Financial Theory IV: Macrofinance II, Households

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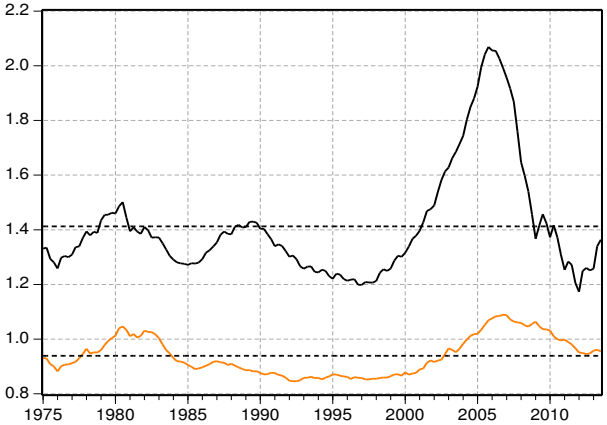
Introduction

- Today's lecture: interaction of households with financial markets.
  - Focus on housing and mortgages.
  - Why? Dominant asset for typical household, while mortgage is the dominant liability.
  - Housing and mortgage markets at center of global financial crisis.
- This lecture:
  1. Basic facts.
  2. Credit standards: LTV vs. PTI limits.
  3. When does credit move house prices?
  4. Some final thoughts about the research process.

Housing and Mortgages: Stylized Facts

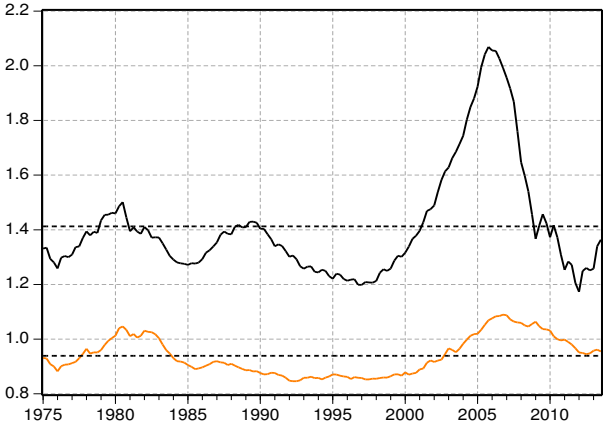
Housing Wealth

- Plots from Davis and Van Nieuwerburgh (2014).



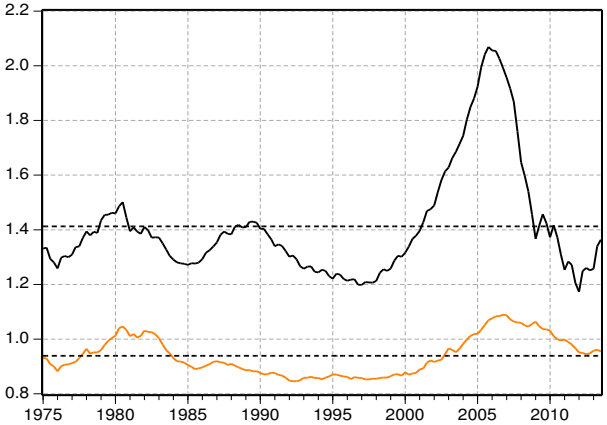
Housing Wealth

- Ratios of **housing wealth** and **structures** to GDP, 1975:Q1 - 2013:Q3.



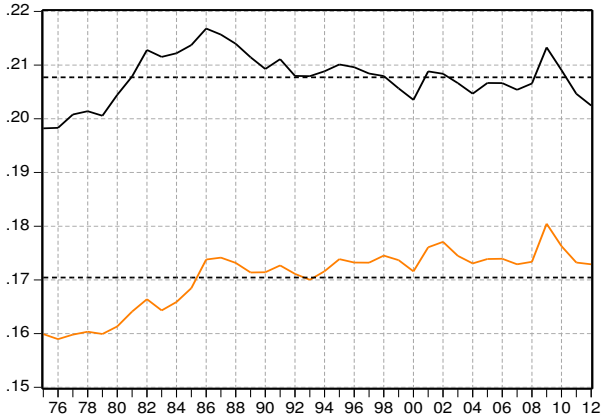
Housing Wealth

- Market value of land is $\sim 1/3$ of housing wealth, but highly volatile. Biggest factor in recent boom-bust.



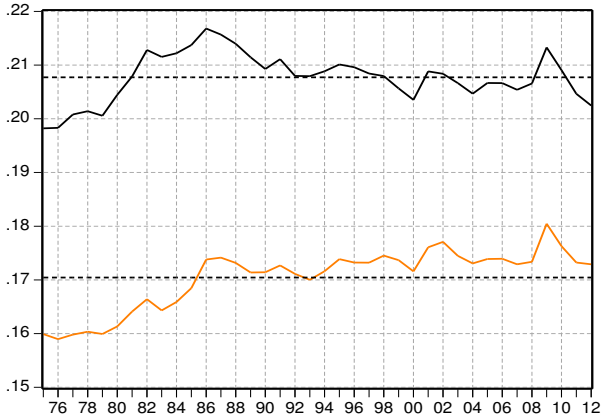
Housing Expenditures

- Ratios of **housing and utilities spending** and **housing spending** to nondurable consumption expenditures, 1975:Q1 - 2013:Q3.



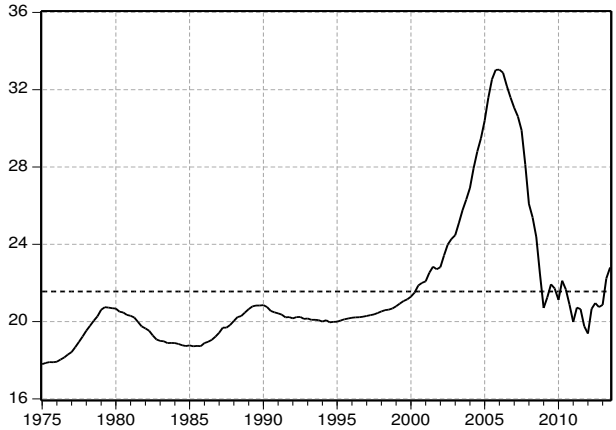
Housing Expenditures

- Very stable, little realized composition risk in recent years.



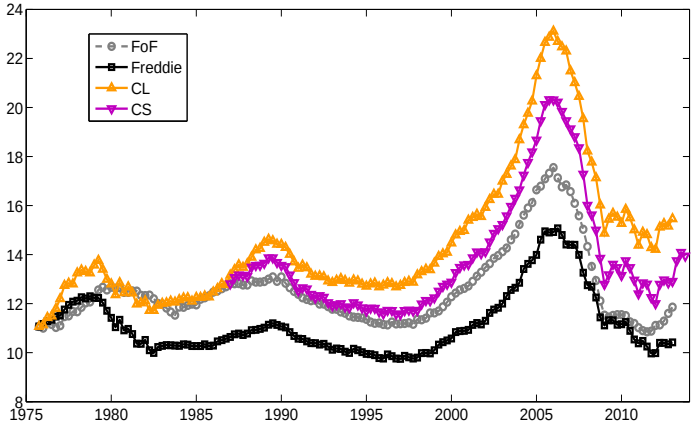
Price-Rent Ratios

- Instead, 2000s boom was mostly in price-rent ratios.



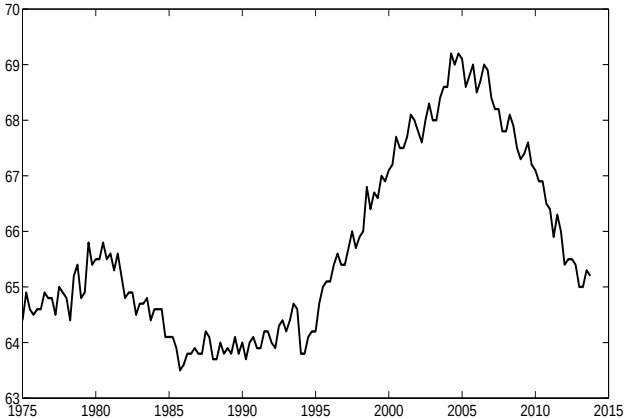
Price-Rent Ratios

- Many ways to measure price-rent ratios, but all tell a similar story.



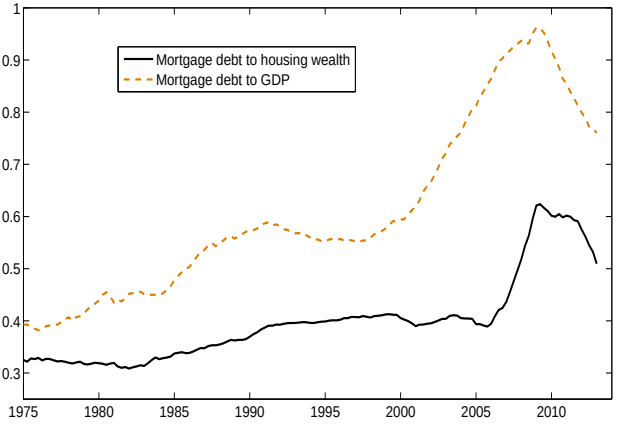
Homeownership Rate

- Homeownership rate has similar boom-bust, slightly leading price-rent ratios.



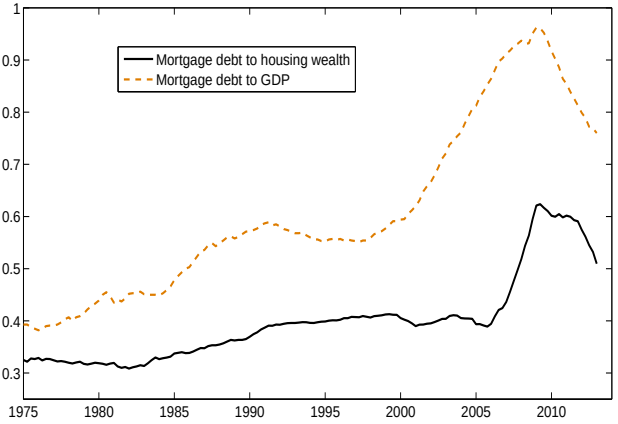
Mortgage Debt

- Mortgage debt rising relative to GDP throughout boom.



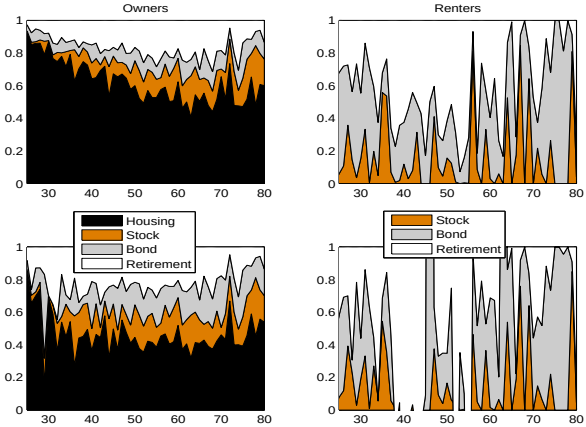
Mortgage Debt

- But debt-housing wealth is flat over boom, only spikes when house prices fall in bust.



Household Portfolios

- Shares of portfolio (top) and net worth (bottom). For most homeowners, housing is by far most important asset.



