China's Housing Bubble, Infrastructure Investment, and Economic Growth

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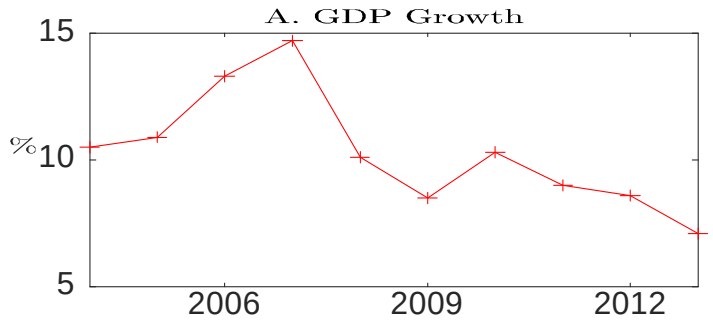
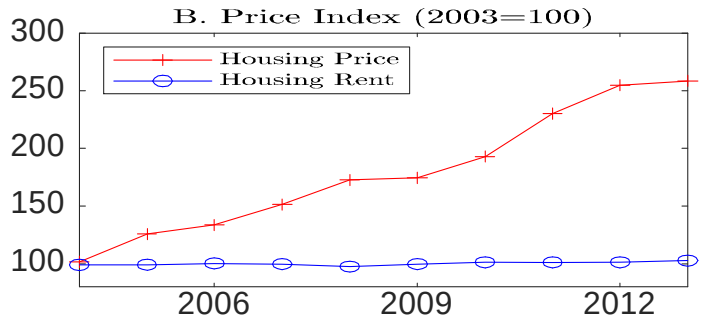
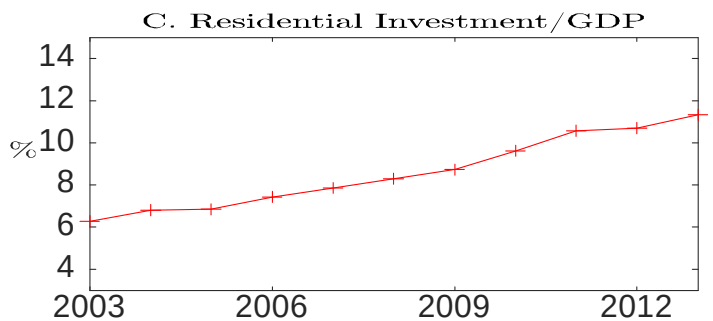
Motivation

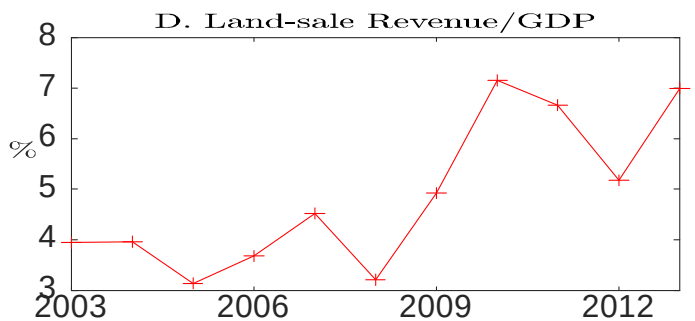
- China implemented a series of market-oriented housing reforms in the 1990s.
- Since then, the Chinese real estate market has experienced a dramatic and long-lasting boom.
- What is the impact on the Chinese macroeconomy?
- What would happen if housing bubbles burst?
- What would the impact of property tax be?

