Overbuilding and Underinvestment over Housing Boom-Bust Cycles

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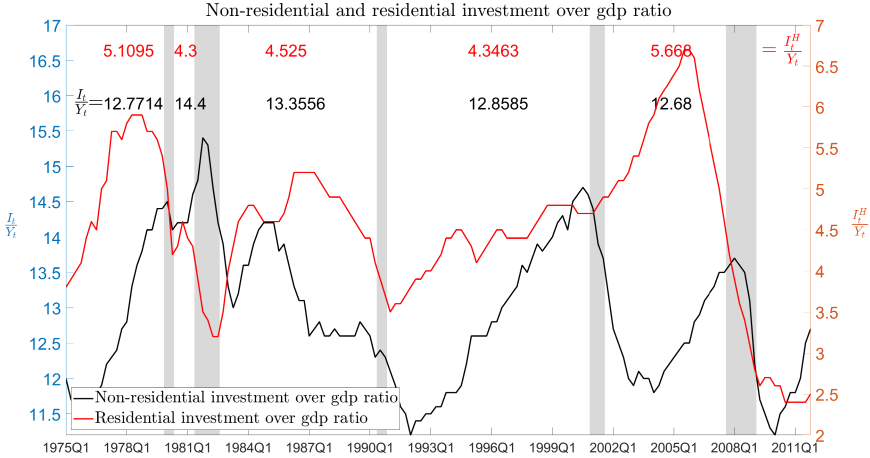
Non-residential Investment crowds out Residential Investment



1990-1999: $\mathrm{corr}(\frac{I_t^H}{Y_t}, \frac{I_t}{Y_t}) = 0.76$; 2000-2007: $\mathrm{corr}(\frac{I_t^H}{Y_t}, \frac{I_t}{Y_t}) = -0.65$; 1947-2019: $\mathrm{corr}(\frac{I_t^H}{Y_t}, \frac{I_t}{Y_t}) = -0.34$

Housing Market Boom and Crowded-out Capital

- Demand driven housing market boom
  - Residential investment and housing price jump up $I_t^H \uparrow$
  - Expansion in nondurable consumption $C_t \uparrow$
    - Wealth Effect: more asset works as collateral and equity extraction

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    - Wealth Effect: more asset works as collateral and equity extraction
- Physical Investment is crowded out
  - Macro: general equilibrium.

$$Y_t = C_t \uparrow + I_t + I_t^H \uparrow$$

  - Micro: investment portfolio reallocation $\rightarrow$ decrease holding of capital(equity); increase holding of residential asset

Overbuilding and Underinvestment

- Housing market boom without fundamental support
    - Increased new construction in housing market: **Overbuilding**

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- Crowded-out physical investment: **Underinvestment**
  - Macro: Capital misallocation. Too much residential asset yet too little physical capital
  - Micro: A large capital distortion and higher real interest rate(relative to LR real interest rate)

Overbuilding and Underinvestment

- Housing market boom without fundamental support
  - Increased new construction in housing market: **Overbuilding**
- Crowded-out physical investment: **Underinvestment**
  - Macro: Capital misallocation. Too much residential asset yet too little physical capital
  - Micro: A large capital distortion and higher real interest rate(relative to LR real interest rate)
- Amplified economic loss during bust period Market Share

Imperfect Information and (Fake) News Shock

- Throughout this paper I use news and fake news shock to analyze the crowding-out effect
- Intuitive introduction to the (fake) news shock
  - what the shock is
  - why I use this shock
- Takeaway: the crowding-out effect is not limited to the (fake) news shock

Imperfect Information and (Fake) News Shock

- Intuitive example

$$p_t^h = \rho p_{t-1}^h + \beta x_t + w_{t-3} + u_t + \alpha w_t$$

  where w_t is the news shock; p_t^h is the housing price; x_t other macro variables

- Imperfect information and inefficiency: w_t cannot be perfectly observed
  - instead $\widetilde{w}_t = w_t + \nu_t$ where ν_t is the noisy to the news w_t
  - non-fundamental supported boom: ν_t instead of w_t
- News shock w_t; Fake news shock ν_t

Why (Fake) News Shock?

- Long-lasting housing market boom (in data)→significant amount of crowded-out physical capital Other Types of Shock
  - consecutive lower physical investment I_t
  - significant change in state variable: capital (we expect a scarcity in capital caused by crowd-out effect)
- Require assumption on the persistent of a standard shock such as credit shock or sentiment shock
- Imperfect information, news and fake (inefficiency) news shock
  - merit 1: one single shock can generate persistent housing market boom
  - merit 2: indeed explains a moderate share of variation of housing price in reality

Novelty in This Paper

- News and fake news shock $\widetilde{w}_t = w_t + \nu_t$

$$p_t^h = \rho p_{t-1}^h + \beta x_t + w_{t-3} + u_t + \alpha \widetilde{w}_t$$

- An improvement on Barsky and Sims (2012)
  - VAR identification to observation shock $\widetilde{w}_t$ (with contemporaneous endogeneity α)
- A new algorithm to identify fake news shock ν_t
- Empirically crowding-out effect is significant

Novelty in This Paper

- (Fake) News shock on preference
  - Utility function follows $U_t = \frac{\left(c_t^{\phi_t} h_t^{1-\phi_t}\right)^{1-\sigma}}{1-\sigma}$
  - Stochastic preference $\log(\phi_t) = \log(\overline{\phi}) + \rho_\phi \log(\phi_{t-1}) + w_{t-3} + u_t$
- Theoretically crowding-out effect is affected by three factors in demand side:
  - Relative intratemporal elasticity of substitution $\frac{U_H}{U_C} = f\left(p_t^H, p_{t+1}^H\right)$ (to intertemporal elasticity $U_C = \beta R U_{C'}$)
  - Financial friction
  - Idiosyncratic income shock and wealth distribution
- Quantitatively crowd-out effect can explain 13% welfare loss.
- After introducing a macroprudential policy which curbs the LTV ratio, the welfare loss is reduced significantly

Literature Review

- VAR Identification on news shock with contemporaneous endogeneity
    - Lorenzoni (2009), Barsky and Sims (2012)
- VAR Identification on fake news shock
    - Chahrour and Jurado (2018), Wolf and McKay (2022)
- Crowding-out effect works through general equilibrium and pay more attention on the pass-through between residential investment and consumption
    - Capital Misallocation: Rognlie et al. (2018), Chodorow-Reich et al. (2021), and Feng et al. (2022)
- Crowding-out effect amplifies on the supply side: scarcity of physical capital
    - Mian et al. (2013), Favilukis et al. (2017), and McQuinn et al. (2021)
- Solving heterogeneous agent model with imperfect information (noisy shock) and quantitative result
    - Etheridge (2019), Kaplan et al. (2020) and Auclert et al. (2021)

Outline

Empirical Evidence

- Introduction to VAR model and identification to news shock
- Algorithm to identify the fake news shock
- Empirical evidence
- Historical decomposition: significance in reality

VAR identification

- VAR

$$y_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_4 y_{t-4} + R\varepsilon_t \tag{1}$$

- y_t vector of macro variables
  - output, consumption, physical investment, housing price, housing supply and capital (equity) price
  - 1985-2007, Quarterly
- ε_t vector of shocks
  - monetary policy shock, productivity shock $\varepsilon_{i,t}$
  - land supply shock $\varepsilon_{s,t}$
  - housing market demand shock $\varepsilon_{u,t}$
  - housing market demand news shock $\varepsilon_{w,t}$
- Objective: identify the structure shocks' effect (column) R_w

VAR identification (conceptual framework)

- Objective: IRF of macro variables responding to fake news (noisy) shock ν_t
  - News and fake news shock $\widetilde{w}_t = w_t + \nu_t$

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- Variation of housing price is driven by $\mathrm{var}(p_t^h) = \alpha_i \mathrm{var}(\varepsilon_{i,t}) + \alpha_s \mathrm{var}(\varepsilon_{s,t}) + \alpha_u \mathrm{var}(u_t) + \alpha_w \mathrm{var}(\widetilde{w}_t) + \ldots$

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- Sign restriction to rule out any shock on supply side

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- Sign restriction to rule out any shock on supply side
- Orthogonal restriction to rule out any contemporaneous housing market demand shock u_t Purification

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- Sign restriction to rule out any shock on supply side
- Orthogonal restriction to rule out any contemporaneous housing market demand shock u_t Purification
- Assumption: Housing market demand news shock explains the housing price most

VAR identification (conceptual framework)

- Chahrour and Jurado (2018): Theoretically fake news shock ν_t is observational equivalent with two incorporated shocks
  - $\widetilde{w}_t$ realizes first at t
  - τ period later, when w_t works at $t+\tau$, a negative $-u_{t+\tau}$ offsets its effect

