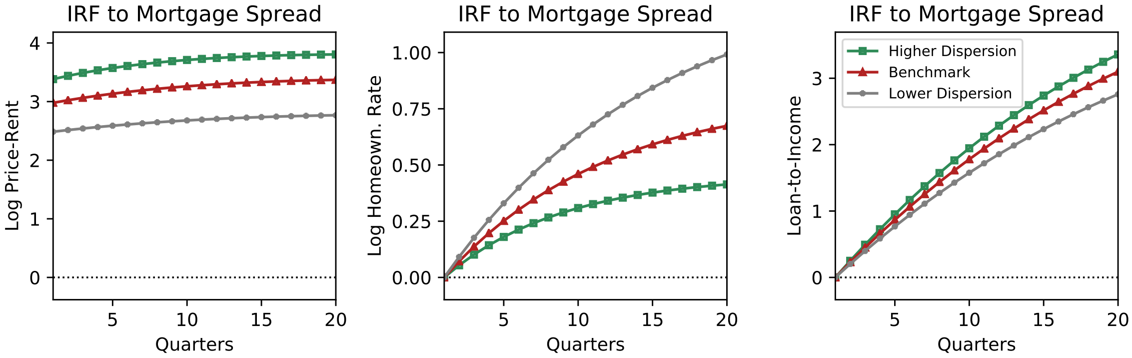
$$\Gamma_{\omega}^{j}(\omega) = \left[1 + \exp\left\{-\left(\frac{\omega - \mu_{\omega,j}}{\sigma_{\omega,j}}\right)\right\}\right]^{-1} \qquad j \in \{B, L\}.$$

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	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	0.2	N	Davis and Ortalo-Magne (2011)
Saver housing demand	$\bar{H}_S$	5.299	Y	Steady state optimum
Ownership Benefit Heterogeneity				
Landlord het. (location)	$\mu_{\omega,L}$	-0.109	Y	Avg. homeownership rate
Landlord het. (scale)	$\sigma_{\omega,L}$	2.877	Y	Empirical elasticities
Borr. het. (location)	$\mu_{\omega,B}$	0.217	Y	Borr. VTI (1998 SCF)
Borr. het. (scale)	$\sigma_{\omega,B}$	0.319	Y	Berger, Turner, Zwick (see text)

Calibration: Parameter Values

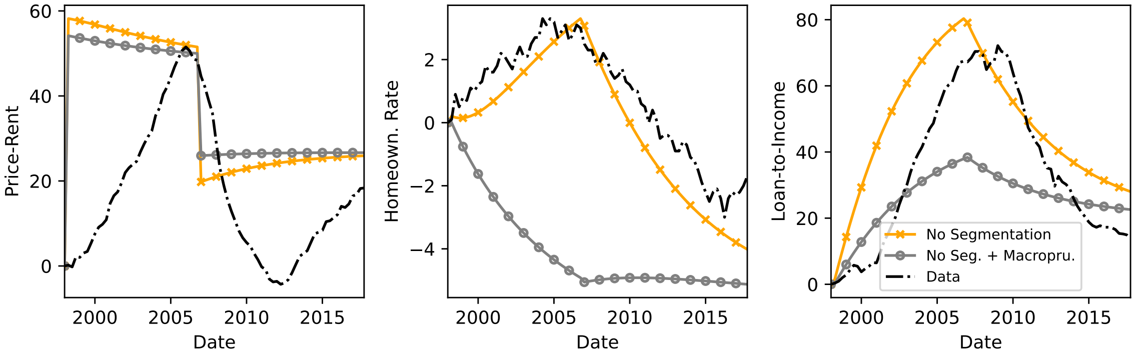
Back

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}	0.85	N	Greenwald (2018)
PTI Limit	θ^{PTI}	0.36	N	Greenwald (2018)
PTI offset (taxes etc.)	α	0.001	N	Greenwald (2018)