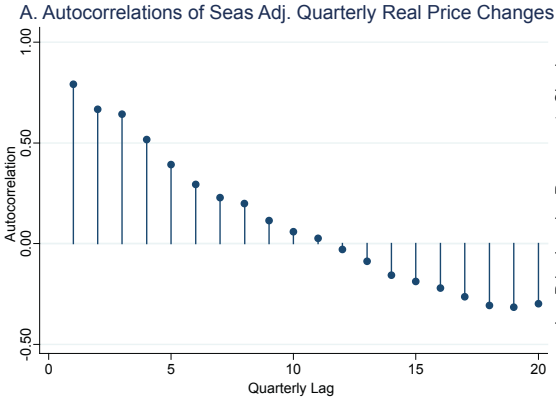
Housing Cyclicalities

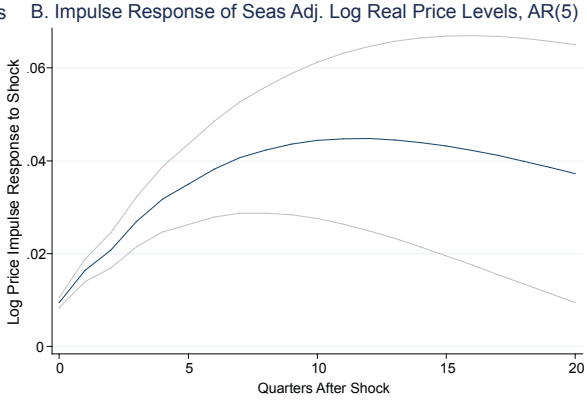
- House prices, residential investment strongly procyclical.
- Residential investment extremely volatile, leads business cycle.

	Variable X	Std. Dev	Relative Std. Dev	Correlation of Variable X_s and GDP_t s = t-3	t-2	t-1	t	t+1	t+2	t+3
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(a)	GDP	1.54	1.00	0.40	0.64	0.86	1.00	0.86	0.65	0.42
(b)	Consumption	0.85	0.55	0.49	0.67	0.81	0.84	0.75	0.59	0.41
(c)	Non-Res. Invest	4.74	3.07	0.13	0.36	0.61	0.81	0.87	0.82	0.70
(d)	Res. Invest	9.98	6.47	0.67	0.75	0.76	0.66	0.45	0.21	-0.02
(e)	House Prices*	4.16	2.70	0.47	0.53	0.55	0.52	0.46	0.41	0.35
(f)	Durables Quant.	4.49	2.91	0.51	0.67	0.79	0.82	0.65	0.44	0.21
(g)	Durables Prices	0.93	0.60	0.13	0.05	-0.04	-0.15	-0.24	-0.30	-0.35

Housing Cyclicalities

- House prices exhibit substantial momentum, eventual reversal (Guren, 2016).





House Price Determinants: Basic Theory

Simple Model

- Traditional macro-housing model with one-period debt (Iacoviello, 2005).
- Representative borrower maximizes

$$V_{b,t} = E_t \sum_{j=0}^{\infty} \beta_b^j u(c_{b,t+j}, h_{b,t+j-1})$$

subject to

$$c_{b,t} \leq y_t - p_t^h(h_t - h_{t-1}) + m_t - R_{t-1}m_{t-1}$$
$$m_t \leq \theta p_t^h h_t.$$

- Housing optimality condition:

$$p_t^h = \frac{E_t\left[\Lambda_{b,t+1}\left(\rho_{t+1} + p_{t+1}^h\right)\right]}{1 - \mu_t\theta}$$

where $\rho_t = u_{b,t}^h / u_{b,t}^c$ and μ_t is multiplier on collateral constraint.

Simple Model

- Express as price-rent ratio $PR_t = p_t^h / \rho_t$:

$$PR_t = \frac{E_t \left[\Lambda_{b,t+1} \left(1 + PR_{t+1} \right) \left(\rho_{t+1} / \rho_t \right) \right]}{1 - \mu_t \theta}$$

- Three possible reasons price-rent ratios move.

1. Change in risk premium. (e.g., Favilukis et al., 2017).
2. Change in expected rent growth. (e.g., Kaplan et al., 2020).
3. Change in collateral premium. (e.g., Greenwald, 2018).

House Prices and Credit Constraints

Justiniano, Primiceri, Tambalotti (2019)

- In simple LTV-only model, increasing θ increases prices.
- Now consider extension with two constraints, no heterogeneity:

$$m_t \leq \theta p_t^h h_t$$
$$m_t \leq \bar{M}_t.$$

- Optimality conditions:

$$p_t^h = \frac{E_t\left[\Lambda_{b,t+1}\left(\rho_{t+1} + p_{t+1}^h\right)\right]}{1 - \theta\mu_{1,t}}$$
$$\mu_t \equiv \mu_{1,t} + \mu_{2,t} = 1 - R_t E_t\left[\Lambda_{b,t+1}\right]$$

- Surprising result: region of state space with positive measure where both constraints bind.

Justiniano, Primiceri, Tambalotti (2019)

- Proof by contradiction.
- If only collateral constraint binds, $\mu_{1,t} = \mu_t$ and price is

$$\bar{q}_t^h = \frac{E_t\left[\Lambda_{b,t+1}\left(\rho_{t+1} + p_{t+1}^h\right)\right]}{1 - \theta\mu_t}$$

- If only alternative constraint binds, $\mu_{1,t} = 0$ and price is

$$\underline{q}_t^h = E_t\left[\Lambda_{b,t+1}\left(\rho_{t+1} + p_{t+1}^h\right)\right] < \bar{q}_t^h$$

- For $\theta \underline{q}_t^h h_t \leq \bar{M}_t \leq \theta \bar{q}_t^h h_t$, must have both constraints binding (only way to get $0 < \mu_{1,t} < \mu_t$).
- In this region, we have $q_t^h = \bar{M}_t / \theta h_t$.
  - Price moves one-for-one with $\bar{M}_t$, while price falls with θ.

Justiniano, Primiceri, Tambalotti (2019)

- JPT further claim that second constraint $\bar{M}$ needs to be on lender side.
- Demand-driven credit booms have counterfactual prediction that interest rates should rise:

$$R_t = \frac{1 - \mu_t}{\beta E_t \left[\Lambda_{b,t+1}\right]}$$

since $\mu_t \to 0$ as constraints loosen.

- Instead, can use lending supply constraint:

$$R_t = \frac{1 + \tilde{\mu}_t}{\beta E_t \left[\Lambda_{s,t+1}\right]}$$

where $\tilde{\mu}$ is lender multiplier.

- Now rates fall as $\tilde{\mu} \to 0$, matching boom experience.

Justiniano, Primiceri, Tambalotti (2019)

- What's behind these results?
- Rate borrowers are willing to pay higher than rate lenders willing to accept.
- When only borrowers are constrained, effectively have all bargaining power, lenders forced to compete for them.
  - Equilibrium rate is lender reservation rate.
- When only lenders are constrained, situation is reversed, rate is borrower reservation rate.
- At the end of the day, comes down to assumptions on who has bargaining power. Can support many prices when credit is rationed.
  - Possible area for future research!

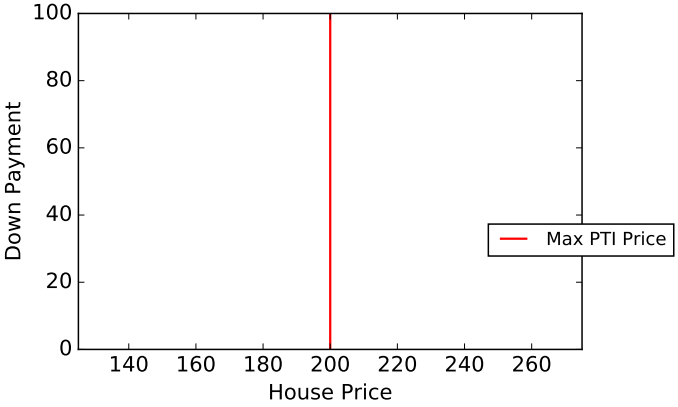
Case Study: The Mortgage Credit Channel of Macroeconomic Transmission

Greenwald (2018)

- **Approach**: General equilibrium framework with two novel features.
  1. Size of new loans limited by payment-to-income (PTI) constraint, alongside loan-to-value (LTV) constraint.
  2. Borrowers hold long-term, fixed-rate loans and can choose to prepay existing loans and replace with new ones (see paper).
- **Main Finding**: PTI liberalization appears essential to boom-bust.
  - Changes in LTV standards alone insufficient. PTI liberalization compelling theoretically and empirically.
  - Quantitative impact: 35% of observed rise in price-rent ratios, 42% of the rise in debt-household income from PTI relaxation alone.

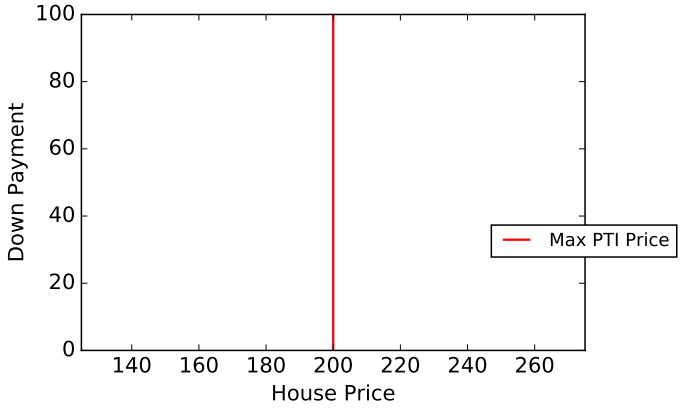
Simple Example

- Consider homebuyer who wants large house, minimal down payment. Faces PTI limit of 28%, LTV limit of 80%.



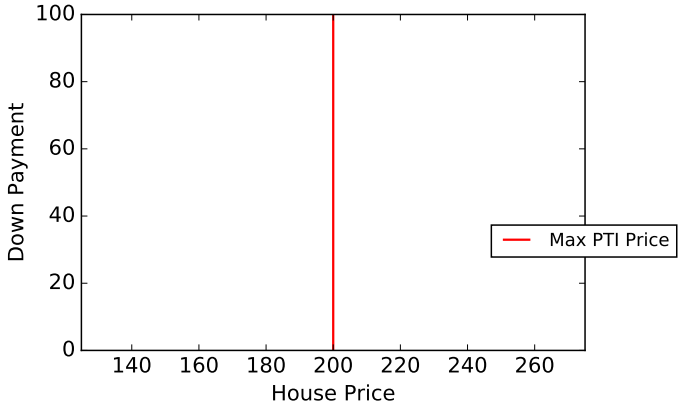
Simple Example

- At income of \$50k per year, 28% PTI limit $\implies$ max monthly payment of $\sim$ \$1,200.



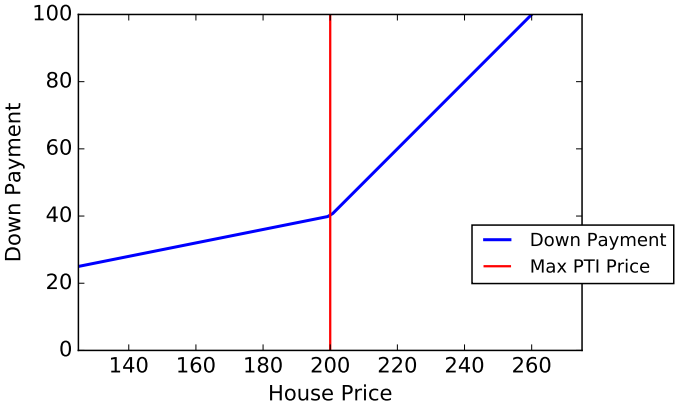
Simple Example

- At 6% interest rate, $1,200 payment $\implies$ maximum PTI loan size $160k. Plus 20% down payment $\implies$ house price of $200k.