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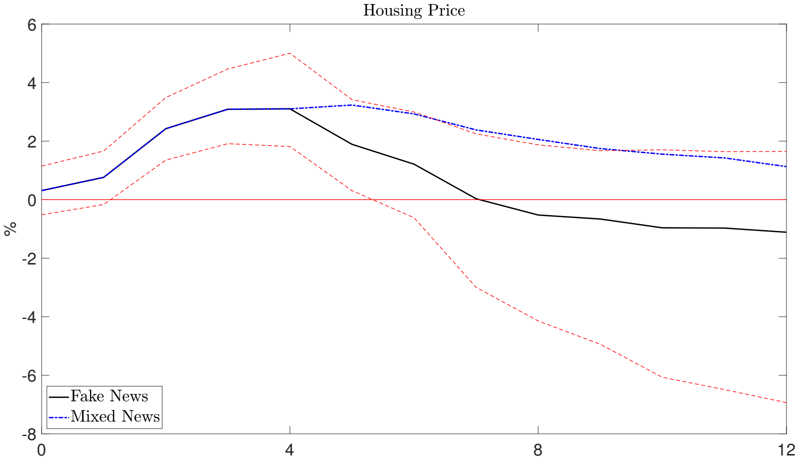
  - τ period later, when w_t works at $t+\tau$, a negative $-u_{t+\tau}$ offsets its effect
- Identification to fake news as Microfoundation

$$\widehat{y}_i^F = \begin{cases} y_i & i \leq \tau \\ y_i - \frac{e_k' y_{k,\tau+1}}{e_k' y_{k,0}^\tau} y_{i-\tau-1}^\tau & i > \tau \end{cases} \tag{2}$$

where $y_i \in U$ and y_i^τ is the response path to a contemporaneous shock on direct fundamental impact, variable k, in equation 10

Housing Market Boom-Bust Cycle



90% confidence band; percentage derivation from mean
Housing market boom-bust cycles

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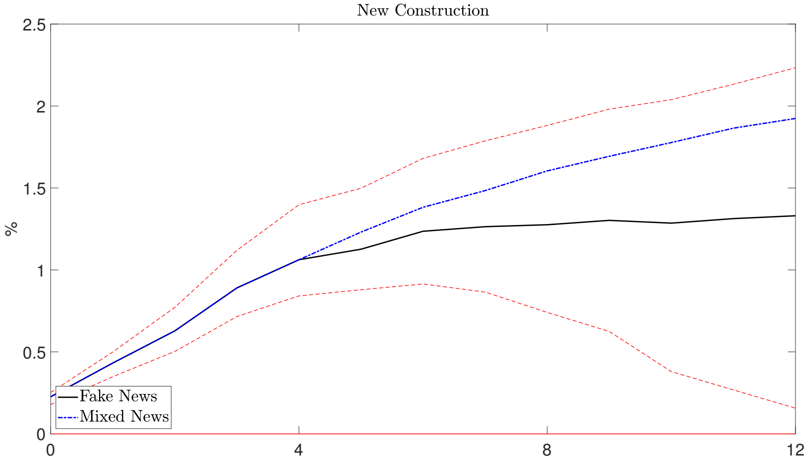

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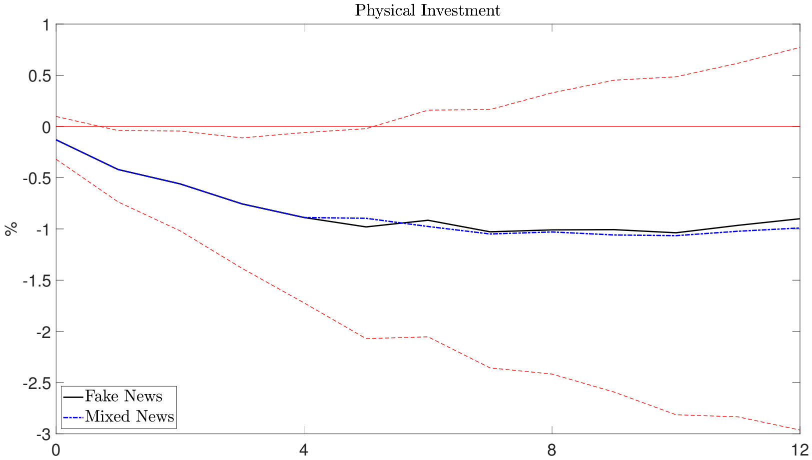
Crowded-out Physical Investment

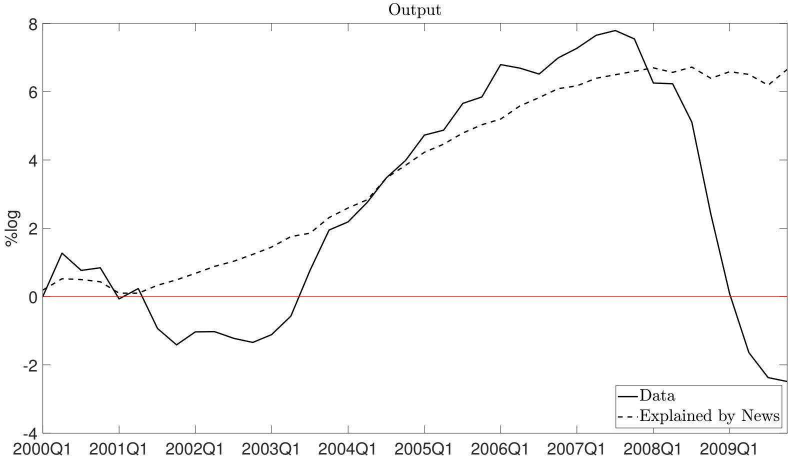


Inertia in physical investment

Recession period. Less demand on physical capital and production.

Is fake news or news important in reality?

Historical variance decomposition

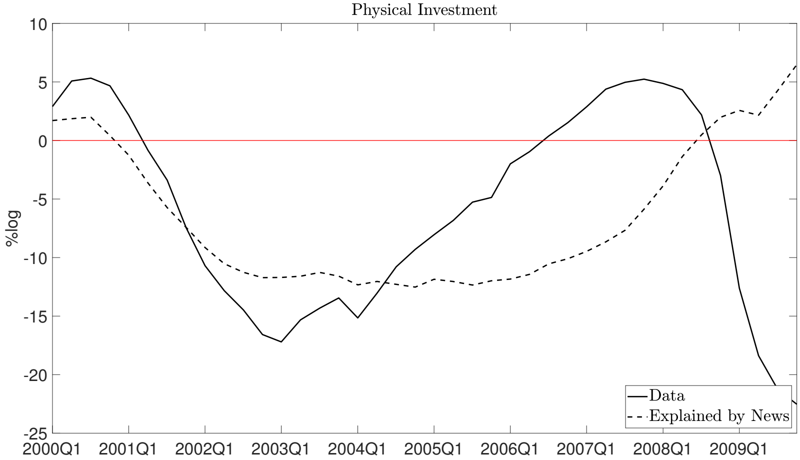


$\log(Y_t) - \log(Y_t^T)$ where Y_t^T is the trend component that calculated by average growth rate

Driven by news shock during boom period; significant divergence during bust period;

Is fake news or news important in reality?

Historical variance decomposition



$\log(I_t) - \log(I_t^T)$ where I_t^T is the trend component that calculated by average growth rate

Driven by news shock during boom period; significant divergence during bust period;

Empirically Significant

- A new algorithm to identify fake news shock
- Empirically crowding-out effect is significant
- Historical decomposition: news shock and fake news shock can explain part of the boom-bust cycle in housing market

Model Implication

- Model setting: Bewley-Huggett-Aiyagari model
  - heterogeneous household
  - representative producers
- Crowding-out effect is influenced by three factors on demand side

An Bewley-Huggett-Aiyagari model without aggregate shock

- Household maximize their utility by choosing housing services, non-durable consumption and liquid asset

$$\max_{c_t^i, h_t^i, a_t^i} \sum_{t=0}^{\infty} \beta^t U_t^i \left(c_t^i, h_t^i\right) \tag{3}$$

- Inelastic labor supply and idiosyncratic income shock

$$c_t^i + a_t^i + p_t^H h_t^i = R_t a_{t-1}^i + w_t \varepsilon_t^i + \left(1 - \delta^H\right) p_t^H h_{t-1}^i + T_t \tag{4}$$

- Financial Friction: occasional bound collateral constraint

$$-a_t^i \leq \gamma p_t^H h_t^i \tag{5}$$

An Bewley-Huggett-Aiyagari model without aggregate shock

- Two sector model (on supply side) with representative producers
- Construction Sector: $Y_{H,t} = A_{H,t}\mathscr{L}^{\theta}K_{H,t-1}^{\nu}L_{H,t}^{1-\nu-\theta}$
  - New construction is built through TFP on construction sector A_H, Land $\mathscr{L}$, physical capital (used by construction sector) K_H and labor L_H
  - Land supply $\mathscr{L}$ is fixed
- Final Goods production: $Y_{N,t} = A_{N,t}K_{N,t-1}^{\alpha}L_{N,t}^{1-\alpha}$
- Complete market

An Bewley-Huggett-Aiyagari model without aggregate shock

- Capital and labor are provided by household $K_{N,t-1} + K_{H,t-1} = K_{t-1} = \int a^i_{t-1} di$ and $L_{N,t} + L_{H,t} = \int \varepsilon^i_t di$
- Housing market clearing condition: $Y_{H,t} = H_t - (1 - \delta^H) H_{t-1}$ where $H_{t-1} = \int h^i_{t-1} di$
- Final goods can either be consumed or be invested

$$Y_{N,t} = K_t - (1 - \delta) K_{t-1} + C_t$$

Heuristic Analysis

- Expectation of housing prices in the future$p^H_{t+T+1} \uparrow$
- Residential investment and consumption will response to it
- Physical investment is crowded out
- Perturbation around s.s; Partial on housing price (fix other prices)
- Derivation: $\widetilde{h}_t$, $\widetilde{c}_t$ and $\widetilde{I}_t$