Boom Counterfactuals: Beliefs Only

Back

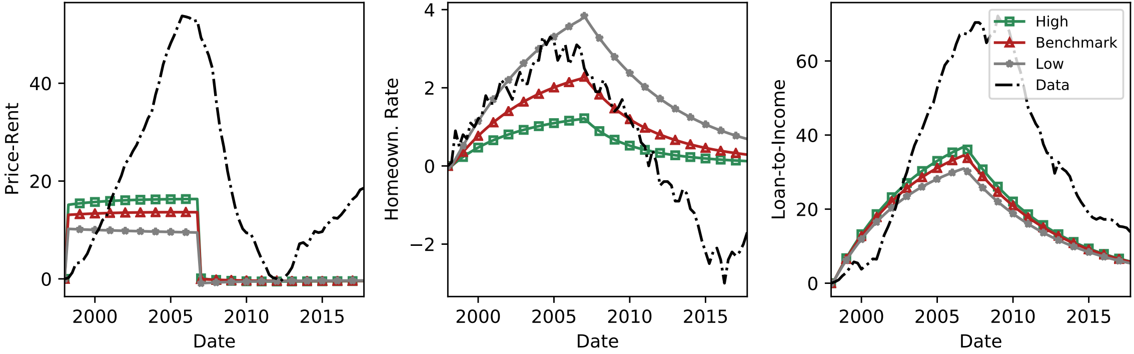
- Removing credit expansion + interest rates (leaving beliefs only) reduces rise in price-rent ratios by 3%, rise in LTI by 47%.



Credit Expansion: Robustness

Back

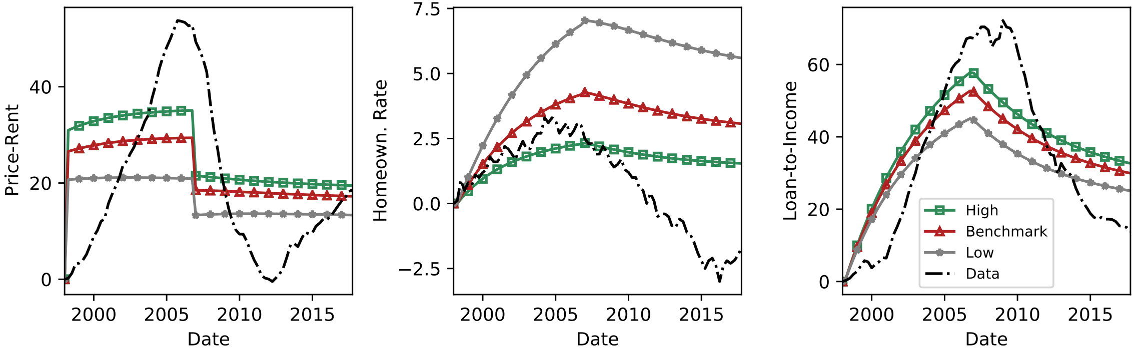
- Credit expansion alone explains 18% of increase in price-rent ratios when matching slope of 2.5, 31% for slope of 10 (28% in baseline)



Credit Expansion + Rates: Robustness

Back

- Credit expansion plus 2ppt drop in rates explains 40% of increase in price-rent ratios when matching slope of 2.5, 66% for slope of 10 (60% in baseline)