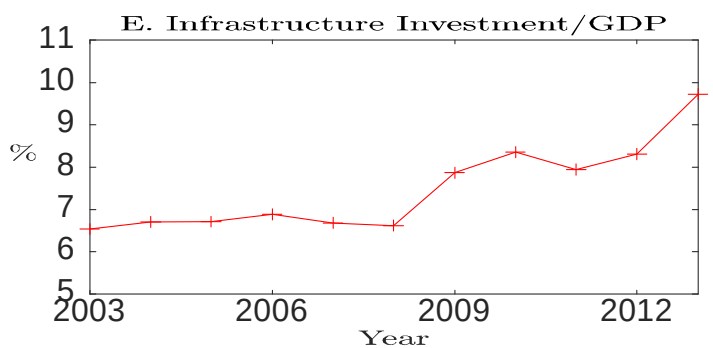
Stylized Facts

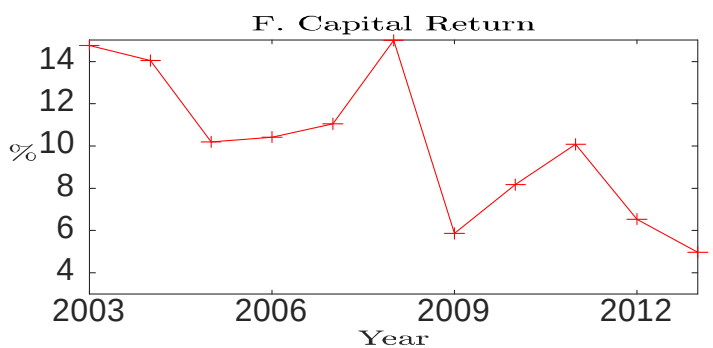












Stylized Facts for 2003-2013

- High (10%) and declining GDP growth
- High growth (10%) of housing prices and low growth of rents (0.5%)
- Increasing residential investment to GDP ratio (8.6%)
- Increasing land-sale revenue to GDP ratio (4.9%)
- Increasing infrastructure investment to GDP ratio (7.5%)
- High average (10%) and declining capital return

Our Story

- Housing and non-housing sectors
- OLG: workers and entrepreneurs
- Entrepreneurs face borrowing constraints and invest in capital and houses
- Land is an input to produce houses
- Shortage of assets and speculation fuel a housing bubble $\longrightarrow$ High land prices

Our Story: China institution Feature

- Government owns land and collects land-sale revenues to finance infrastructure investment
- Infrastructure raises TFP of non-housing production

Our Story: Impact of Housing Bubble

- Crowding-in effect: Housing bubble $\longrightarrow$ land-sale revenue $\uparrow \longrightarrow$ infrastructure investment $\uparrow \longrightarrow$ productivity and output $\uparrow$
- Crowding-out effect (Tirole 1985): Capital investment $\downarrow$
- Reallocation effect: capital and labor flow from non-housing sector to housing sector
- Net effects ambiguous: GDP = Nonhousing ouput + Residential investment + Rents

Supporting Evidence

Table: Estimation Result: Crowding-in and Crowding-out

VARIABLES	(1) *growth_infr*	(2) *growth_capital*	(3) *growth_labor*
growth_hp	0.0645^{*}	-0.1832^{***}	-0.0969^{**}
	(0.032)	(0.043)	(0.037)
growth_gdp	0.3278	1.2913^{***}	0.1101
	(0.288)	(0.183)	(0.195)
Constant	0.1612^{***}	0.0613^{**}	0.0430
	(0.040)	(0.026)	(0.025)
Observations	372	372	217
Adjusted R-squared	0.284	0.410	0.232
Province	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Basic Model

- A small open economy two-sector deterministic OLG model
- No long-run growth
- House is a pure bubble asset
- Constant interest rate R^f

Workers

- Supply one unit of labor inelastically
- Decision problem

$$\begin{aligned} \max \quad & \log(c_{1t}^w) + \beta \log(c_{2,t+1}^w) \\ s.t. \quad & c_{1t}^w + b_{t+1} = w_t, \\ & c_{2,t+1}^w = R^f b_{t+1} \end{aligned}$$

Entrepreneurs

- A young entrepreneur inherits wealth m_t from the old and invests in capital and houses
- He/she cannot borrow

$$\begin{aligned} \max \quad & \log(c_{1t}^e) + \beta \log(c_{2,t+1}^e) \\ s.t. \quad & c_{1t}^e + k_{t+1} + Q_t h_{t+1} = m_t, \\ & c_{2,t+1}^e = R_{t+1} k_{t+1} + Q_{t+1}(1-\delta_h) h_{t+1}, \end{aligned}$$