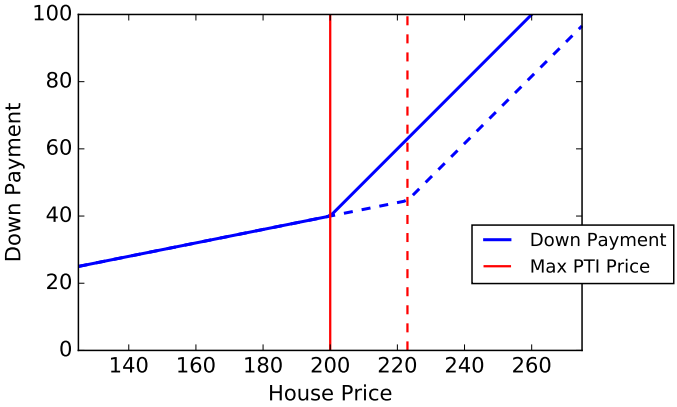
Simple Example

- Kink in down payment at price $200k. Below this point size of loan limited by LTV, above by PTI. Kink likely optimum for homebuyers.



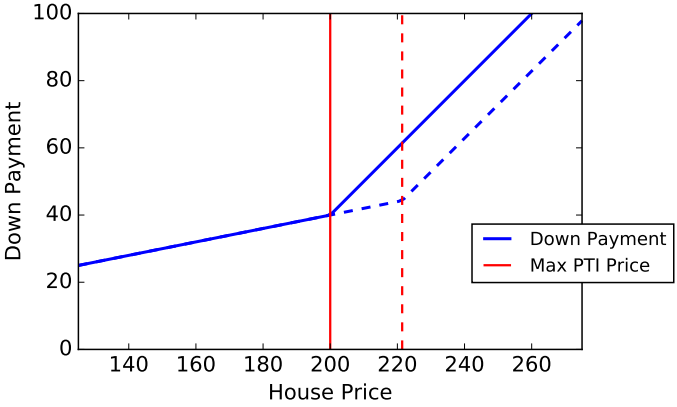
Simple Example

- Interest rates fall from 6% to 5%. Borrower's max PTI now limits loan to $178k (rise of 11%). Kink price now $223k, housing demand increases.



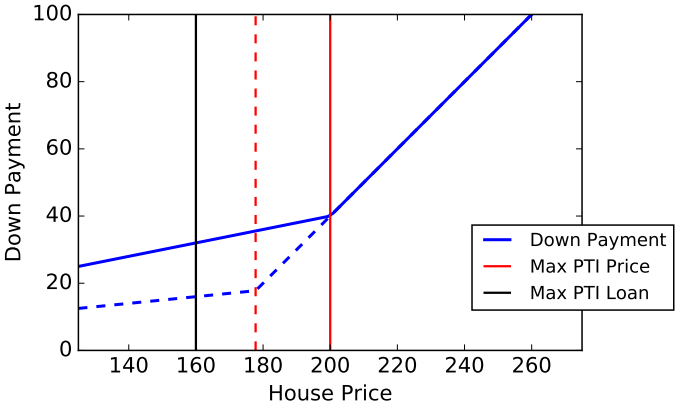
Simple Example

- Increasing the maximum PTI ratio from 28% to 31% has a similar effect to fall in rates, increases max loan size and corresponding price.



Simple Example

- In contrast, increasing maximum LTV ratio from 80% to 90% means that $160k loan associated with only $178k house. Housing demand falls.



Model Overview

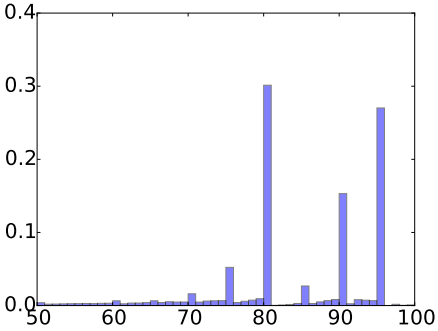
- Borrowing $\implies$ impatient borrowers/patient savers.
  - Permanent types with fixed measure χ_j for $j \in \{b, s\}$.
  - Preferences:
$$V_{j,t} = \log(c_{j,t}/\chi_j) + \xi \log(h_{j,t}/\chi_j) - \eta \frac{(n_{j,t}/\chi_j)^{1+\varphi}}{1+\varphi} + \beta_j E_t V_{j,t+1}$$
- Mortgage debt $\implies$ durable housing.
  - Divisible, cannot change stock without prepaying mortgage.
  - Fixed housing stock, saver housing demand.
- Realistic mortgage contracts $\implies$ long-term fixed-rate bonds
  - Endogenous fraction ρ_t prepay each period, update balance and interest rate.
- Movements in long rates $\implies$ shock to inflation target (nominal), term premia (real).
- Effects on real economy $\implies$ labor supply, sticky prices, TFP shocks.

Credit Limits

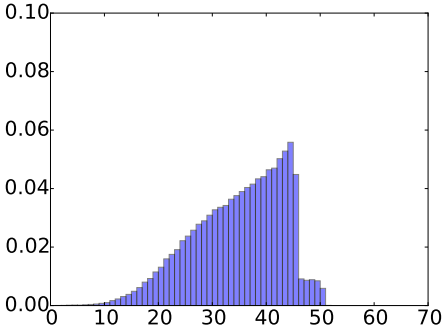
- Borrowers face two credit limits at origination only.
- Loan-to-value constraint: $m^*_{i,t} \leq \theta^{ltv} p^h_t h^*_{i,t}$.
  - Widely studied in the literature.
  - Key property: moves with house prices.
  - $\bar{m}^{ltv}_{i,t} \equiv \theta^{ltv} p^h_t h^*_{i,t}$.
- Payment-to-income constraint: $(r^*_t + \alpha) m^*_{i,t} \leq (\theta^{pti} - \omega) \cdot \text{income}_{i,t}$.
  - Real constraint affecting all US borrowers, but largely unstudied in macro.
  - Key property: moves with interest rates (elasticity $\simeq 8$).
  - $\bar{m}^{pti}_{i,t} \equiv (\theta^{pti} - \omega) \cdot \text{income}_{i,t} / (r^*_t + \alpha)$.
- Overall limit: $m^*_{i,t} \leq \min\left(\bar{m}^{ltv}_{i,t}, \bar{m}^{pti}_{i,t}\right)$.

LTV and PTI in the Data

- LTV limits show up as large single-bin spikes at various institutional limits.



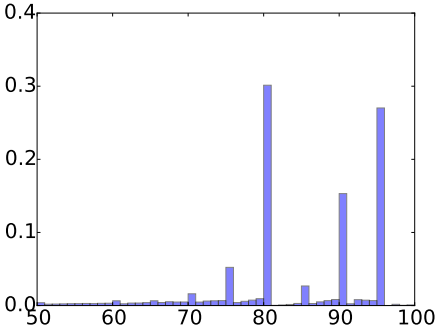
(a) CLTV Histogram: 2014 Q3



(b) PTI Histogram: 2014 Q3

LTV and PTI in the Data

- PTI ratios instead look like truncated distribution. Are borrowers constrained?



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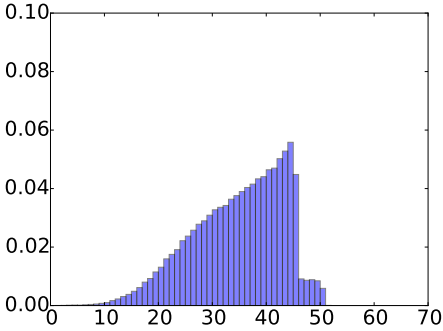
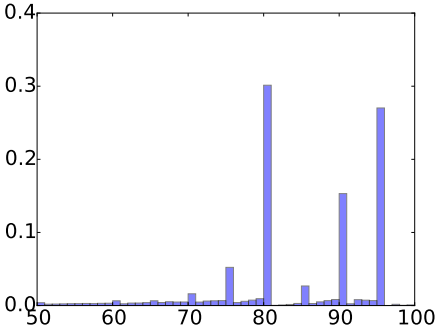


(b) PTI Histogram: 2014 Q3

LTV and PTI in the Data

- Interpretation: some borrowers search for a house that exactly satisfies both limits, but may end up with one a little smaller. Then max out LTV.



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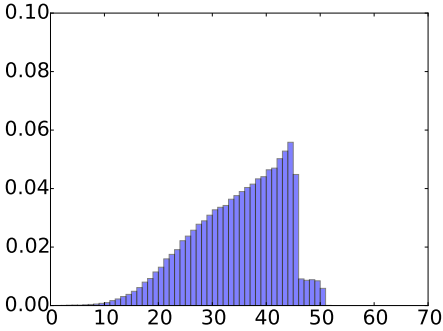
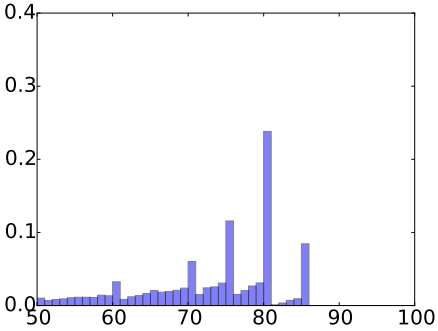


(b) PTI Histogram: 2014 Q3

LTV and PTI in the Data

- Support for theory: PTI bunching larger in cash-out refinances, where no housing search occurs (even though LTVs lower).



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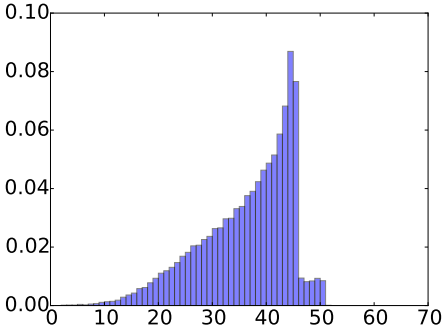

(b) PTI Histogram: 2014 Q3

Representative Borrower's Housing Decision

- Housing optimality condition (unconstrained or no LTV):

$$p_t^h = \frac{u_{b,t}^h / u_{b,t}^c + E_t \left\{ \Lambda_{b,t+1} p_{t+1}^h \left[1 - \delta \right] \right\}}{1}$$

- $\Lambda_{b,t+1}$ is borrower stochastic discount factor, μ_t is multiplier on credit constraint.
- $\mathcal{C}_t$ ("collateral value") is marginal value of relaxing constraint via extra \$1 of house value:

$$\mathcal{C}_t \equiv \mu_t F_t^{ltv} \theta^{ltv}$$

  where F_t^{ltv} is fraction constrained by LTV.

- Note: p_t^h is the price of housing that can be used to collateralize a new loan.

Representative Borrower's Housing Decision

- Housing optimality condition ($\rho_{t+1} = 1$, LTV only):

$$p_t^h = \frac{u_{b,t}^h / u_{b,t}^c + E_t \left\{ \Lambda_{b,t+1} p_{t+1}^h \left[1 - \delta \right] \right\}}{1 - \mu_t \theta^{ltv}}$$

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Representative Borrower's Housing Decision

- Housing optimality condition ($\rho_{t+1} = 1$, LTV and PTI):

$$p_t^h = \frac{u_{b,t}^h / u_{b,t}^c + E_t \left\{ \Lambda_{b,t+1} p_{t+1}^h \left[1 - \delta \right] \right\}}{1 - \mathcal{C}_t}$$

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- Note: p_t^h is the price of housing that can be used to collateralize a new loan.

Representative Borrower's Housing Decision

- Housing optimality condition (Benchmark model):

$$p_t^h = \frac{u_{b,t}^h / u_{b,t}^c + E_t \left\{ \Lambda_{b,t+1} p_{t+1}^h \left[1 - \delta - (1 - \rho_{t+1}) \mathcal{C}_{t+1} \right] \right\}}{1 - \mathcal{C}_t}$$

- $\Lambda_{b,t+1}$ is borrower stochastic discount factor, μ_t is multiplier on credit constraint.
- $\mathcal{C}_t$ ("collateral value") is marginal value of relaxing constraint via extra \$1 of house value:

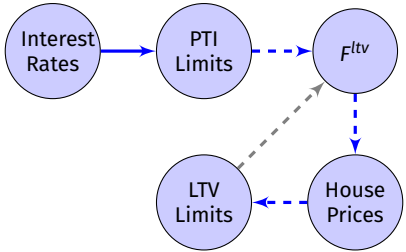
$$\mathcal{C}_t \equiv \mu_t F_t^{ltv} \theta^{ltv}$$

  where F_t^{ltv} is fraction constrained by LTV.