Crowding-out effect: increased in housing demand

Corollary 1

A positive expectation about the housing price change at time $T+1$ will induce a jump in demand for housing at time t. The response extends as follows:

$$\widetilde{h}_t\Big|_{h_{t+i},\mu_{t+i},\lambda_{t+i},,i\in[1,T]} = \zeta_t dp^H_{t+T+1} \tag{6}$$

where $\zeta_t = -\frac{1}{u''_h}\mathbb{E}_t\left[\beta\left(1-\delta^H\right)\right]^T \prod_{s=1}^T \frac{\lambda_{t+s}}{\lambda_{t+s}-\mu_{t+s}}\lambda_{t+T+1}$

Crowd-out effect of Overbuilding: Passthrough

Proposition 1

Household will adjust their consumption of non-durable goods based on overbuilding and precautionary saving. The extent of adjustment is decided by

$$\widetilde{c}_t = \underbrace{\Phi_H \widetilde{h}_t}_{\text{substitution effect}} - \underbrace{\Phi_\mu \widetilde{\mu}_t}_{\text{credit effect}} + \underbrace{\Phi_{p^H}\left[\frac{1}{1-\left(1-\delta^H\right)\frac{1}{R}} F^H(\widetilde{H}_t) - \frac{\left(1-\delta^H\right)\frac{1}{R}}{1-\left(1-\delta^H\right)\frac{1}{R}} F^H(\widetilde{H}_{t+1})\right]}_{\text{wealth effect}}$$
$$- \underbrace{\Phi_{cov}\widetilde{cov}_t}_{\text{precautionary saving effect}}$$

where $F^H(\cdot)$ is the inverse supply function

Crowd-out effect of Overbuilding

Proposition 2

The aggregate investment is driven by overbuilding and precautionary saving following

$$\begin{aligned} I\widetilde{I}_t = -\Bigg\{ & \left(\Phi_H + \frac{\nu}{\alpha} p^H H\right) \int \widetilde{h}_t^{\,i} di - \Phi_\mu \int \widetilde{\mu}_t^i di \\ & + \Phi_{p^H} \left[\frac{1}{1 - (1-\delta^H)\frac{1}{R}} F^H(\widetilde{H}_t) - \frac{(1-\delta^H)\frac{1}{R}}{1-(1-\delta^H)\frac{1}{R}} \mathbb{E}_t F^H(\widetilde{H}_{t+1}) \right] \\ & - \Phi_{cov}^i \int \widetilde{cov}_t^i di + \frac{\nu}{\alpha} Y_H p^H F^H(\widetilde{H}_t) \Bigg\} \end{aligned}$$

The overbuilding, $\widetilde{H}_t = \int \widetilde{h}_t^{\,i} di > 0$, will crowd out physical investment as long as the substitution effect Φ_H and wealth effect Φ_{p^H} are not negative enough.

Which elements affect this crowding-out effect?

- Smaller Relative Intratemporal elasticity of substitution Numerical Mechanism
  - Intratemporal elasticity of substitution $\frac{U_H}{U_C} = f\left(p_t^H, p_{t+1}^H\right)$: consumption bundle arrangement within this period
  - Intertemporal elasticity of substitution $U_C = \beta R U_{C'}$: consumption bundle arrangement over different period
  - "Smaller Relative": Intratemporal$\downarrow$ and Intertemporal$\uparrow$
  - Consumption responses to increased holding of housing less (for unconstrained households)
  - Crowding-out effect $\uparrow$

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    - "Smaller Relative": Intratemporal↓ and Intertemporal↑
    - Consumption responses to increased holding of housing less (for unconstrained households)
    - Crowding-out effect ↑
- Larger financial friction Numerical Mechanism
    - Marginal value of house increases
    - More constrained households
    - Crowding-out effect ↑

Which elements affect this crowding-out effect?

Proposition 3

When the housing supply is fixed; initial housing distribution over dynamic path is exogenous and $\left(\frac{\frac{1-\beta}{\beta}}{\alpha A}\right)^{\frac{1}{\alpha-1}} > \frac{K}{L} > \left(\frac{\delta}{\alpha A}\right)^{\frac{1}{\alpha-1}}$ *holds, substitution effect* Φ_H *and wealth effect* Φ_{p^H} *will decrease as relative intratemporal elasticity of substitution (collateral constraint) is higher (slacker). Further, when the aggregate Khun-Tucker multiplier is not too large, credit effect* Φ_μ *will increase as relative intratemporal elasticity of substitution (collateral constraint) is higher (slacker).*

Which elements affect this crowding-out effect?

- Heterogeneous response along wealth distribution Numerical Mechanism Numerical(Inequality)
- Inequality and wealth distribution
  - Wealth people hold a large share of assets
  - Unconstrained households have the capacity and willingness to invest in real estate market
  - Amplification in $\int \widetilde{h_t}^i di$
- Marginal propensity to consume is right-skewed $\rightarrow$ Amplification in $\int \widetilde{\mu}_t^i di$

Theoretical Analysis

- An increased expectation on housing price in the future will trigger a housing market boom and crowd out physical investment
- Three factors on demand side influence the crowding-out effect
  - Relative Intratemporal elasticity of substitution
  - Financial friction
  - Wealth and MPC distribution

Quantitative Result

- Calibration and Bayesian estimation
- Welfare loss from crowding-out effect
- Distributional effect
- Macroprudential policy (countercyclical LTV ratio) reduces the welfare loss significantly

Full-fledged Model

- Two types of assets: liquid and illiquid asset

$$c_t + Q_t b_t + p_t^h \left[h_t - (1-\delta^h) h_{t-1} \right] = R_t Q_{t-1} b_{t-1} + (1-\tau) w_t l_t \varepsilon_t - p_t^h C\left(h_t, h_{t-1}\right) + T_t$$

where

$$C\left(h_t, h_{t-1}\right) = \frac{\kappa_1}{\kappa_2}\left(h_{t-1} + \kappa_0\right) \left| \frac{h_t - h_{t-1}}{h_{t-1} + \kappa_0} \right|^{\kappa_2}$$

Full-fledged Model

- Capital producer

$$\max E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \Lambda_{t,t+\tau} \left\{ Q_\tau I_\tau \eta_{I,t} - f\left(I_\tau, I_{\tau-1}\right) I_\tau \eta_{I,t} - I_\tau \right\}$$

$$\text{s.t. } f\left(I_\tau, I_{\tau-1}\right) = \frac{\psi_I}{2} \left(\frac{I_\tau}{I_{\tau-1}} - 1 \right)^2$$

- Capital price

$$Q_t \eta_{I,t} = 1 + \frac{\psi_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \eta_{I,t} + \psi_I \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} \eta_{I,t} -$$

$$E_t \beta \Lambda_{t,t+1} \psi_I \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2$$

where $\eta_{I,t}$ is the marginal efficiency of the investment shock, following Justiniano et al. (2011)

Fake news shock on preference to houses

- Utility function

$$U_t\left(c_t, h_t, l_t\right) = \frac{\left(c_t^{\phi_t} h_t^{1-\phi_t}\right)^{1-\sigma}}{1-\sigma} - \kappa \frac{l_t^{1+\psi}}{1+\psi}$$

- Preference ϕ_t follows

$$\log(\phi_t) = \log(\overline{\phi}) + \rho_\phi \log(\phi_{t-1}) + w_{t-8} + u_t$$

From Model to Data (Steady State): Calibration

- Computational burden and time consuming in solving the steady state
  - Calibrate the model in steady state to pin down parameters that affect the steady state
  - Use Bayesian estimation to pin down the rest
- Most parameters come from literature
- Use discount factor, disutility to labor supply, TFP of two production to match real interest rate, labor supply, physical investment over GDP ratio, and new construction over GDP ratio
- Distributional Moments are out of the scope of pre-matching

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Table: Distribution Moments

Description	Data	Model
Poor Hand-to-Mouth Household	0.121	0.1102
Wealthy Hand-to-Mouth Household	0.192	0.2059
Top 10 percent share of Liquid asset	0.8	0.5
Top 10 percent share of Iliquid asset	0.7	0.3

From Model to Data (Dynamic): Bayesian Estimation

- Full Information Bayesian Estimation Solution Method
- 7 variables (1975-2007)
  - output, consumption, physical investment, residential investment, housing price, capital price, real interest
- 7 shock series
  - TFP shocks
  - Land supply shock
  - Preference (on residential asset) shock
  - Marginal efficiency of the investment shock
  - News shocks on land supply and preference