- No-arbitrage equation for bubble

$$R_{t+1} = \frac{Q_{t+1}(1-\delta_h)}{Q_t}.$$

Nonhousing Sector

- Each old entrepreneur owns a firm

$$y_{t+1} \equiv \hat{A}_{t+1}^{\theta} k_{t+1}^{\alpha} n_{c,t+1}^{1-\alpha},$$

- Productivity $\hat{A}_{t+1}$ depends on infrastructure A_{t+1} :

$$\hat{A}_{t+1} \equiv A_{t+1} / (K_{t+1}^{\rho} N_{c,t+1}^{1-\rho}),$$

  where K_{t+1} and $N_{c,t+1}$ are aggregate capital and labor used in non-housing sector

- Congestion effect

Capital Return and Inheritance

- A fraction of after-tax profits as inheritance

$$m_{t+1} = \psi\left((1-\tau)y_{t+1} - w_{t+1}n_{c,t+1}\right).$$

- The remainder is capital return

$$R_{t+1}k_{t+1} \equiv \max_{n_{c,t+1}} \quad (1-\psi)\left((1-\tau)\hat{A}^{\theta}_{t+1}k^{\alpha}_{t+1}n^{1-\alpha}_{c,t+1} - w_{t+1}n_{c,t+1}\right).$$

Portfolio Choice

- Fraction of housing asset

$$\phi_t \equiv \frac{Q_t h_{t+1}}{k_{t+1} + Q_t h_{t+1}}$$

- Optimal capital investment

$$k_{t+1} = (1 - \phi_t)\frac{\beta}{1+\beta} m_t = (1 - \phi_t)\frac{\beta}{1+\beta}\psi\alpha(1-\tau)y_t.$$

- Bubble ($Q_t > 0$) crowds out capital $\phi_t \in (0, 1)$

Housing Sector

- Competitive firms buy land from government at price p_{Lt}

$$\max_{l_t, n_{ht}} \; Q_t l_t^{\alpha_l} n_{ht}^{1-\alpha_l} - p_{Lt} l_t - w_t n_{ht}$$

- Exogenous land supply L_t

$$p_{Lt} = Q_t \alpha_l L_t^{\alpha_l - 1} N_{ht}^{1-\alpha_l}$$

- Aggregate housing output

$$Y_{ht} = L_t^{\alpha_l} N_{ht}^{1-\alpha_l},$$

- The total housing stock H_t evolves as

$$H_{t+1} = (1 - \delta_h) H_t + Y_{ht}$$

Government

- Runs balanced budget
- Use taxes and land-sale revenues to finance infrastructure investment

$$A_{t+1} - (1 - \delta_a)A_t = \tau Y_t + p_{Lt} L_t$$

Equilibrium

- Bubbly $Q_t > 0$ for all $t \longrightarrow p_{Lt} > 0$
- Bubbleless (fundamental) $Q_t = 0$ for all $t \longrightarrow p_{Lt} = 0$, housing and land markets collapse