- Note: p_t^h is the price of housing that can be used to collateralize a new loan.

Constraint Switching Effect

- When rates fall, PTI limits loosen.
- Borrowers switch from PTI-constrained to LTV-constrained, increasing F_t^{ltv}.
- House prices rise, also loosening LTV limits.

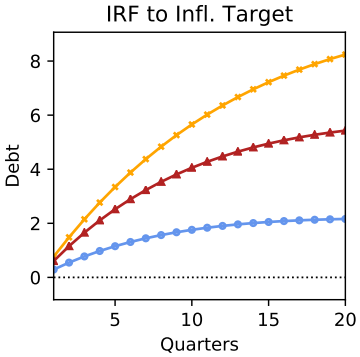


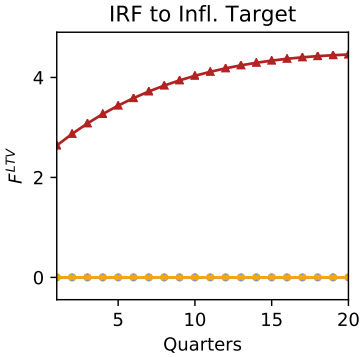
Comparison of Models

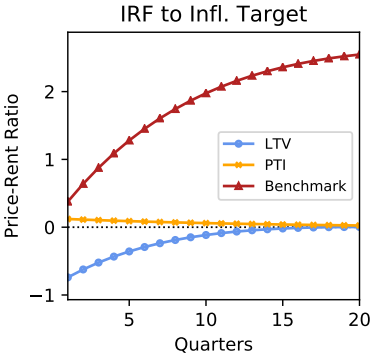
- **Main Result #1:** Strong transmission from interest rates into debt, house prices, economic activity.
- **Experiment:** consider economies that differ by credit limit and compare propagation of shocks:
  1. **LTV Economy**: LTV constraint only.
  2. **PTI Economy**: PTI constraint only.
  3. **Benchmark Economy**: Both constraints, applied borrower by borrower.
- **Computation:** Linearize model to obtain impulse responses.

Constraint Switching Effect (Monetary Policy Shock)

- Important feature of PTI limits: endogenously shifted by interest rates.
- IRF to near-permanent -1% (annualized) fall in nominal rates.

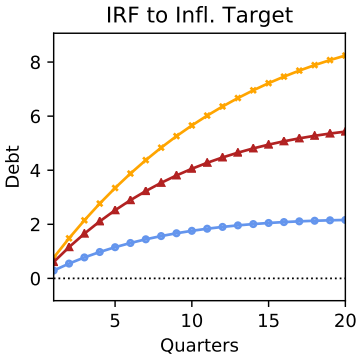


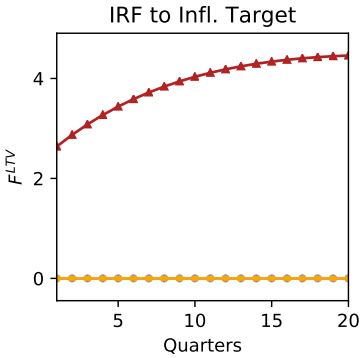


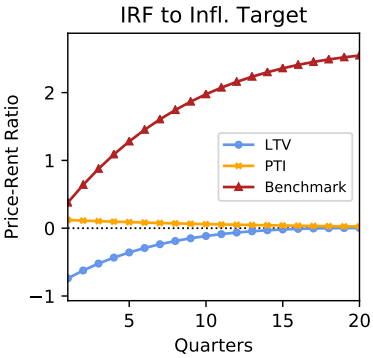


Constraint Switching Effect (Monetary Policy Shock)

- Debt response of Benchmark Economy closer to PTI Economy even though most borrowers constrained by LTV (75% in steady state).





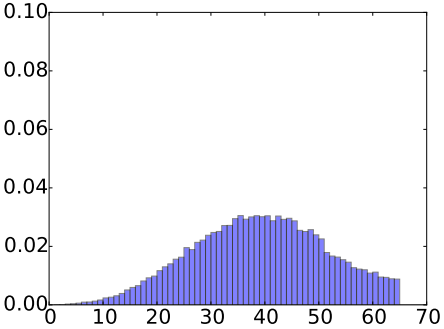


Credit Standards and the Boom-Bust

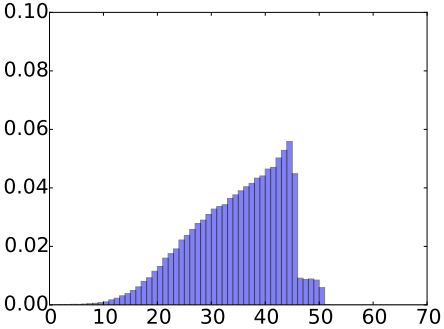
- **Main Finding:** PTI liberalization essential to the boom-bust.
  - So far, have been treating maximum ratios $\theta^{ltv}, \theta^{pti}$ as fixed, but credit standards can change.
  - Fannie/Freddie origination data: substantial increase in PTI ratios in boom.

Credit Standards and the Boom-Bust

- Fannie Mae data: PTI constraints appear to bind after bust but not during boom.



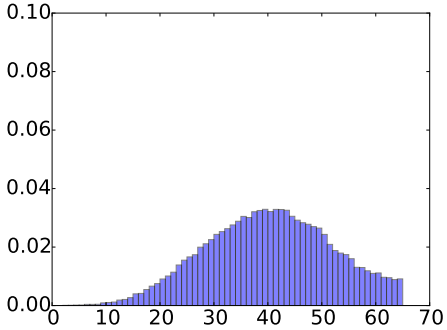
(a) PTI Histogram: 2006 Q1



(b) PTI Histogram: 2014 Q3

Credit Standards and the Boom-Bust

- Cash-out refi plots even more striking.



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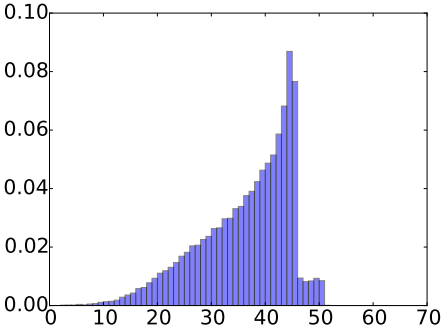
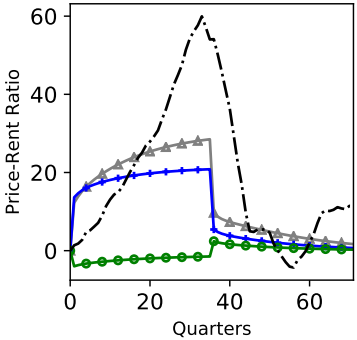


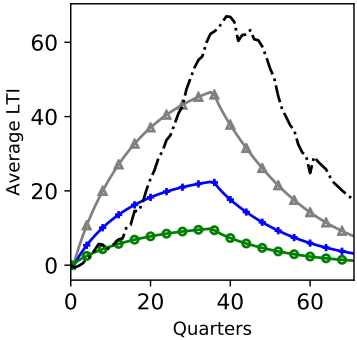
(b) PTI Histogram: 2014 Q3

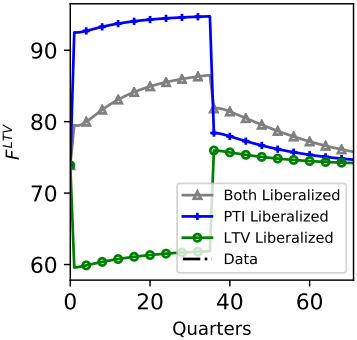
- **Main Finding:** PTI liberalization essential to the boom-bust.
  - So far, have been treating maximum ratios $\theta^{ltv}, \theta^{pti}$ as fixed, but credit standards can change.
  - Fannie/Freddie origination data: substantial increase in PTI ratios in boom.
- **Experiment**: unexpectedly change parameters, unexpectedly return to baseline 32Q later.
  1. **PTI Liberalization**: θ^{pti} from 0.36 $\rightarrow$ 0.54.
  2. **LTV Liberalization**: θ^{ltv} from 0.85 $\rightarrow$ 0.99.
- Computation: nonlinear transition paths.
  - Reference: Juillard, Laxton, McAdam, Pioro (1998).

Credit Liberalization Experiment

- LTV liberalization generates small rise in debt-to-household income (15%). House prices, price-rent ratios **fall** (-2%).

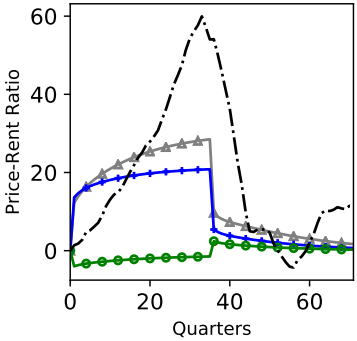


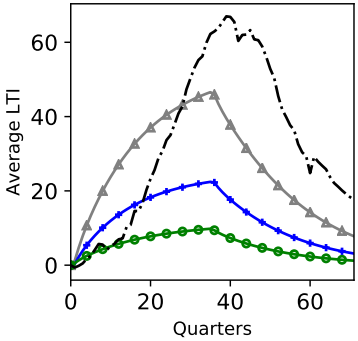


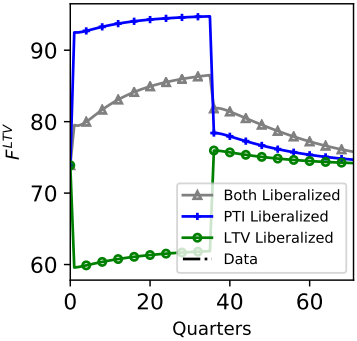


Credit Liberalization Experiment

- PTI liberalization generates large boom in house prices, price-rent ratios (35%), debt-household income (33%).

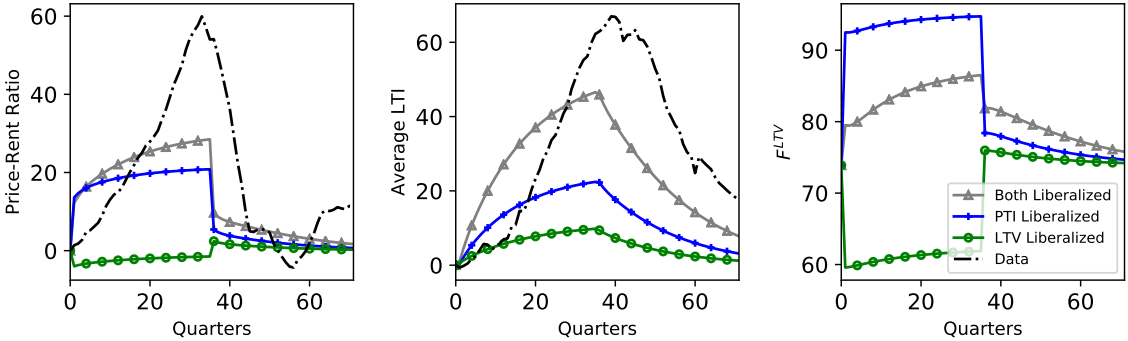






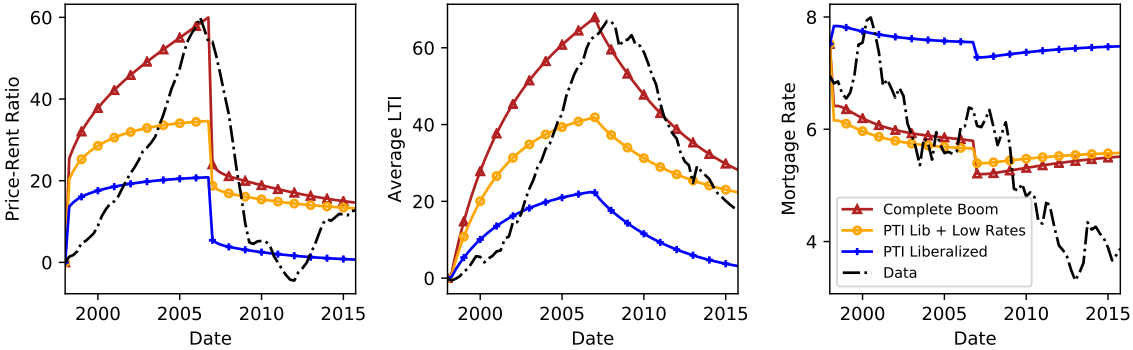
Credit Liberalization Experiment

- Liberalized PTI amplifies contribution of other factors (e.g., LTV liberalization) to boom.