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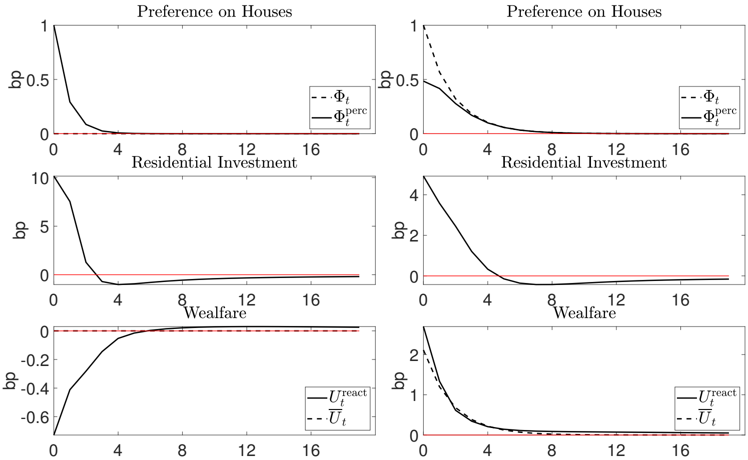
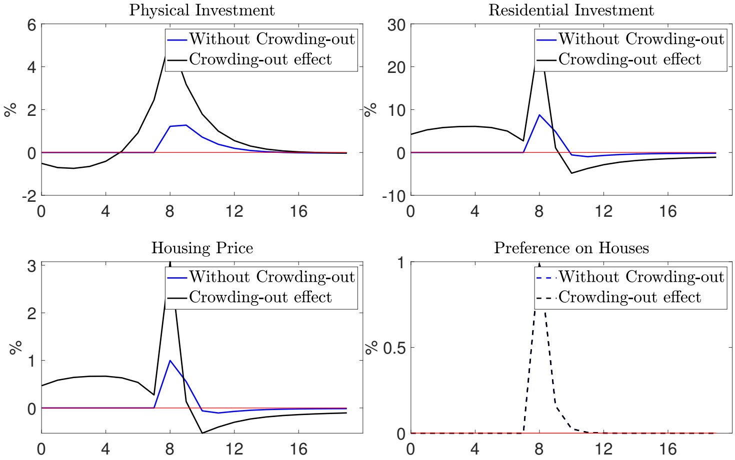
Moments	**Data**	**Model**
$\mathrm{corr}(p^H, I^H)$	0.42	0.23
$\mathrm{corr}(I, I^H)$	-0.15	-0.28
$\mathrm{corr}(I, Y)$	0.06	0.19
$\mathrm{corr}(I, Q)$	0.40	0.32

Fake News and Inefficient reaction → Welfare loss



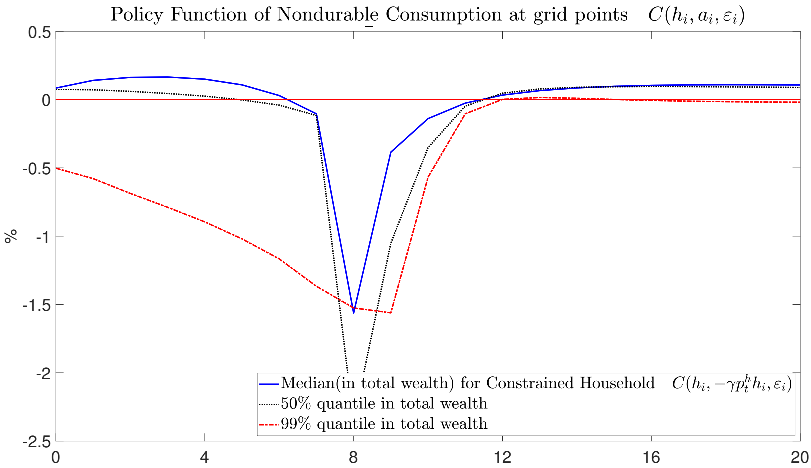
Crowd-out effect and boom-bust cycle

- Fake news shock at $t = 0$ and contemporaneous noise shock at $t = 8$
- The only difference: crowding-out effet



Distributional Effect

Right-Skewed distribution of MPC



Macroprudential Policy

- procyclical collateral constraint on capital-output ratio (countercyclical restriction on housing market boom)

$$\frac{\gamma_t}{\overline{\gamma}} = \left(\frac{\gamma_{t-1}}{\overline{\gamma}}\right)^{\rho_\gamma} \left(\frac{\upsilon_t}{\overline{\upsilon}}\right)^{\eta_\gamma(1-\rho_\gamma)}$$

  where γ_t is the collateral constraint in equation and υ_t is the capital-output ratio. $\overline{\gamma}$ and $\overline{\upsilon}$ are their corresponding value in steady state.
- The welfare loss of crowd-out effect decrease from 13% to 7%

Conclusion

- Document a new mechanism through which the housing market boom magnifies the recession.
- Empirically identify the crowding-out effect of overbuilding.
- Crowding-out effect of overbuilding is affected by relative intratemporal elasticity of substitution, financial friction and wealth distribution.
- A fake news that results in housing market boom can explain 13% welfare loss.

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Smets, Frank, and Raf Wouters. 2003. "An estimated dynamic stochastic general equilibrium model of the euro area." *Journal of the European economic association* 1 (5): 1123–1175.

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What is the difference between this drawback and other capital misallocation? (Other Literature such as Firm Dynamic, Uncertainty, Asset Pricing?)

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- General Equilibrium Effect: Powerful Back

Boom to Bubble: Inefficiency Problem

- Frictions in economy blow the boom further to a bubble

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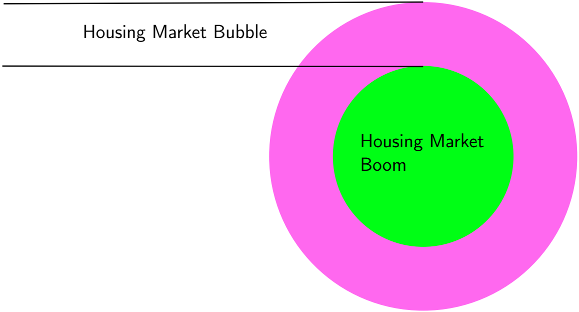

Boom to Bubble: Inefficiency Problem

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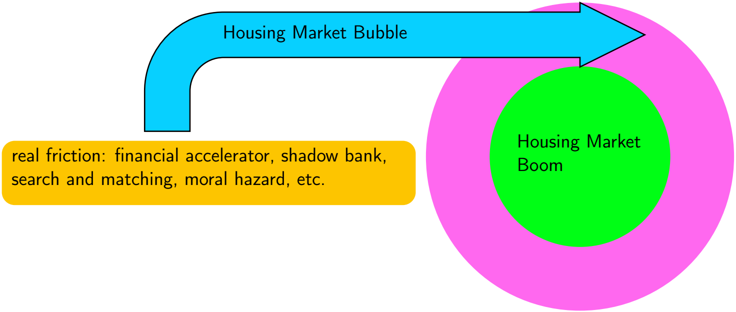

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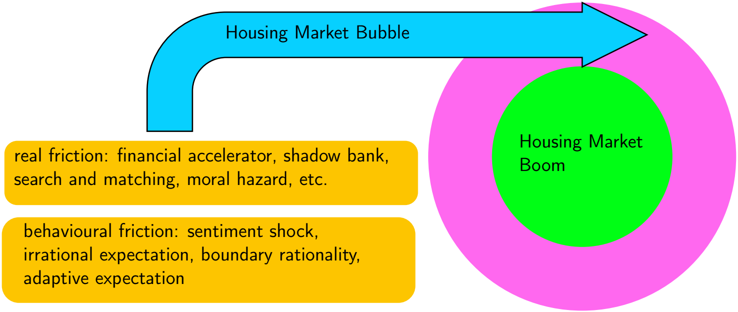

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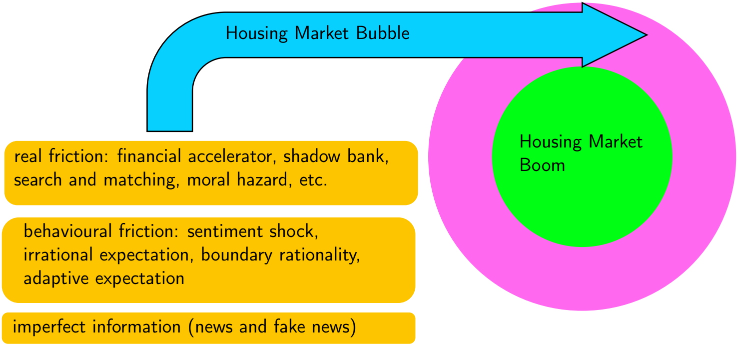

VAR identification

- VAR
$$y_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_q y_{t-q} + R\varepsilon_t \tag{7}$$
- R cannot be directly identified as what we get from data is the residual $u_t = R\varepsilon_t$
  - we can get $\mathrm{cov}(u_t) = RR' = \Omega$ yet not R itself
  - Cholesky decomposition of $\mathrm{cov}(u_t)$ will uniquely pin down Cholesky $P = \mathrm{chol}(\Omega)$
  - R can be identified up to rotation (orthogonal matrix Q) i.e. $R = PQ$

VAR identification: news shock

- we do not need to identify all the shocks but the one that we focus
  - Identify one column of rotation Q instead of the whole matrix
- Notation:
  - column related to shock i of Q: Qe_i
  - "identify the effect of news shock"≡"find the column Qe_w"≡"find the column $R^* = PQe_w$"≡"the shock of news"
  - $y^j_{i,t}$: the variation (IRF) of variable i that triggered by shock j at time t

VAR Identification Strategy: News shock

- solve the problem that Purification

$$R^* = \operatorname{argmax} \frac{\operatorname{var}\left(y_{i,t}^{w}\right)}{\operatorname{var}\left(y_{i,t}\right)} = \operatorname{argmax} \sum_{h=0}^{H} \frac{e_n' \left(\sum_{s=0}^{h} \Phi^s P R R' P' \Phi'^s\right) e_n}{e_n' \left(\sum_{s=0}^{h} \Phi^s P P' \Phi'^s\right) e_n} \tag{8}$$

s.t

$$R'R = 1 \tag{9}$$

$$e_k' P R = 0 \tag{10}$$

- The identified shock R^* can explain most of the forecast error of variable n.