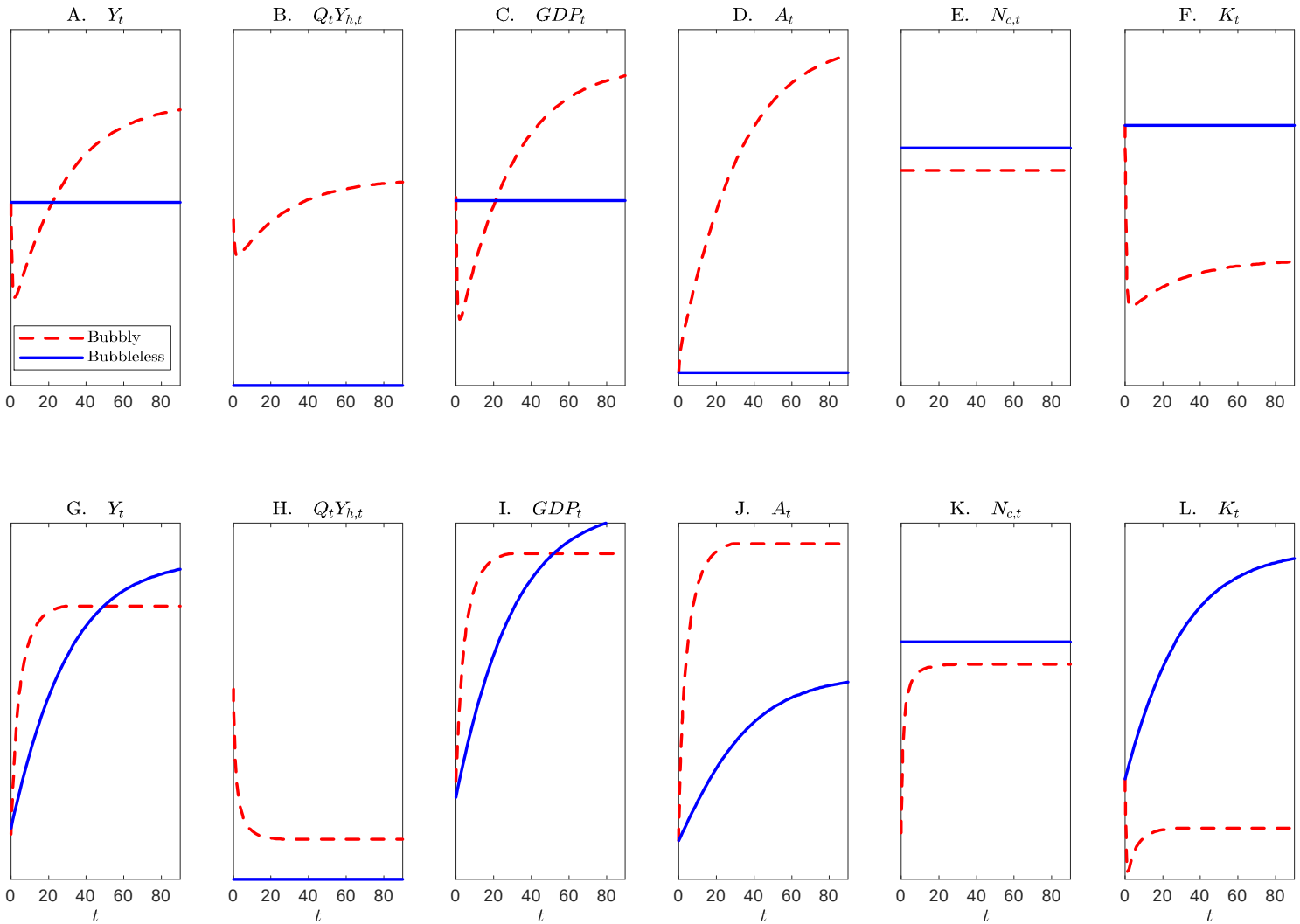
Inspecting Mechanism

- Crowd in: Bubbly houses $Q_t > 0$ for all $t \longrightarrow p_{Lt} > 0 \longrightarrow$ collects land-sale revenues $\longrightarrow$ finance more infrastructure investment in non-housing sector
- Crowd out capital
- Reallocate labor from nonhousing sector to housing sector
- In steady state

$$\frac{K^b}{K^n} < \frac{Y^b}{Y^n} < \frac{A^b}{A^n}.$$

- Whether $Y^b > Y^n$ depends on parameters, θ

Transition


A. Y_t
B. $Q_t Y_{h,t}$
C. GDP_t
D. A_t
E. $N_{c,t}$
F. K_t
Bubbly
Bubbleless
G. Y_t
H. $Q_t Y_{h,t}$
I. GDP_t
J. A_t
K. $N_{c,t}$
L. K_t
0 20 40 60 80
t