Explaining the Boom

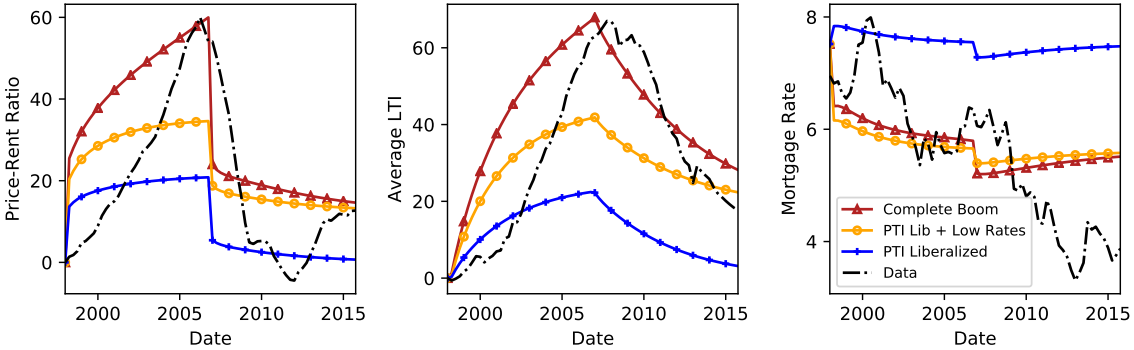
- Add observed drop in mortgage rates: 0.82% fall in expected inflation, 1.08% fall in real rates. Captures 58% of price-rent, 62% of LTI increases.



▸ More Series

Explaining the Boom

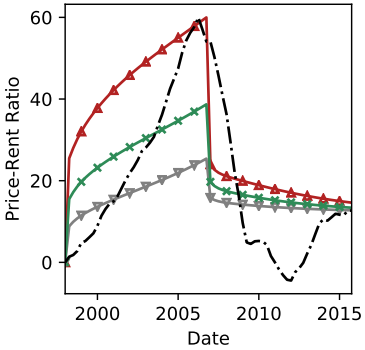
- Overoptimistic HP beliefs (anticipated 24% increase in utility) small increase in LTV limit (85% $\rightarrow$ 88%) can explain remaining share.

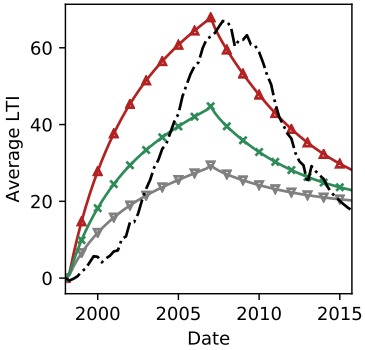


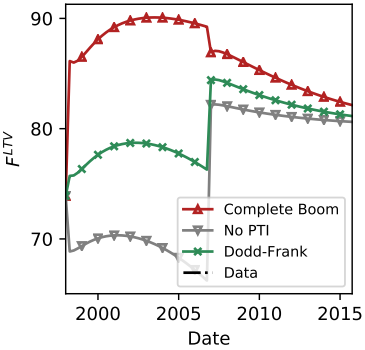
More Series

Macroprudential Policy

- But without PTI liberalization, other forces severely diminished, explain only 42% of price-rent, 43% of debt-income $\implies$ necessary condition.



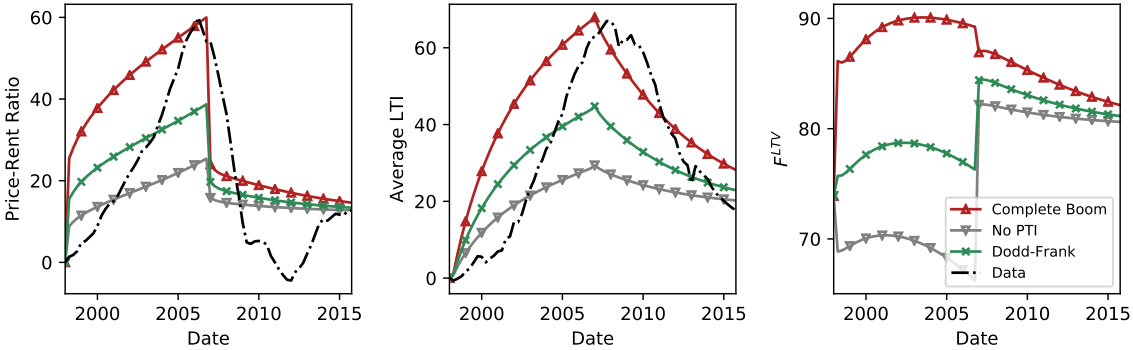




▸ More Series

Macroprudential Policy

- Liberalizing PTI only to Dodd-Frank limit of (36% $\rightarrow$ 43%) would have made a big difference (down to 65% of price-rent, debt-income).



▸ More Series

Summary: Credit Standards

- Two key constraints in US mortgage market: LTV and PTI.
- Interaction $\implies$ constraint switching effect:
  - Shifts in PTI limits lead to large movements in house prices.
- Loosening PTI limits key to 2000s housing boom.
  - Largest change in credit standards from microdata.
  - Model: observed PTI relaxation alone can explain $\sim 1/3$ of boom.
  - Removing PTI would kill $\sim 60\%$ of boom due to interaction with expectations.
- Note: PTI limits has loosened again (to a smaller degree).

Case Study:
Do Credit Conditions Move House Prices?

Greenwald and Guren (2024)

- **Do Credit Conditions Move House Prices?**
- Previous paper considers which constraint was most relevant for housing boom.
- Broader debate in the literature: did credit matter at all?
  - Fundamental question for macroprudential policy.
- Two prominent (and opposing) examples:
  - Faviliukis-Ludvigson-Van Nieuwerburgh: Credit explains most (60%) of movement in prices.
  - Kaplan-Mitman-Violante: Credit had virtually no effect on prices.

Favilukis, Ludvigson, Van Nieuwerburgh (2017 JPE)

- Large scale heterogeneous agent life-cycle model with idio + aggregate shocks.
- Financial market liberalization (modeled as increase in LTV ratio) explains housing boom.
- Two separate contributions of LTV relaxation:
  - Increase in collateral value.
  - Fall in risk premia due to improved risk sharing.
- Risk sharing result likely depends on how mortgage contract is modeled.
  - Hurst and Stafford (2004) show this is an important margin.
  - FLVN use one-period debt, ideal for consumption smoothing in normal times/boom.
  - With realistic debt that is long-term, costly to refinance, risk-sharing impact may be smaller.

Kaplan, Mitman, Violante (2020 JPE)

- Large scale heterogeneous agent life-cycle model with idio + aggregate shocks.
- Financial market liberalization (modeled as increase in LTV + PTI ratios) **cannot** explain housing boom.
  - Relaxation of credit leads households to buy from their landlords.
  - Increases the homeownership rate, but not the price-rent ratio.
- Instead, shocks to **expectations** of future rental growth explain the rise in price-rent ratio.

Greenwald and Guren (2024)

- **Do Credit Conditions Move House Prices?**
- Previous paper considers which constraint was most relevant for housing boom.
- Broader debate in the literature: did credit matter at all?
  - Fundamental question for macroprudential policy.
- Two prominent (and opposing) 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.

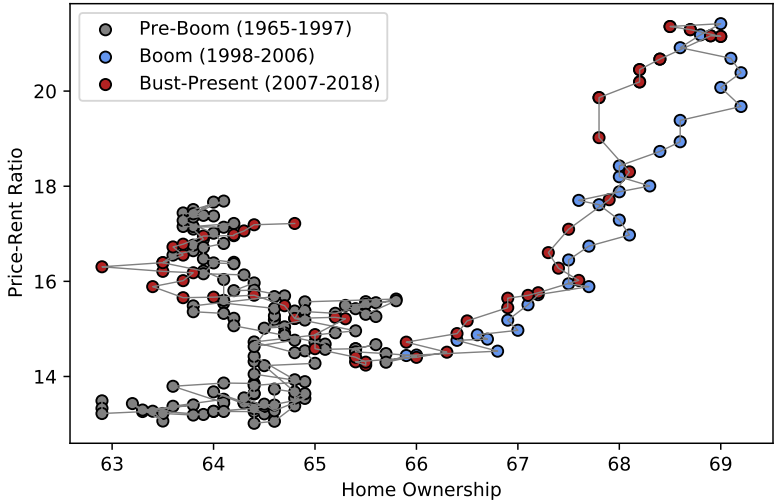
Greenwald and Guren (2024)

- 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 landlord, prices pinned down by PV of rents (e.g., KMV).
- **Unconstrained savers** can play similar role unless their housing is segmented.

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 **3**$\times$ 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.

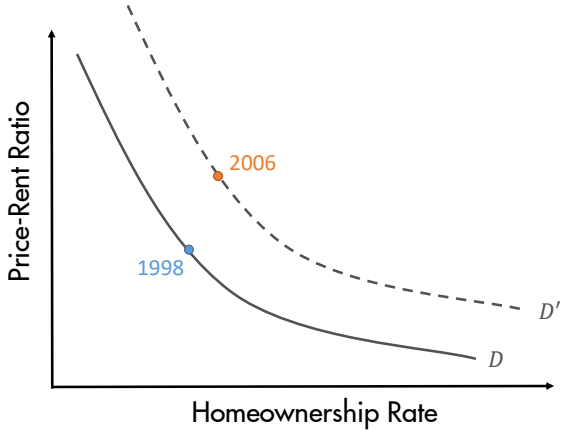
Time Series: Price-Rent Ratio vs. Home Ownership Rate