VAR identification: news shock

- Housing price news shock q^*: A shock that can explain the variation of expectation error of housing price most, yet subject to
- Orthogonality (a constraint on the scalar (norm) of shock): $q'q = 1$
- Non-contemporaneous effect on variable k:
  $e_k' Pq = 0$ Orthogonal Requirement Purification

VAR identification: news shock

$$y_{p^H,t+3} - E_t y_{p^H,t+3} = \left.\underbrace{R_{w^d}}_{w^d_{t+3}} + \underbrace{\Phi R_{w^d}}_{w^d_{t+2}} + \underbrace{\Phi^2 R_{w^d}}_{w^d_{t+1}}\right\} \text{housing price news shock on demand}$$

$$+ \left.\underbrace{R_{w^s}}_{w^s_{t+3}} + \underbrace{\Phi R_{w^s}}_{w^s_{t+2}} + \underbrace{\Phi^2 R_{w^s}}_{w^s_{t+1}}\right\} \text{housing price news shock on supply}$$

VAR identification: news shock

$$
\begin{aligned}
y_{p^H,t+3} - E_t y_{p^H,t+3} = & \left.\underbrace{R_{w^d}}_{w^d_{t+3}} + \underbrace{\Phi R_{w^d}}_{w^d_{t+2}} + \underbrace{\Phi^2 R_{w^d}}_{w^d_{t+1}}\right\} \text{housing price news shock on demand} \\
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& \left.+ \underbrace{R_u}_{u_{t+3}} + \underbrace{\Phi R_u}_{u_{t+2}} + \underbrace{\Phi^2 R_u}_{u_{t+1}}\right\} \text{housing price contemporaneous shock} \\
& \left.+ \underbrace{R_\varepsilon}_{\varepsilon_{t+3}} + \underbrace{\Phi R_\varepsilon}_{\varepsilon_{t+2}} + \underbrace{\Phi^2 R_\varepsilon}_{\varepsilon_{t+1}}\right\} \text{other macro shocks} \\
& \left.+ \underbrace{R_\xi}_{\xi_{t+3}} + \underbrace{\Phi R_\xi}_{\xi_{t+2}} + \underbrace{\Phi^2 R_\xi}_{\xi_{t+1}}\right\} \text{other macro news shocks}
\end{aligned}
$$

VAR identification: news shock

Sign Restriction rules out supply shock

$$
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y_{p^H,t+3} - E_t y_{p^H,t+3} = & \left.\underbrace{R_{w^d}}_{w^d_{t+3}} + \underbrace{\Phi R_{w^d}}_{w^d_{t+2}} + \underbrace{\Phi^2 R_{w^d}}_{w^d_{t+1}}\right\} \text{housing price news shock on demand} \\
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\end{aligned}
$$

VAR identification: news shock

Mild Assumption on the effects of macro shock (i.e. most of the variation of housing price cannot come from monetary policy, TFP variation or marginal cost shock

$$\left.\begin{aligned} y_{p^H,t+3} - E_t y_{p^H,t+3} = \underbrace{R_{w^d}}_{w^d_{t+3}} + \underbrace{\Phi R_{w^d}}_{w^d_{t+2}} + \underbrace{\Phi^2 R_{w^d}}_{w^d_{t+1}} \end{aligned}\right\} \text{housing price news shock on demand}$$

$$\left. + \underbrace{R_u}_{u_{t+3}} + \underbrace{\Phi R_u}_{u_{t+2}} + \underbrace{\Phi^2 R_u}_{u_{t+1}} \right\} \text{housing price contemporaneous shock}$$

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\end{aligned}
$$

Solve a shock R_w that can explain the variation of expectation error of housing price **most**

VAR identification: news shock

Zero Restriction: Find a variable k which satisfies $y^{u}_{p^H,0} = 0$ and $y^{w}_{p^H,0} \neq 0$

$$\left. y_{p^H,t+3} - E_t y_{p^H,t+3} = \underbrace{R_{w^d}}_{w^d_{t+3}} + \underbrace{\Phi R_{w^d}}_{w^d_{t+2}} + \underbrace{\Phi^2 R_{w^d}}_{w^d_{t+1}} \right\} \text{housing price news shock on demand}$$

VAR identification: news shock

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subject the constraint $e_k' R_w = 0$

Purification

- Endogenous response to News

$$\Upsilon_t = \rho_g \Upsilon_{t-1} + \alpha_1 x_t + w_{t-3} + u_t + \alpha_2 w_t \tag{11}$$

where x_t denotes any macro variable such as interest rate, GDP, unemployment rate, etc. α_1 measures the cross-connection effect between macro economics and perception about fundamental. In other words a monetary policy shock may driven the interest rate and output first and then Υ_t comoves with the output and interest rate. w_{t-3} is just the news shock which announced 3 period ahead. u_t is the contemporaneous shock and α_2 measures the endogenous contemporaneous effect induced by news shock w_t.

- Purification objective: Construct a time series

$$y_{k,t} = \widehat{\Upsilon}_t = \Upsilon_t - \alpha_2 w_t$$

Purification: Heuristic Explanation

- Expectation: survey data

$$E_t \Upsilon_{t+6} = \rho^6 \Upsilon_t + \rho^5 w_{t-2} + \rho^4 w_{t-1} + \rho^3 w_t$$

- Regression of $E_t \Upsilon_{t+6}$ on Υ_t

$$\gamma_t^E = \rho^5 w_{t-2} + \rho^4 w_{t-1} + \rho^3 w_t$$

- Regression of Υ_t on γ_t^E

$$\gamma_t = \Upsilon_t - \beta \gamma_t^E$$

Back

VAR Identification Strategy: News shock

- Fundamental impact indicator k: an index to the fundamental element that drives the demand function of housing demand function
  - i.e. the preference ϕ_t in Cobb–Douglas utility function $U(c_t, h_t, l_t) = \frac{\left(c_t^{\phi_t} h_t^{1-\phi_t}\right)^{1-\sigma}}{1-\sigma} + \kappa \frac{l_t^{1+\psi}}{1+\psi}$ which follows $\phi_t = (1-\rho_\phi)\overline{\phi} + \rho_\phi \phi_{t-1} + w_{t-\tau} + w_t^\tau$ and $w_{t-\tau}$ is the news shock to housing demand.
- NAHB/Wells Fargo Housing Market Index (HMI)
  - a monthly survey on NAHB members about their perception about the housing market right now him_t, and expectation over the next six month $E_t\mathrm{him}_{t+6}$
  - pure contemporaneous impact u_t^{him} from him_t

$$\mathrm{him}_t = \alpha_0 + \alpha_1 E_{t-6}\mathrm{him}_t + \alpha_2 E_t\mathrm{him}_{t+6} + u_t^{\mathrm{him}}$$

VAR Identification Strategy: News shock

Proposition 4

The identification to a news shock R^* through equation 8 is unique to covariance of the residual $\Omega = PP'$ from VAR's DGP 1.

VAR Identification Strategy: News shock

- Since my interest is to explore the house market boom, I further do the sign restriction on the vector IRF_t based on the rule

$$\text{IRF}_t^{sign} = \begin{cases} \text{IRF}_t & \text{if } e_n' \text{IRF}_{\boldsymbol{t}} e_n \geq 0 \\ -\text{IRF}_t & \text{if } e_n' \text{IRF}_{\boldsymbol{t}} e_n < 0 \end{cases}$$

Back

VAR Identification Strategy: Fake News shock

- Household

$$c_t^{-\sigma} = \beta R_{t+1} c_{t+1}^{-\sigma}$$
$$h_t^{\varphi} = w c_t^{-\sigma}$$

- Firm

$$R_t = \alpha \frac{y_t}{k_{t-1}} + \delta - 1$$
$$w_t = (1-\alpha)\frac{y_t}{h_t}$$
$$y_t = A_t k_{t-t}^{\alpha} h_t^{1-\alpha}$$

- Market Cleaning

$$y_t = c_t + I_t + \log(G_t)$$
$$I_t = k_t - (1-\delta)k_{t-1}$$
$$g_t = \rho_g g_{t-1} + w_{t-\tau} + w_t^{\tau} \tag{12}$$

VAR Identification Strategy: Fake News shock

- The household cannot know the value of G_t and w_t but a signal to then

$$\widetilde{g}_t = g_t + \nu_t^\tau$$

$$\widetilde{w}_{t-\tau} = w_{t-\tau} + \nu_{t-\tau}$$

- Household at time $t-\tau$ will have a perception of $w_{t-\tau}$ given the observation $\widetilde{w}_{t-\tau}$ and I denote it as $w_{t-\tau|t-\tau} = \theta \widetilde{w}_{t-\tau}$
- Denote $\widetilde{w}_t^i$ as an observation to shock w_{t-i}. For example, a news shock w_t will have effect on G at $t+\tau$. At time $t+1$ household gets a new observation related to w_t, $\widetilde{w}_{t+1}^1$, in addition to the old observation of w_t at time t $\widetilde{w}_t$. I further assume

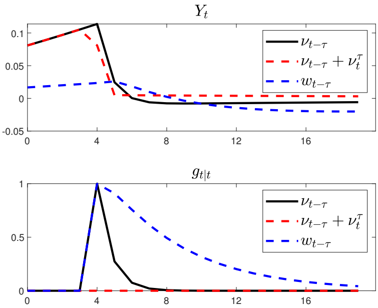
$$\widetilde{w}_{t-\tau+1}^1 = \widetilde{w}_{t-\tau+2}^2 = \cdots = \widetilde{w}_{t-1}^{\tau-1} = 0$$

holds. Therefore

$$w_{t-\tau|t-\tau} = w_{t-\tau|t-\tau+1} = w_{t-\tau|t-\tau+2} = \cdots = w_{t-\tau|t-1}$$

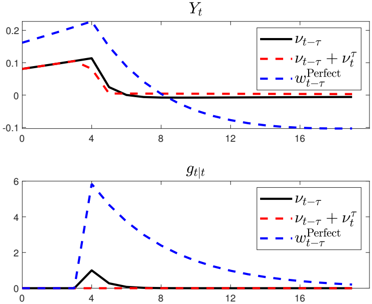
VAR Identification Strategy: Fake News shock

- Throughout exercise 1 to 3, imperfect information holds.
- Same perception: $g^{\nu}_{t|t} = g^{w}_{t|t} = g^{\nu+\nu^{\tau}}_{t|t}$
  1. Only noisy shock $\nu_{t-\tau}$;
  2. Fake news shock. A noisy shock on $w_{t-\tau}$ at time $t-\tau$, $\nu_{t-\tau}$, as well as a negative noisy shock on g_t at time t, ν^{τ}_t;
  3. A news shock $w_{t-\tau}$.