New Homeownership Data

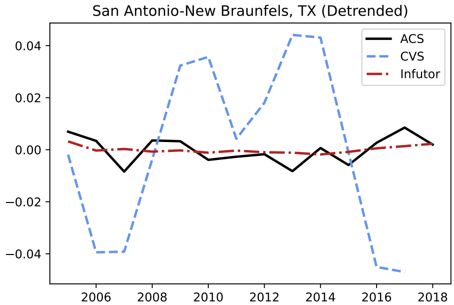
Back

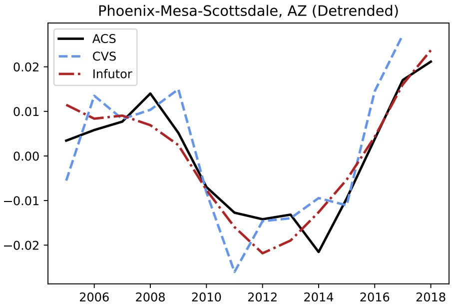
- Main challenge to current empirics is imprecision of homeownership estimates.
  - Census Vacancy Survey is noisy and has broken panel due to CBSA redefinition every 10 years.
  - ACS is better, but only begins in 2005.
- Our approach): construct our own homeownership rates directly from microdata.
  - Infutor data tracking address history of most adults.
  - ZTRAX deeds data.
- By merging these, we know for each address at each time (i) who lives there, and (ii) who the owners are.
  - If there is any overlap (using last name for now) then the unit is owner-occupied.
  - Remove trends in Infutor coverage by benchmarking to decennial census + ACS.

Homeownership Data Comparison

▸ Back

- Compare ACS, CVS, Infutor (new) series.
- Remove time, geographic fixed effects, as well as location-specific linear trend.
- Removes noise but still able to pick up actual movements well.

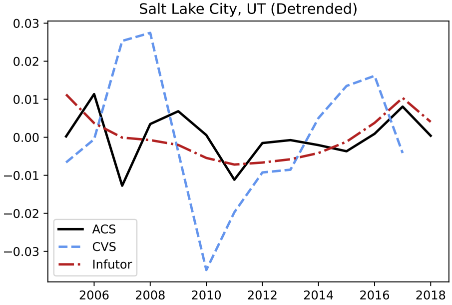


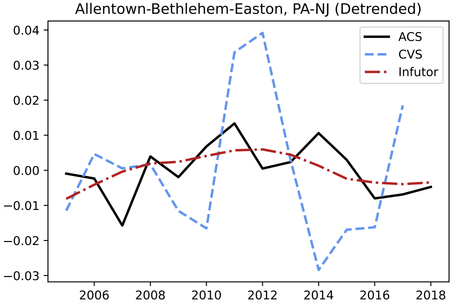


Homeownership Data Comparison

▶ Back

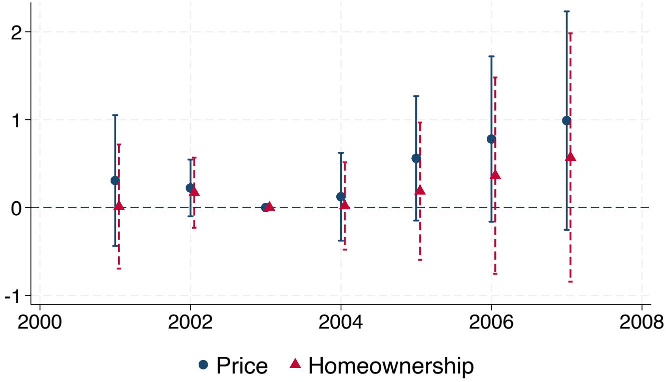
- Additional examples of noise reduction:





DiMaggio-Kermani With Census HVS Data

Back



Mian-Sufi With Census HVS Data

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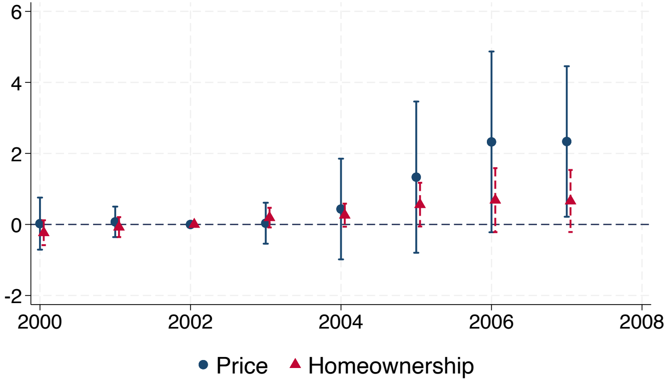

Comparison of HOR Data

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