Extended Model

- Population growth g_n and technology growth g_e
- Live for $T = 50$ years, work for 30 years
- Housing delivers rents, grow at g_r
- Housing firms also use capital input
- Introduce government debt using land sales as collateral

Stochastic Bubbles

- Housing bubble bursts with prob $p_t = p_0 e^{-\eta t}$
- Once it bursts, it will never reemerge
- Can generate high housing price growth during transition period
- Allow housing price to grow faster than capital return

Calibration

Parameter	Description
$R^f = 1.003$	Annual interest rate
$g_n = 0.005$	Growth of population
$g_r = 0.005$	Growth of rents
$\tau = 0.13$	Tax rate in nonhousing sector
$\tau_h = 0.16$	Tax rate in housing sector
$\alpha_l = 0.56$	Land income share in housing sector
$\alpha_k = 0.24$	Capital income share in housing sector
$\alpha = 0.54$	Capital income share in nonhousing sector
$\theta = 0.1$	Output elasticity of infrastructure
$\rho = 0.5$	Capital congestion elasticity
$\zeta_b = 0.46$	Share of government expenditure in debt
$\kappa = 0.53$	Share of infrastructure investment in land-sale revenue
$\delta_h = 0.014$	Housing depreciation rate
$\delta_k = 0.1$	Capital depreciation rate
$\delta_a = 0.095$	Infrastructure depreciation rate

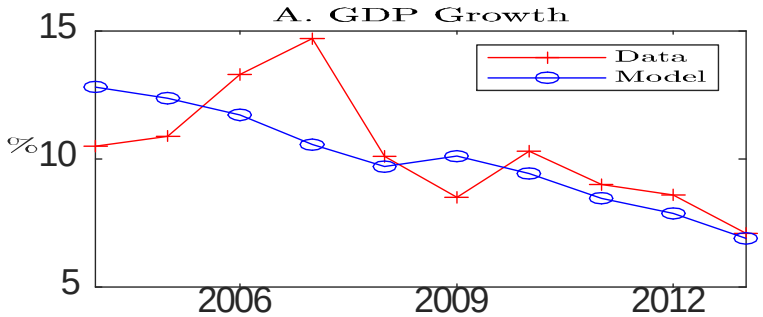
Table: Parameters estimated outside the model