VAR Identification Strategy: Fake News shock

- Throughout exercise 1 to 2, imperfect information holds. In exercise 3, it is the type of perfect news.
- Same observation at time $t-\tau$: $\widetilde{w}_{t-\tau}$
  1. Only noisy shock $\nu_{t-\tau}$;
  2. Fake news shock. A noisy shock on $w_{t-\tau}$ at time $t-\tau$, $\nu_{t-\tau}$, as well as a negative noisy shock on g_t at time t, ν_t^τ;
  3. A perfect news shock $w_{t-\tau}$.



VAR Identification Strategy: Fake News shock

- Notation: Throughout exercise 1 to 3, imperfect information holds.
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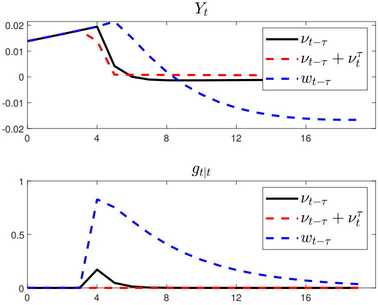
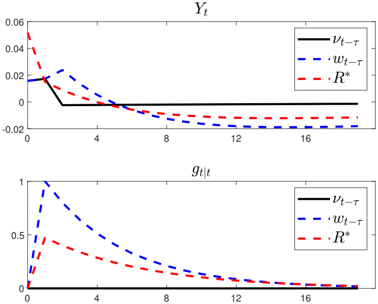


Back

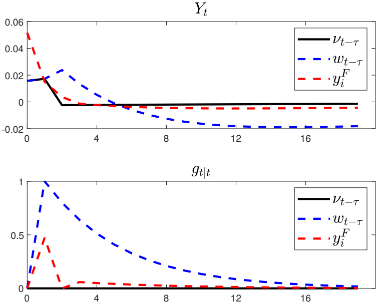
VAR Identification Strategy: Fake News shock

- The fundamental impact g_t is observable.

Identification to news shock R^*



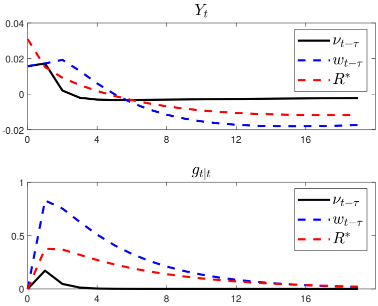
Identification to fake news shock R_F^*



VAR Identification Strategy: Fake News shock

- The fundamental impact g_t is unobservable.

Identification to news shock R^*



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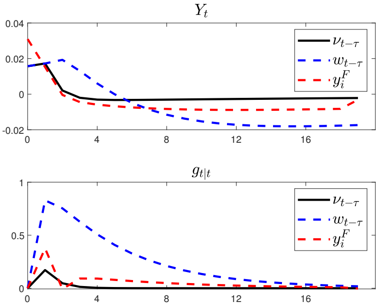

Back

VAR Identification Strategy: Fake News shock

- The fundamental impact g_t is observable
  - $g_t = \rho_g g_{t-1} + w_{t-\tau} + w_t^\tau$ and $\widetilde{w}_{t-\tau} = w_{t-\tau} + \nu_{t-\tau}$
  - whether the news $\widetilde{w}_{t-\tau}$ is true or fake is informed to household via g_t at time t without any delay
  - $y_{i-\tau-1}^\tau$ in equation 2 works as a contemporaneous shock w_t^τ offsets the true shock realized at t, $w_{t-\tau}$ and generates $g_t = 0$
- The fundamental impact g_t is unobservable.
  - there is no other signal that household can use to infer whether $\widetilde{w}_{t-\tau}$ comes from $w_{t-\tau}$ or $\nu_{t-\tau}$ but learn through observation gradually
  - $g_{t|t} = \gamma_1 g_{t-1|t-1} + \gamma_2 w_{t-\tau|t-\tau} + \gamma_3 g_{t-1} + \gamma_4 w_{t-\tau} + \gamma_5 \nu_t^\tau + \gamma_6 w_t^\tau$ where $\gamma_1 = \rho\left[1 - \frac{z_{11}}{z_{11}+\sigma^2_{\nu^\tau}}\right]$, $\gamma_2 = 1 - \frac{z_{11}}{z_{11}+\sigma^2_{\nu^\tau}}$, $\gamma_3 = \gamma_7\rho$ and $\gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = \frac{z_{11}}{z_{11}+\sigma^2_{\nu^\tau}}$. z_{11} can be solved from a positive root of quadratic equation
  - $y_{i-\tau-1}^\tau$ in equation 2 works as a contemporaneous shock w_t^τ which offsets the effect of true shock $w_{t-\tau}$ at time t.

Back

VAR identification to fake news shock

Assumption 1

The response to a news shock, either a fake news or a true news, under imperfect information, will be the same before the shock realized. In other words $\overline{R}_1 = \overline{R}_2 = R^*$ *and* $y_i^F = y_i^T = y_i, \forall y^F \in U^F, y^T \in U^T, y \in U, i \in [0, \tau]$ *will hold where* U^F *is the response to fake news and* U^T *is response to true news.* Numerical Example

VAR identification to fake news shock

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The response to a news shock, either a fake news or a true news, under imperfect information, will be the same before the shock realized. In other words $\overline{R}_1 = \overline{R}_2 = R^*$ *and* $y_i^F = y_i^T = y_i, \forall y^F \in U^F, y^T \in U^T, y \in U, i \in [0, \tau]$ *will hold where* U^F *is the response to fake news and* U^T *is response to true news.* Numerical Example

Takeaway

We do not need to separately identify the response before τ, when the news realizes.

VAR identification to fake news shock

Assumption 2

The empirically identified news shock U lies on the medial of response to fake news U^F and response to true news U^T. In other words, $y_i \in \left[y_i^F, y_i^T\right], \forall y^F \in U^F, y^T \in U^T, y \in U, i \in [\tau+1, \infty]$ will hold. Furthermore, the news shock U is a linear combination of U^F and U^T and $y_i = \alpha y_i^F + \beta y_i^T$ holds. Numerical Example

VAR identification to fake news shock

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The empirically identified news shock U lies on the medial of response to fake news U^F and response to true news U^T. In other words, $y_i \in \left[y_i^F, y_i^T\right], \forall y^F \in U^F, y^T \in U^T, y \in U, i \in [\tau+1, \infty]$ *will hold. Furthermore, the news shock U is a linear combination of U^F and U^T and* $y_i = \alpha y_i^F + \beta y_i^T$ *holds.* Numerical Example

Takeaway

The mixed identification result can be refined to fake news by subtracting the realization βy_i^T

Crowd-out effect of Overbuilding

$$
\begin{aligned}
I\widetilde{I}_t = &-\Bigg\{\left(\Phi_H + \frac{\nu}{\alpha}p^H H\right)\int \widetilde{h}_t^{\,i} dG_i - \Phi_\mu \int \widetilde{\mu}_t^i dG_i \\
&+ \Phi_{p^H}\left[\frac{1}{1-\left(1-\delta^H\right)\frac{1}{R}} F^H(\widetilde{H}_t) - \frac{\left(1-\delta^H\right)\frac{1}{R}}{1-\left(1-\delta^H\right)\frac{1}{R}}\mathbb{E}_t F^H(\widetilde{H}_{t+1})\right] \\
&-\Phi_{cov}^i \int \widetilde{cov}_t^i dG_i + \frac{\nu}{\alpha} Y_H p^H F^H(\widetilde{H}_t)\Bigg\}
\end{aligned}
$$

Crowd-out effect of Overbuilding

Demand-Side Effect

$$\widetilde{II_t} = -\Big\{\left(\Phi_H + \frac{\nu}{\alpha} p^H H\right)\int \widetilde{h}_t{}^i dG_i - \Phi_\mu \int \widetilde{\mu}_t^i dG_i$$
$$+ \Phi_{p^H}\left[\frac{1}{1-\left(1-\delta^H\right)\frac{1}{R}} F^H(\widetilde{H}_t) - \frac{\left(1-\delta^H\right)\frac{1}{R}}{1-\left(1-\delta^H\right)\frac{1}{R}}\mathbb{E}_t F^H(\widetilde{H}_{t+1})\right]$$
$$-\Phi^i_{cov}\int \widetilde{cov}^i_t dG_i + \frac{\nu}{\alpha} Y_H p^H F^H(\widetilde{H}_t)\Big\}$$