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

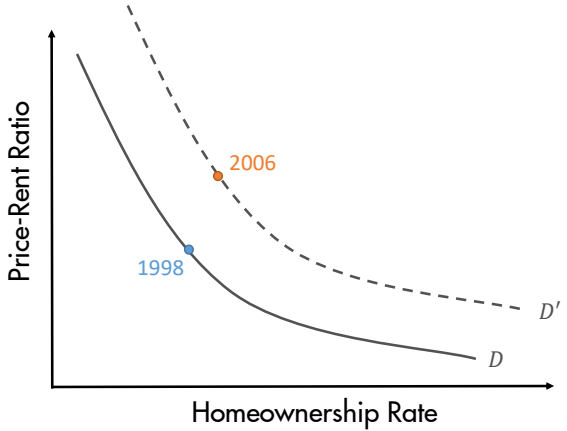
Intuition: Modified Supply and Demand

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



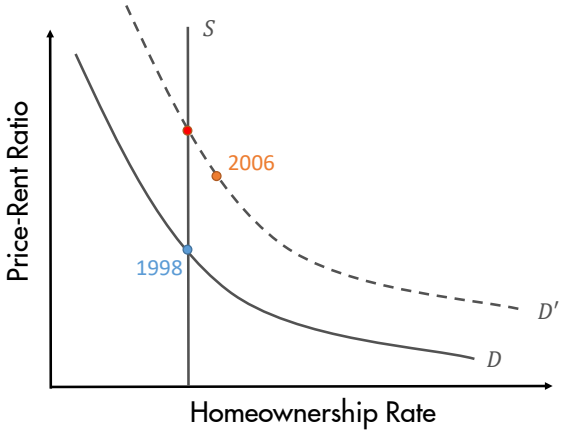
Intuition: Modified Supply and Demand

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



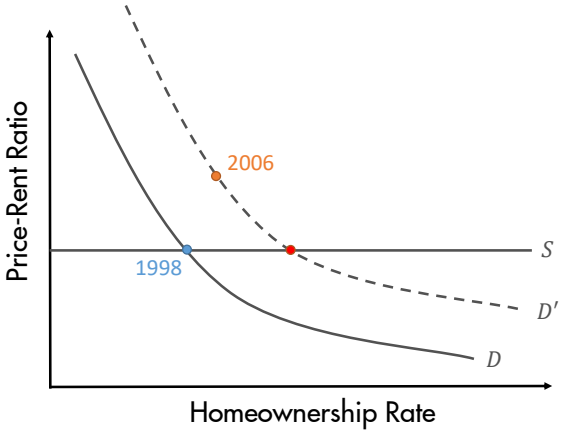
Intuition: Modified Supply and Demand

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



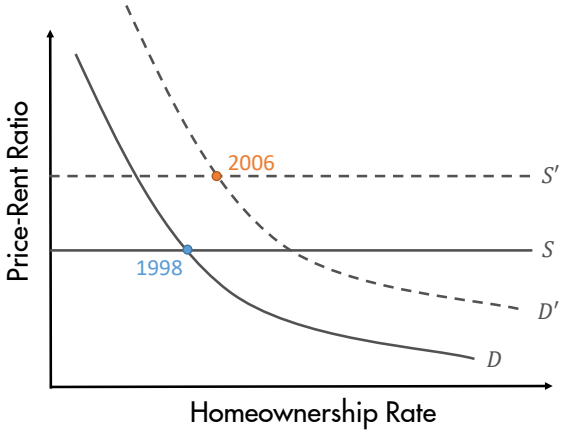
Intuition: Modified Supply and Demand

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



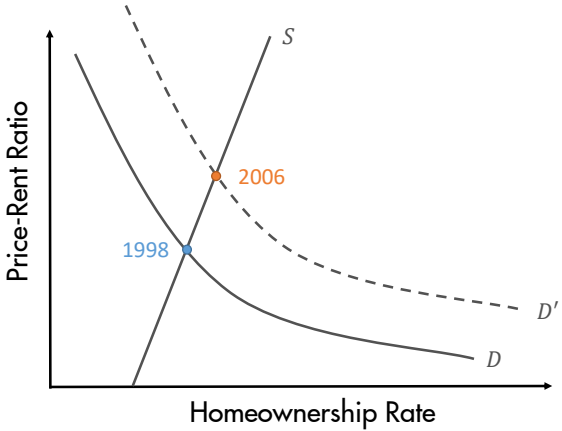
Intuition: Modified Supply and Demand

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



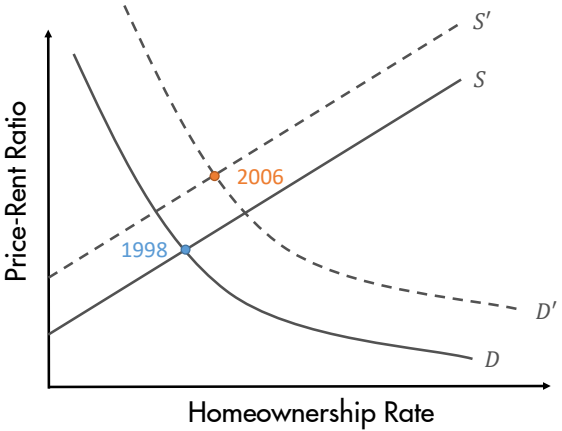
Intuition: Modified Supply and Demand

- 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 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.

Data

- CBSA-Level Panel 1990-2017
- 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: Census Housing and Vacancy Survey
  - CBSA definitions change over time. Drop periods where definitions change.
  - Use state data with fixed definitions as robustness check.

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.
  - Instruments: Frac. originations within 5% of CLL at $t-1 \times$ % change in CLL, interaction of this with Saiz instrument (effect of share-shift estimated for supply elasticity that maximizes power)
- Identifying assumption: No non-credit shock that varies with CLL in time series and affects more exposed cities in cross section.
- Local Projection: for $k = 0, ..., 5$,

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

where X_t includes $Fraction_{i,t-1}$ as well as lags of instruments and credit variable.

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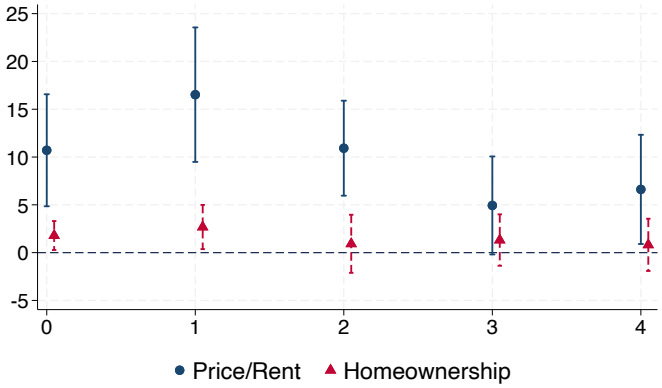
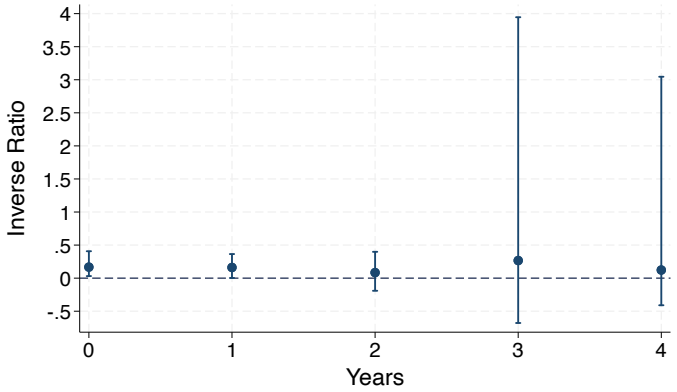
CLL Impulse Response: Credit Shock

- Price-rent ratio peaks at 16.5, compared to 2.7 for HOR.



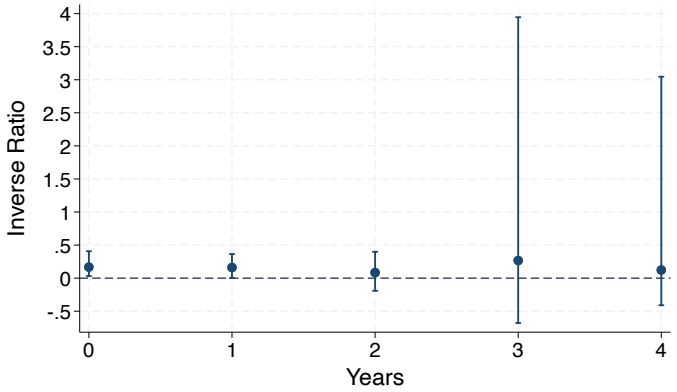
CLL Impulse Response: Credit Shock (Panel Local Projection IV)

- Compute confidence interval for slope by block bootstrapping coefficients.
  - Compute **inverse ratio** because CI for homeownership crosses zero.



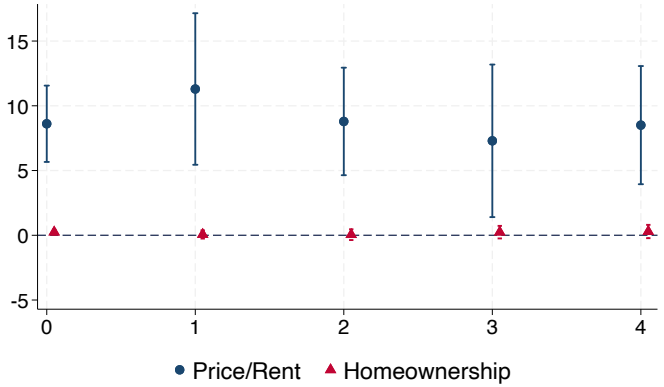
CLL Impulse Response: Credit Shock (Panel Local Projection IV)

- Ratio of point estimates range at least 3.8.
  - 95% CI lower bound at least 2.5 for 0-2 year horizon.
  - 95% CI upper bound is ∞ because cannot reject zero.



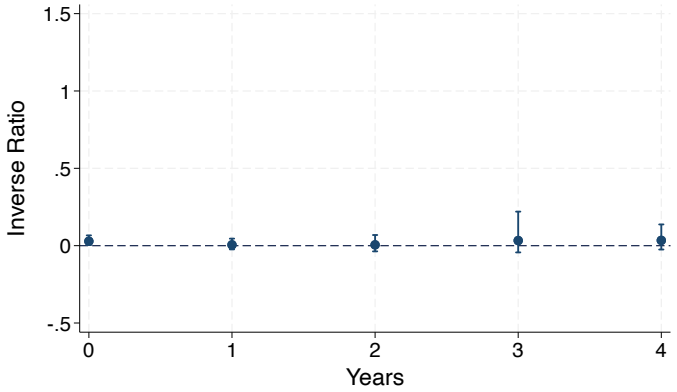
Microdata-Based Homeownership Rate

- Standard errors are large in part because HVS homeownership rate data is noisy.
- We constructed a new homeownership rate measure from deeds and address history data.
- Now find precise near-zeros for homeownership response.



Microdata-Based Homeownership Rate

- Bootstrapped confidence interval for inverse ratio similarly reduced.



Alternate Empirical Approaches

▸ DK Details ▸ MS Details

- **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, **both approaches yield similar slope estimates**.
  - Large ratio of point estimates (15 or more) when using GG-Microdata homeownership rate.
  - Lower bound of at least 2.1 for block bootstrapped confidence intervals.
  - Complementary empirical approaches reinforce confidence in this moment.

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 (extension: saver market integrated not segmented).
- 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.

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:

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

- Implies elasticity of investment to prices of $\varphi/(1-\varphi)$.

Heterogeneity

- Implementation of borrower and landlord heterogeneity:
  - Borrower i gets benefit $(1+\omega_{i,t}^{B})rent_t H_{i,t}$ from ownership, where $\omega_{i,t}^{B} \overset{iid}{\sim} \Gamma_{\omega,B}$.
  - Landlords get benefit $(1+\omega_{j,t}^{L})rent_t H_{j,t}$ from ownership of property j, where $\omega_{j,t}^{L} \overset{iid}{\sim} \Gamma_{\omega,L}$.
- 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:
  - All households with $\omega_{i,t}^{B} \geq \bar{\omega}_t^{B}$ own
  - All properties with $\omega_{j,t}^{L} \geq \bar{\omega}_t^{L}$ are rented

Model Solution

▸ Landlord's Problem ▸ Saver's Problem

- Key optimality conditions ($\mathcal{C}_t = \mu_t F_t^{LTV} \theta_t^{LTV}$):

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

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

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

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

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

Calibration Strategy

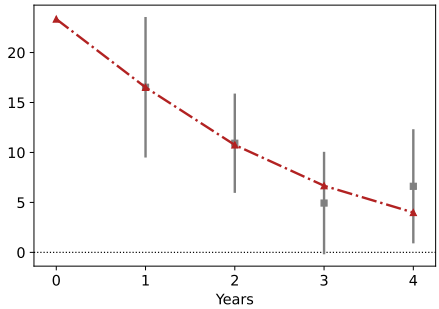
▸ Parameter Values ▸ Parameterization of Heterogeneity

- 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.