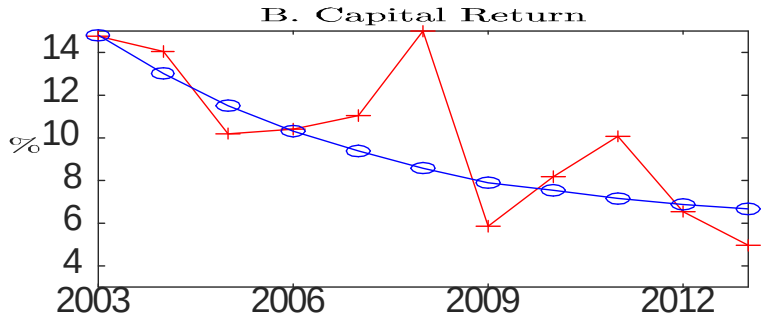
Calibration

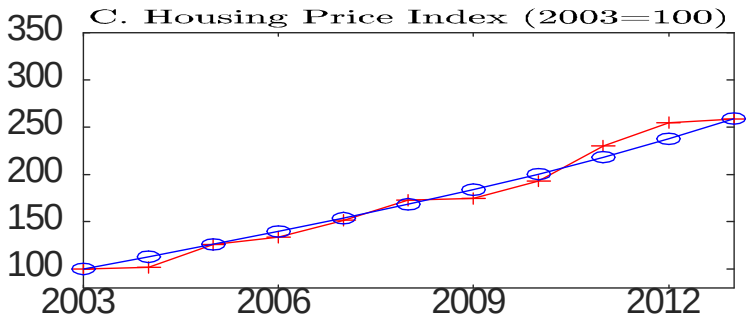
Parameter	Description	Target
$\beta = 0.999$	Discount factor	Average saving rate
$\psi = 0.42$	Wealth transfer share	Capital return in 2003
$\xi = 0.17$	Leverage ratio of firm	Average capital investment to GDP ratio
$g_e = 0.036$	Growth of labor efficiency	Average GDP growth rate
$g_l = 0.08$	Diminishing speed of land quality	Average residential investment to GDP ratio
$p_0 = 0.24$	Probability of bubble burst in 2003	Average housing price growth during 2003-2008
$\eta = 0.095$	Decay rate of burst probability	Average housing price growth during 2009-2013
$\zeta_y = 0.1$	Government expenditure/GDP ratio	Average infrastructure investment to GDP ratio
$\xi_g(t) = 2.37$, if $t < 7$	Leverage ratio of government	Average local government debt to GDP ratio during 2003-2008
$\xi_g(t) = 3$, if $t \geq 7$	Leverage ratio of government	Average local government debt to GDP ratio during 2009-2013
$K_0 = 1$	Initial capital stock	Output to capital ratio in 2003
$A_0 = 0.37$	Initial infrastructure stock	Infrastructure to capital ratio in 2003
$H_0 = 0.15$	Initial housing stock	Housing stock to capital ratio in 2003
$r_0 = 0.01$	Initial rent	Residential investment to GDP ratio in 2003

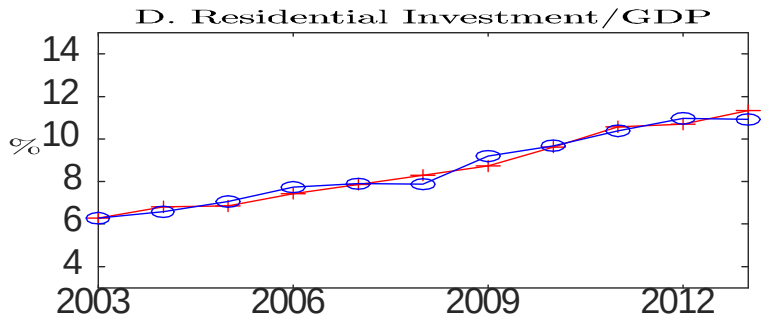
Table: Parameters calibrated in the model