Crowd-out effect of Overbuilding

Supply-Side Effect

$$\widetilde{II_t} = -\Bigg\{ \left(\Phi_H + \frac{\nu}{\alpha} p^H H\right) \int \widetilde{h_t}^i dG_i - \Phi_\mu \int \widetilde{\mu}_t^i dG_i$$

$$+ \Phi_{p^H} \left[\frac{1}{1-(1-\delta^H)\frac{1}{R}} F^H(\widetilde{H}_t) - \frac{(1-\delta^H)\frac{1}{R}}{1-(1-\delta^H)\frac{1}{R}} \mathbb{E}_t F^H(\widetilde{H}_{t+1}) \right]$$

$$-\Phi_{cov}^i \int \widetilde{cov}_t^i dG_i + \frac{\nu}{\alpha} Y_H p^H F^H(\widetilde{H}_t) \Bigg\}$$

Mechanism: Relative Intratemporal Elasticity

- A smaller intratemporal elasticity of substitution $\rightarrow$ A larger complement effect contemporaneously
- Financial friction works $\rightarrow$ marginal value of housing servicing $\uparrow$
  - One unit extra wealth $\Delta c_t^1 = 0.5$, $\Delta h_t^1 = 0.5$ or $\Delta c_t^2 = 0.5$, $\Delta h_t^2 = 0.2$
  - $\Delta \mu_t^1 < \Delta \mu_t^2 < 0$ as $\Delta h > 0$, more housing servicing used to slack the collateral constraint
- Wealth effect: $\Delta p_t^H > 0$, the value, that one unit of housing service provides, now can be transferred to utilitarian value more with a smaller intratemporal elasticity of substitution.

$$\frac{U_{h,t}}{U_{c,t}} = f\left(p_t^{+}, p_{t+1}^{-}\right)$$

Back

Mechanism: Financial Friction

- Marginal Value of housing is larger as now it plays a larger role in collateral constraint(through μ in ss)
- Financial friction works more silent $\rightarrow$ marginal value of housing servicing $\uparrow$
  - One unit extra wealth $\Delta c_t^1 = 0.5$, $\Delta h_t^1 = 0.5$, $\gamma = 0.5$ or $\Delta c_t^2 = 0.5$, $\Delta h_t^2 = 0.5$, $\gamma = 0.8$
  - $\Delta \mu_t^1 < \Delta \mu_t^2 < 0$ as $\Delta h > 0$, more housing servicing used to slack the collateral constraint
- Wealth effect: $\Delta p_t^H > 0$, Same as item 1 as in this scenario p_t^H and h_t are isomorphic in collateral constraint.

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Mechanism: Wealth Distribution

- Left-skewed residential asset response:The more wealthy you are, the more response you would have.
- Left-skewed distribution of residential asset: The more response you have, the larger proportion of your wealth in distribution
- Right-skewed marginal propensity to consumption: Amplified passthrough from residential asset and nondurable consumption

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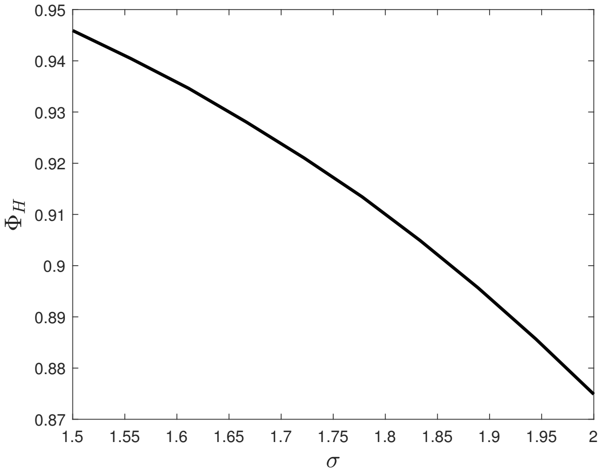
Relative Intratemporal Elasticity of Substitution

Relative Intratemporal Elasticity of Substitution $\sigma \uparrow$



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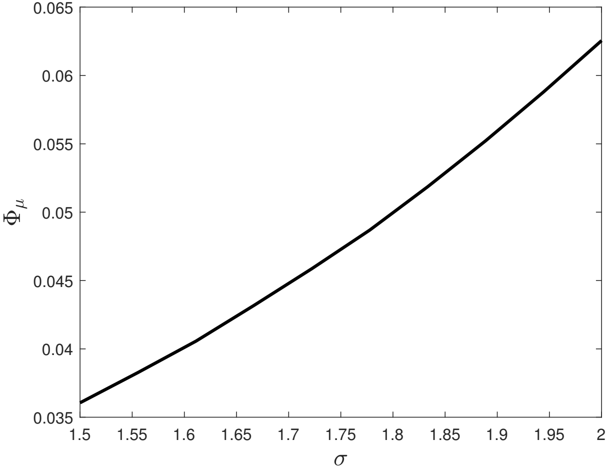
Relative Intratemporal Elasticity of Substitution

Relative Intratemporal Elasticity of Substitution $\sigma \uparrow$



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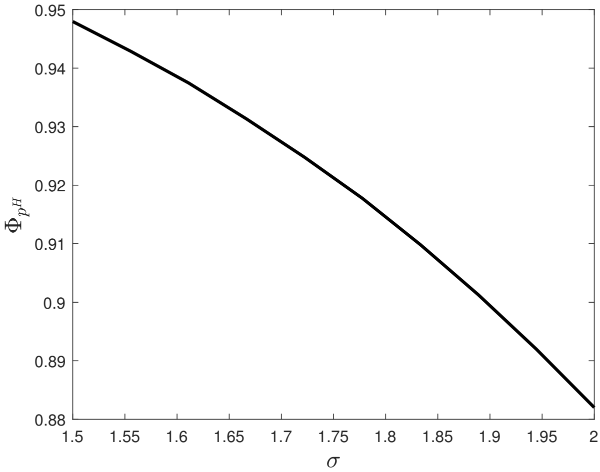
Relative Intratemporal Elasticity of Substitution

Relative Intratemporal Elasticity of Substitution $\sigma \uparrow$



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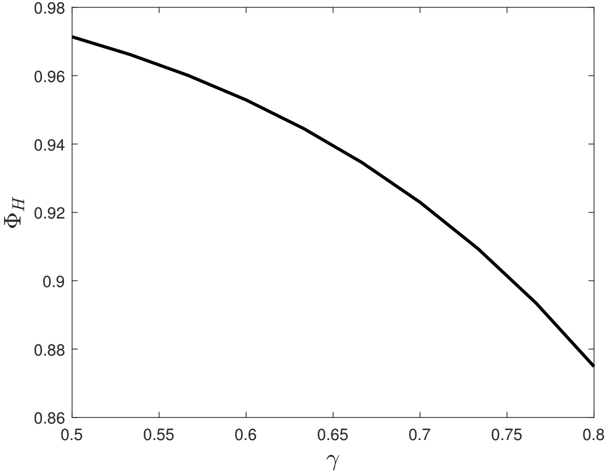
Financial Friction

Looser Collateral Constraint $\gamma \uparrow$



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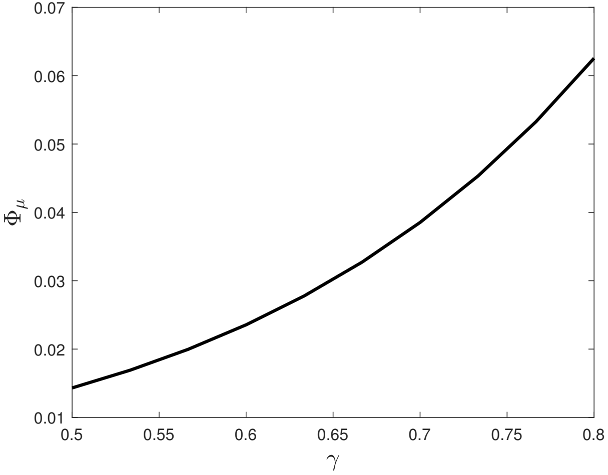
Financial Friction

Looser Collateral Constraint $\gamma \uparrow$



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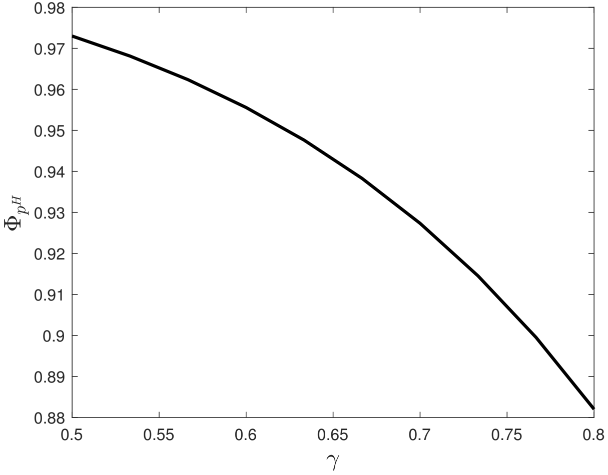
Financial Friction