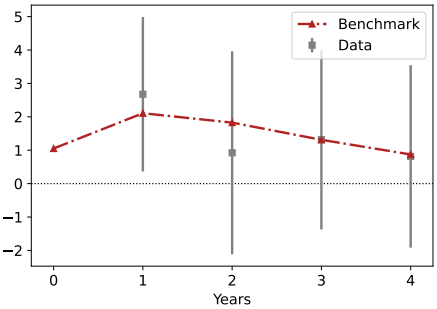
Calibration: Supply Elasticity

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 since our model lacks frictions required for hump-shaped response.



(a) Price-Rent Ratio

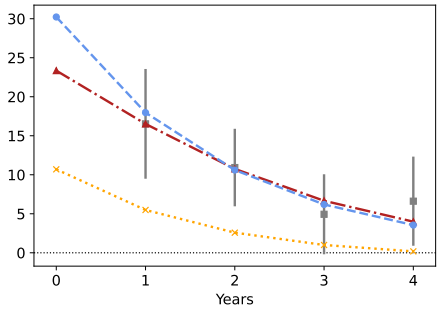


(b) Homeownership Rate

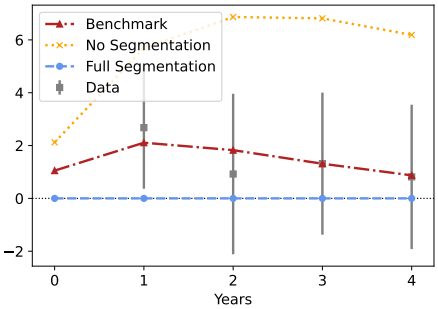
Calibration: Supply Elasticity

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

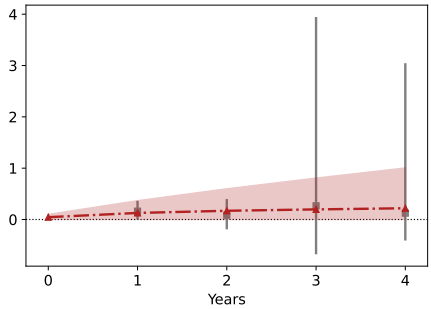


(b) Homeownership Rate

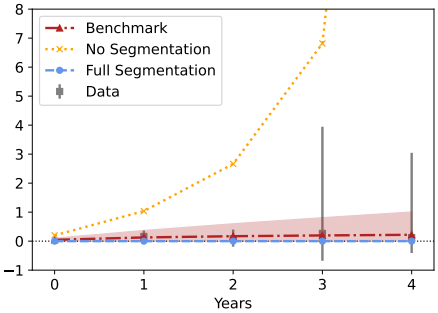
Calibration: Supply Elasticity

Identification

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



(a) Inverse Ratio (Bands)

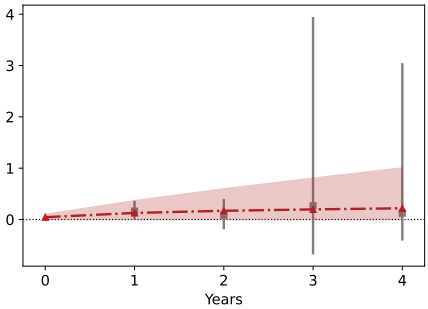


(b) Inverse Ratio (Model Comparison)

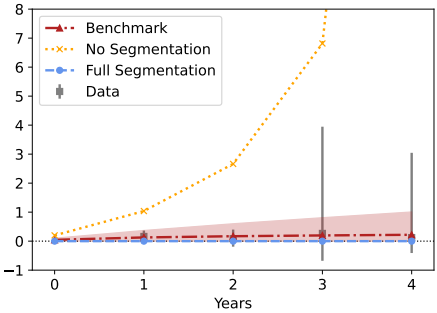
Calibration: Supply Elasticity

Identification

- Provides lower bound for frictions, cannot reject Full Segmentation.
- Can easily reject No Segmentation model.
- Directly estimating $\sigma_{\omega,L}$ to match ratio point estimates would yield much steeper slope.



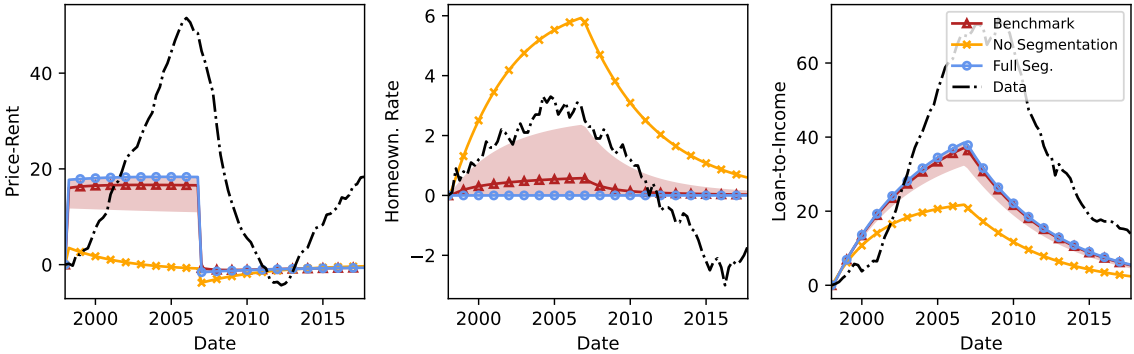
(a) Inverse Ratio (Bands)



(b) Inverse Ratio (Model Comparison)

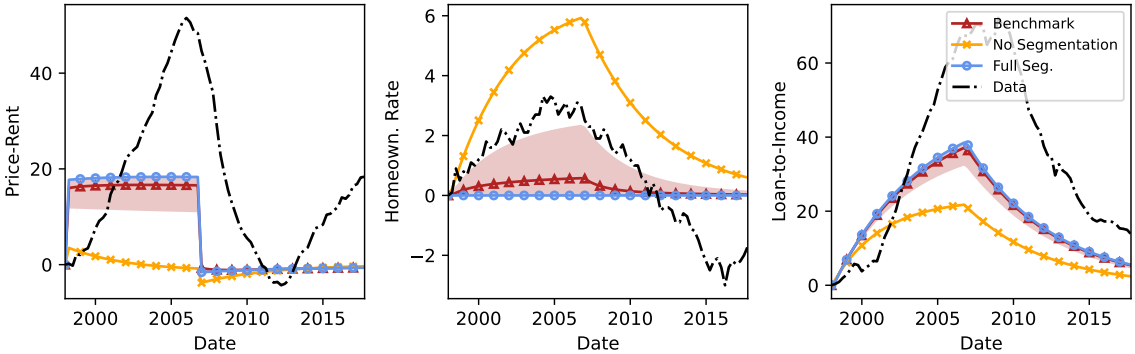
Credit Expansion Experiment

- 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.



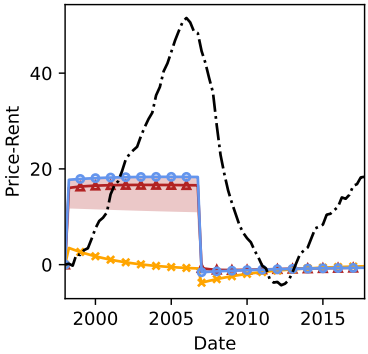
Credit Expansion Experiment

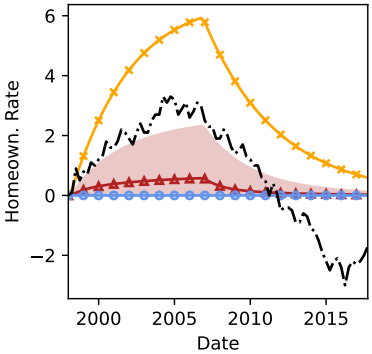
- Benchmark: Credit explains **32%** of peak price-rent increase, **51%** of peak LTI increase.
  - Using lower bound for slope, explains 22% of rise in price-rent, 45% of rise in LTI.
- Perfect rental markets: Credit explains **-2%** of price-rent, only **30%** of peak LTI increase.

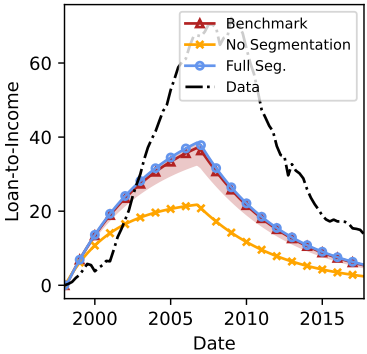


Credit Expansion Experiment

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

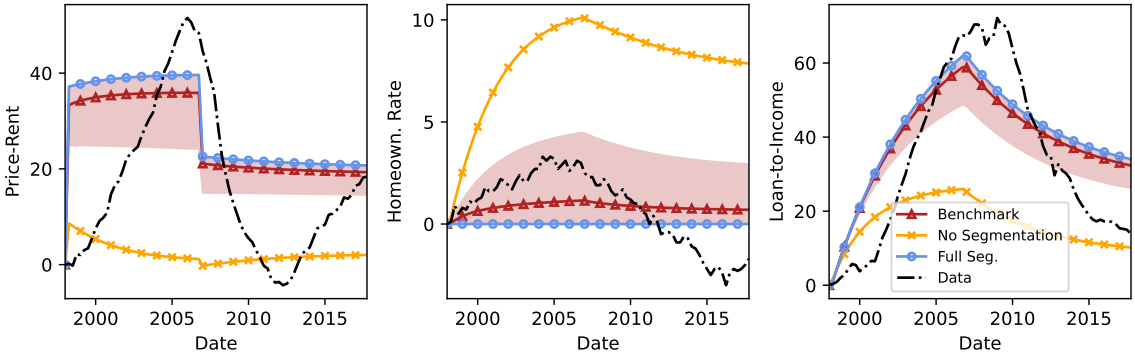






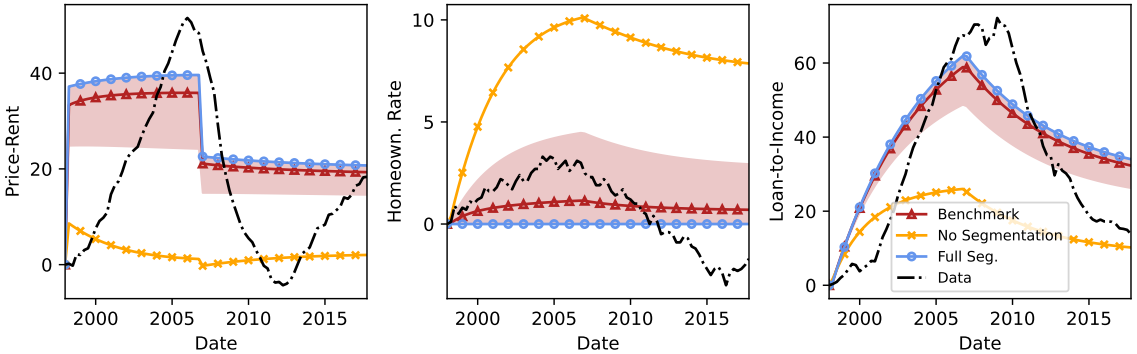
Credit Expansion Experiment

- 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

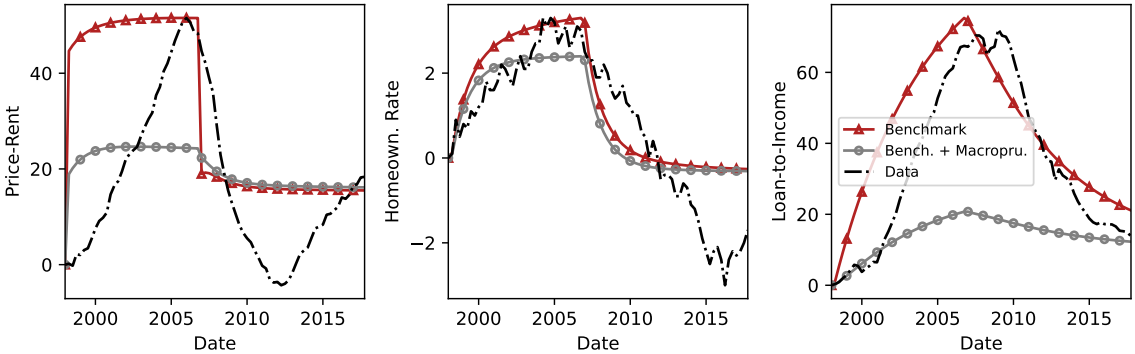
- Contrast to **2%** of rise in price-rent ratios and **36%** of rise in LTI under No Segmentation.
- Extremely favorable credit terms without price appreciation leads to rise in homeownership **306%** that of the data.



Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ No Heterog.

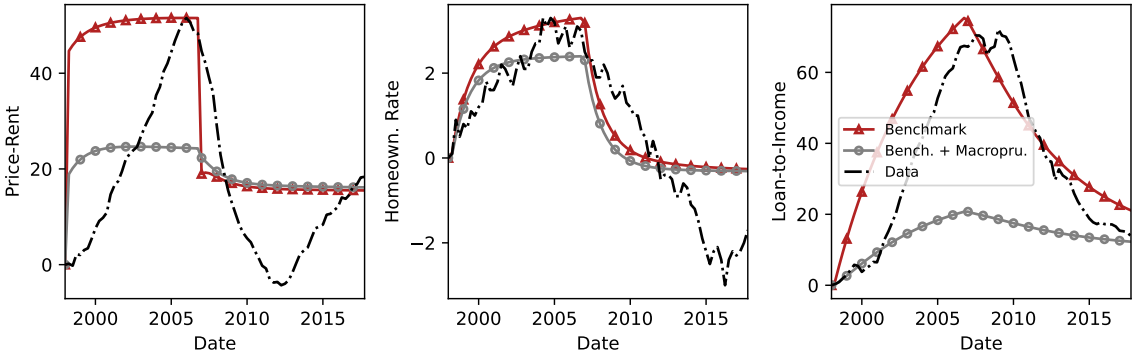
- Add observed fall in interest rates, then use demand and supply shocks (shifts in means of $\Gamma_{\omega,B}, \Gamma_{\omega,L}$ to exactly explain rise in price-rent and homeownership).
- To capture bust, return credit limits to baseline, apply (i) 3% fall in mortgage rates and landlord discount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



Boom Counterfactuals: Benchmark Model

Beliefs Only | No Heterog.

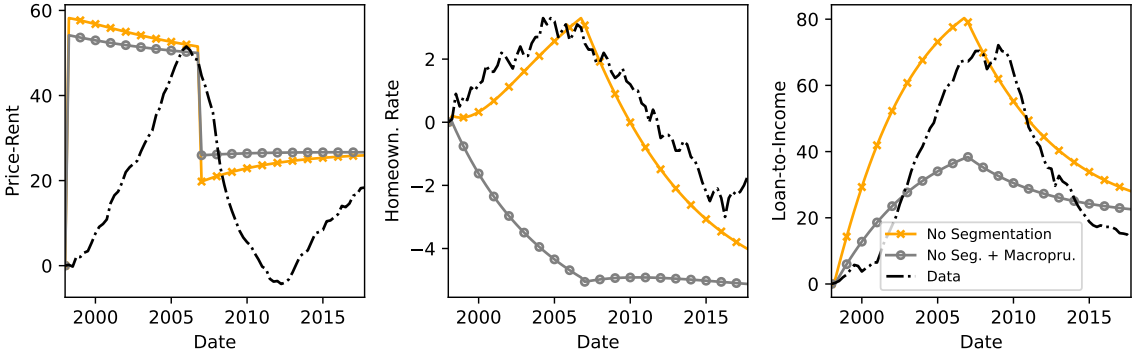
- Now **removing** credit expansion kills **53%** of boom in price-rent, **71%** of boom in LTI.
- Larger because of nonlinear interactions between credit and other shocks boosting house prices (Greenwald, 2018).
- Implies macroprudential, monetary policy can be effective at limiting house price booms.



Boom Counterfactuals: Benchmark Model

▸ Beliefs Only ▸ No Heterog.

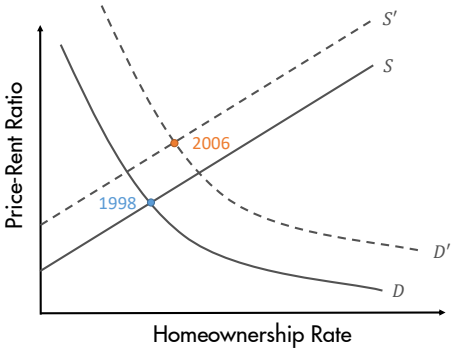
- Under No Segmentation, removing credit relaxation would remove **3%** of boom in price-rent, **47%** of boom in LTI.
- Difficult to distinguish using macro data alone, need IV estimates to tell whether macroprudential policy works.



Model Extensions: Landlord Credit

Back

- 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

Back

- 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.
- Implementation: landlords can borrow with mortgage tech., 65% LTV limit at origination.
- New equilibrium condition ($\mathcal{C}_{L,t} = \mu_{L,t}\theta^L$)

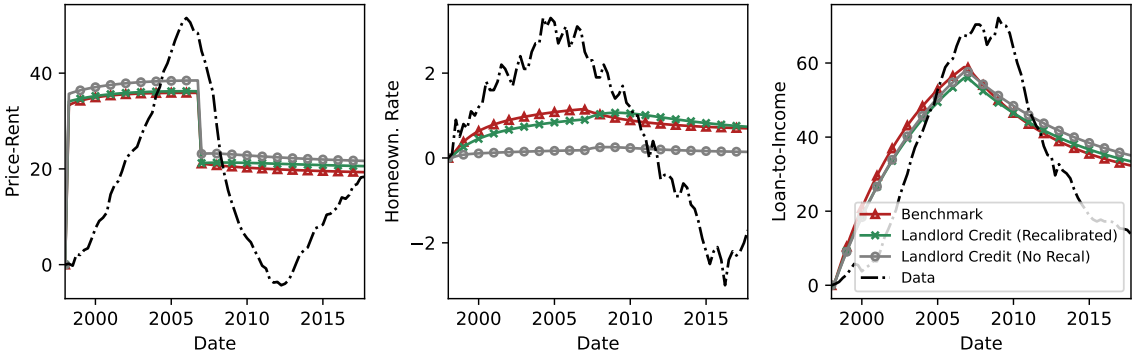
$$p_t^{\text{Supply}} = \underbrace{\left(1 - \mathcal{C}_{L,t}\right)^{-1}}_{\text{credit conditions}} E_t\left\{\Lambda_{t+1}^L\left[\underbrace{\bar{\omega}_t^L + \text{rent}_{t+1}}_{\text{housing services}} + \underbrace{\left(1 - \delta - (1-\rho_{t+1})\mathcal{C}_{L,t+1}\right)p_{t+1}}_{\text{continuation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

allows credit to directly influence supply.

Model Extensions: Landlord Credit

Back

- Results turn out to be similar under landlord credit.
- Why? Calibration pairs shift in tenure supply with flatter tenure supply slope.



Model Extensions: Flexible Saver Demand

Back

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

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

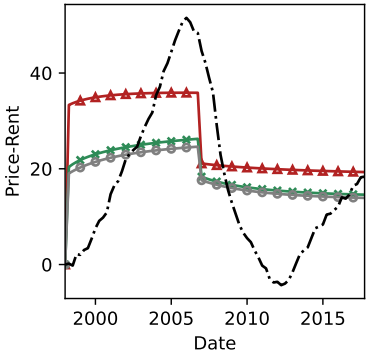
  where saver housing $H_{S,t}$ must equalize saver and borrower/landlord prices.

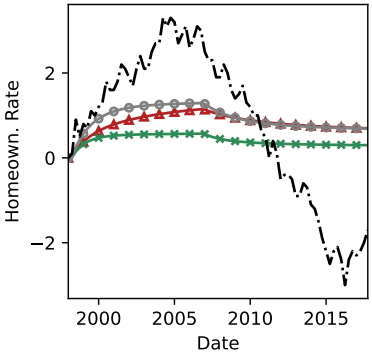
- Because saver demand not directly influenced by credit, saver housing margin can also absorb effect of credit on house prices.
  - Same mechanism highlighted in Landvoigt, Piazzesi, and Schneider (2015).
- Adjustment occurs (unrealistically) along intensive margin due to divisible housing.
  - Typically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

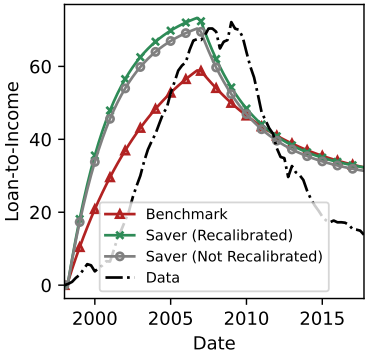
Model Extensions: Flexible Saver Demand

Back

- Flexible saver demand would dampen effects on house prices somewhat.
- But credit standards relaxation + declining rates still explains 51% of observed rise in price-rent ratios.







Summary: Do Credit Conditions Move House Prices?

- What role did credit play in the housing boom and bust?
- Empirical results:
  - Larger, significant response of price-rent ratio to identified credit shocks, vs. smaller, insignificant response for homeownership.
- 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 standards explain 32% – 53% of price-rent growth during boom.
  - Frictions key to effectiveness of macroprudential/monetary policy in dampening price booms.
  - Extensions: Landlord credit (alternative comovement) and saver demand (need segmentation).
- Organizing framework/methodology we hope will be useful to future researchers.

Conclusion: Credit and House Prices

- When does credit matter for house prices?
  - When “supply” from unconstrained agents (landlords, savers) sufficiently segmented.
  - Strong frictions supported by empirical evidence.
- How did credit drive the 2000s boom bust?
  - Key change is large relaxation of PTI limits.
  - PTI relaxation directly increases prices, amplifies effect of expectations.
- Lots of room for continued research!

The Research Process

Research Question

- Asking the right question is key to the research process.
- Good papers ask questions about the world, not questions about a model.
- Bad (but common) question: “is X exactly zero?”
- Ideal question (especially for JMP): interesting/important enough that either/any outcome is a major contribution.
- Okay to refine as you go, but always keep research question in mind.

Research Process

- Should have a reason for everything you include in the setup.
  - Start as simple as possible, then build up as needed.
  - Especially key for JMP with strict deadline.
- Research is like judo: go with the data/results instead of fighting it.
  - Especially important to pull on “loose threads.” If there is a result you don’t understand, figure it out before moving on.
- Think about the scope of what the paper can explain.
  - If you are matching the data, make sure you are only matching what your model should explain!
- Apply more and more rigorous tests to your theory as it develops.

Research Mindset

- Your job is to find the answer, not deliver a particular result.
- All research designs are imperfect, make limitations clear.
- Complexity is costly: include element only if it is first-order for your main question.
- Get feedback earlier than you think you should.