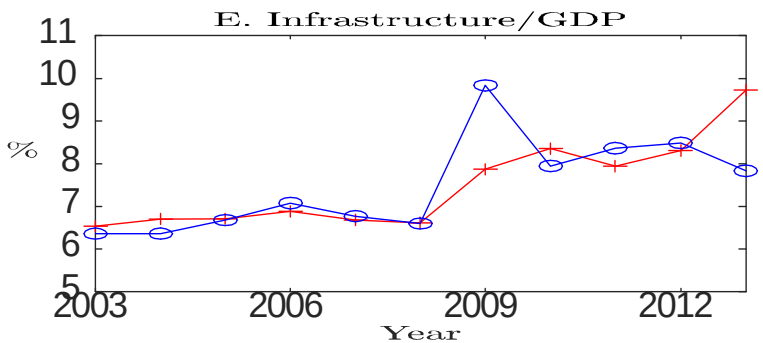
Results

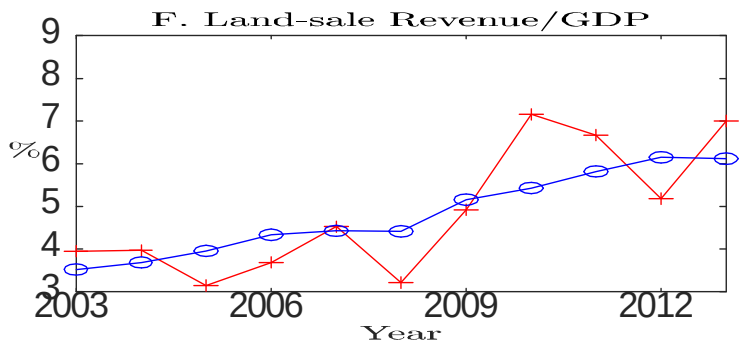

A. GDP Growth
Data
Model
%
15
10
5
2006
2009
2012


B. Capital Return
%
14
12
10
8
6
4
2003
2006
2009
2012

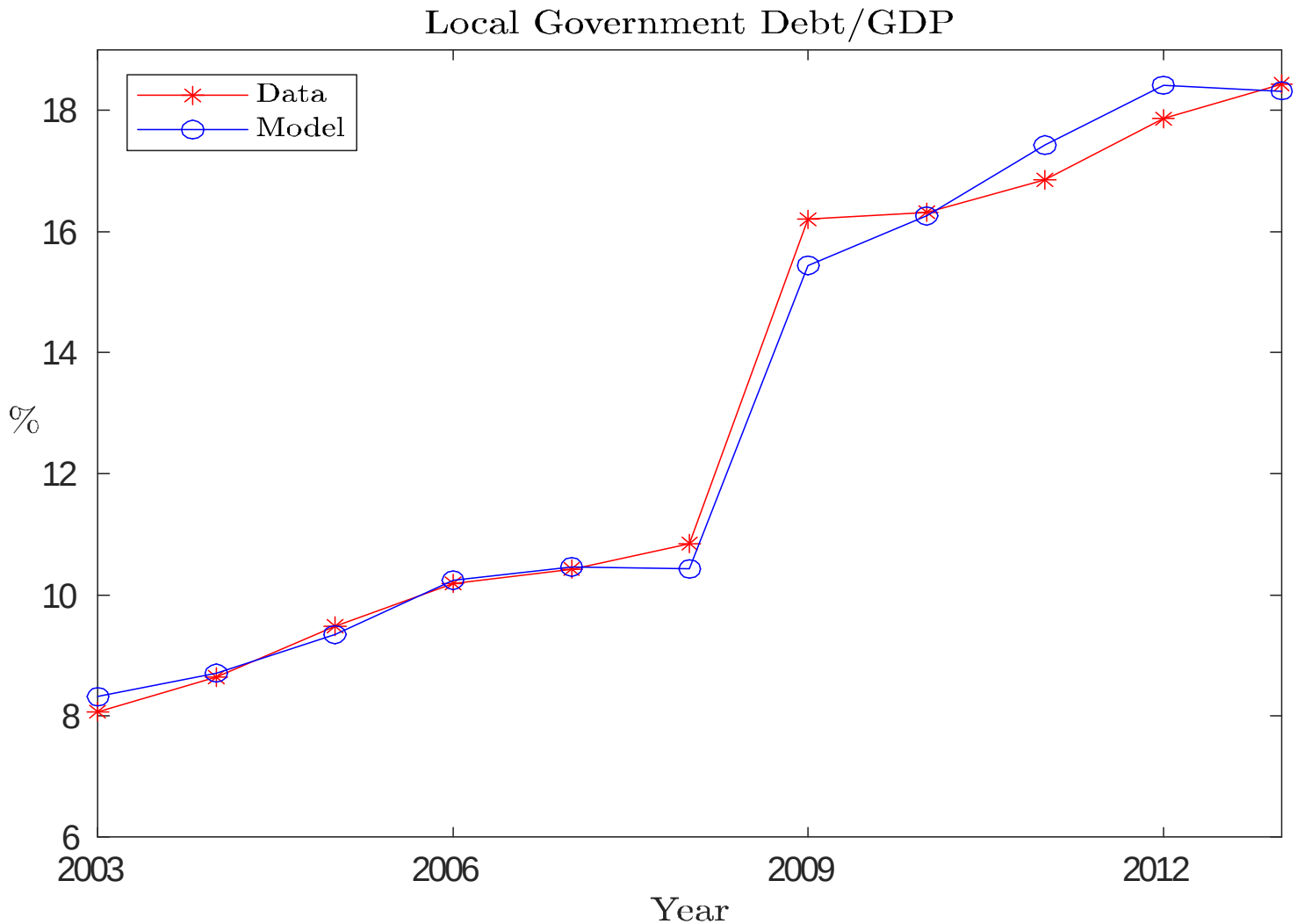

C. Housing Price Index (2003=100)
350
300
250
200
150
100
2003
2006
2009
2012


D. Residential Investment/GDP
%
14
12
10
8
6
4
2003
2006
2009
2012


E. Infrastructure/GDP
%
11
10
9
8
7
6
5
2003
2006
2009
2012
Year


F. Land-sale Revenue/GDP
%
9
8
7
6
5
4
3
2003
2006
2009
2012
Year

Government Debt/GDP



Growth Accounting for 2003-2013

- GDP growth

$$
\begin{aligned}
GDP_t &= Y_t + Q_t Y_{ht} + r_t H_t \\
\frac{\Delta GDP_t}{GDP_t} &\approx \frac{Y_t}{GDP_t}\frac{\Delta Y_t}{Y_t} + \frac{Q_t Y_{ht}}{GDP_t}\frac{\Delta(Q_t Y_{ht})}{Q_t Y_{ht}} + \frac{r_t H_t}{GDP_t}\frac{\Delta(r_t H_t)}{r_t H_t} \\
10\% &\approx 0.9 \times 9.3\% + 0.086 \times 16.2\% + 0.014 \times 17.1\% \\
&\approx 8.4\% + 1.4\% + 0.2\%.
\end{aligned}
$$

Growth Accounting for 2003-2013

- Nonhousing output

$$
\begin{aligned}
Y_t &= A_t^{\theta} K_{ct}^{\alpha-\rho\theta} \left(e_t N_{ct}\right)^{1-\alpha-(1-\rho)\theta} \\