Looser Collateral Constraint $\gamma \uparrow$



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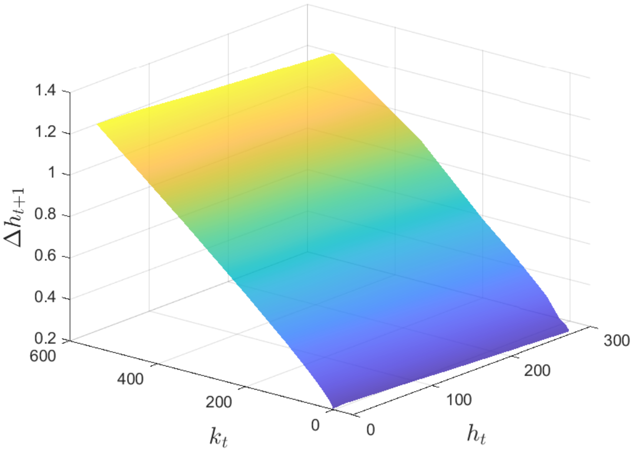
Wealth Distribution

Heterogeneous response along wealth distribution



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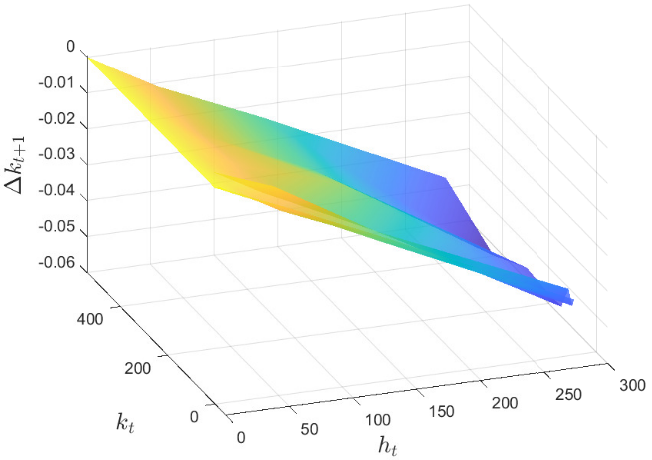
Wealth Distribution

Heterogeneous response along wealth distribution



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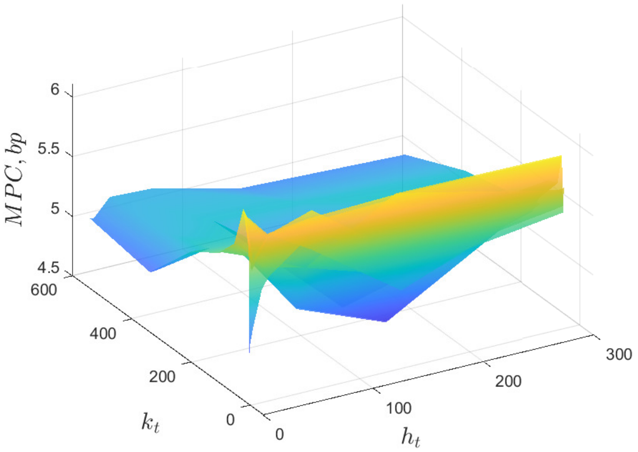
Wealth Distribution

Heterogeneous response along wealth distribution



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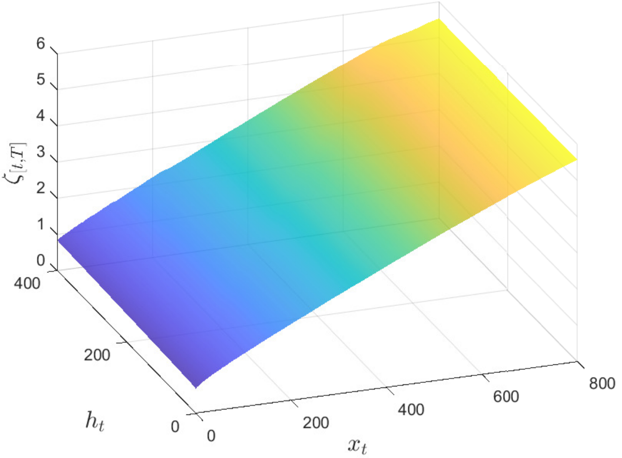
Wealth Distribution

Heterogeneous response along wealth distribution



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Corollary 2

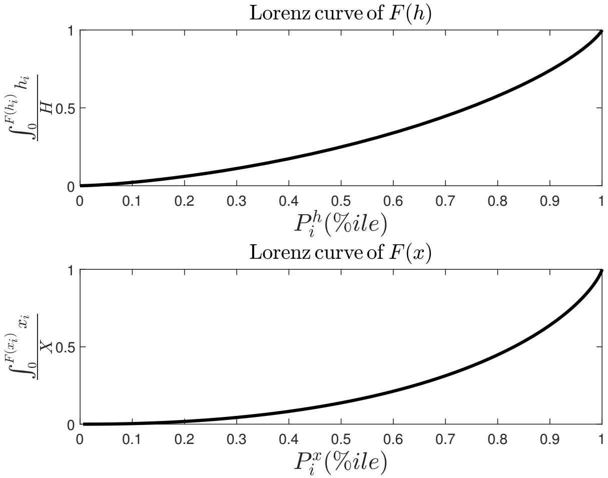
Ceteris paribus, an positive expectation about the housing price change in time $T+1$ will induce a jump in demand of housing service in time t. The response extend follows

$$\left.\widetilde{h}_t^i\right|_{h_{t+i},\mu_{t+i},\lambda_{t+i},,i\in[1,T]} = \zeta_t^i dp_{t+T+1}^H \tag{13}$$

where $\zeta_t^i = -\frac{1}{u''_{h^i}}\mathbb{E}_t\left[\beta\left(1-\delta^H\right)\right]^T \prod_{s=1}^T \frac{\lambda_{t+s}}{\lambda_{t+s}-\mu_{t+s}}\lambda_{t+T+1}$

Wealth Distribution: Inequality

The Lorenz curve of residential asset h and real effective asset x



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Solution Method

- Two endogenous asset: liquid and illiquid asset
- Steady-state policy function: endogenous grid method; Carroll (2006) and Auclert et al. (2021)
- Steady-state distribution: Young (2010)
- Dimensionality reduction: Image Compression; Bayer et al. (2018)
- Perturbation with imperfect information: A new contribution based on Baxter et al. (2011) and Uhlig (1999)

Solution Method

- s_t state variable; c_t control variable; Ξ_t exogenous shocks
- prefect information
  - policy function (matrix) P_1, P_2, Q_1 and Q_2
  - $s_t = P_1 s_{t-1} + Q_1 \Xi_t$ and $c_t = P_2 c_{t-1} + Q_2 \Xi_t$
- imperfect information
  - perception on subset of state variables $s_{2,t}$ and $s_{2,t|t}$
  - law of motion of perception process (bayesian updating) $s_{2,t|t} = A^s s_{2,t-1|t-1} + P^s \widetilde{s}_{2,t}$ where $\widetilde{s}_{2,t}$ is the observation of $s_{2,t}$
  - we can still use P_2 and Q_2 because of CEQ (certainty equivalent) $c_t = P_2 s_{t|t} + \widetilde{Q}_2 \Xi_t$ ($\widetilde{Q}_2$ is adjusted from Q_2 by observation and perception function)
- solve new policy $\widetilde{P}_1$, new mapping $\widetilde{P}_3$ and $\widetilde{Q}_1$ satisfying $s_t = \widetilde{P}_1 s_{t-1} + \widetilde{P}_3 s_{t-1|t-1} + \widetilde{Q}_1 \Xi_t$

Solution Method: solve new policy $\widetilde{P}_1$

- $\widetilde{P}_1$ deviates from P_1 a lot (assuming $s_{t-1|t-1} = 0$)
  - $s_{t|t}$ deviates from s_t $\rightarrow$ $c_t^{\text{imperfect}}$ deviates from c_t^{perfect} $\rightarrow$ investment $I_t^{\text{imperfect}}$ deviates from I_t^{perfect}
  - $s_t^{\text{imperfect}}$ deviates from s_t^{perfect}

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- literature: guess and verify
- new method: solving directly via technique in linear algebra

Full-information Bayesian Estimation

- Following Smets and Wouters (2003, 2007), data is detrended to growth rate with long-run trend $d\log(Y_t) = \overline{y} + y_t$
- State Space Model: To be comparable, implement the same augmentation
  - State Equation

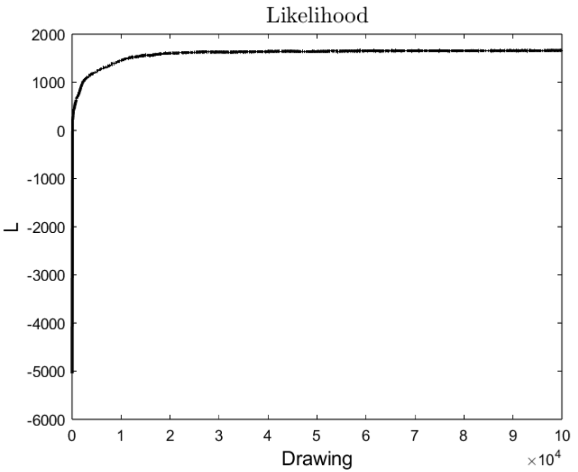
$$\begin{bmatrix} x_t \\ x_{t-1} \end{bmatrix} = \begin{bmatrix} P & 0 \\ I & 0 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \end{bmatrix} + \begin{bmatrix} Q \\ 0 \end{bmatrix} \varepsilon_t$$

  - Measurement Equation

$$y_t = \begin{bmatrix} H & -H \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_t \\ x_{t-1} \end{bmatrix} + S\zeta_t$$

Full-information Bayesian Estimation

- RWMH



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