\frac{\Delta Y_t}{Y_t} &\approx \theta \frac{\Delta A_t}{A_t} + (\alpha - \rho\theta) \frac{\Delta K_{ct}}{K_{ct}} + (1-\alpha-(1-\rho)\theta) \frac{\Delta e_t}{e_t} \\
&\quad + (1-\alpha-(1-\rho)\theta) \frac{\Delta N_{ct}}{N_{ct}} \\
9.3\% &\approx 0.1 * 10.7\% + 0.49 * 13.8\% + 0.41 * 3.6\% + 0.41 * 0.3\% \\
&\approx 1.1\% + 6.7\% + 1.5\% + 0.1\%
\end{aligned}
$$

Growth Accounting

- Residential investment

$$
\begin{aligned}
Q_t Y_{ht} &= Q_t L_t^{\alpha_l} K_{ht}^{\alpha_k} \left(e_t N_{ht}\right)^{1-\alpha_l-\alpha_k} \\
\frac{\Delta(Q_t Y_{ht})}{Q_t Y_{ht}} &\approx \frac{\Delta Q_t}{Q_t} + \alpha_l \left(\frac{\Delta L_t}{L_t} - g_l\right) + \alpha_k \frac{\Delta K_{h,t}}{K_{h,t}} \\
&\quad + (1-\alpha_l-\alpha_k)\frac{\Delta e_t}{e_t} + (1-\alpha_l-\alpha_k)\frac{\Delta N_{ht}}{N_{ht}} \\
16.2\% &\approx 10.0\% + 0.56 * (-1.7\%) + 0.24 * 21\% \\
&\quad + 0.2 * 3.6\% + 0.2 * 6.6\% \\
&\approx 10.0\% + (-1\%) + 5\% + 0.7\% + 1.3\%
\end{aligned}
$$

Why GDP Growth Declined?

- For 2003-2008

$$\begin{aligned} 11.4\% &\approx 0.916 * 10.9\% + 0.072 * 16.6\% + 0.012 * 21.2\% \\ &\approx 10\% + 1.2\% + 0.3\%, \end{aligned}$$

- For 2009-2013

$$\begin{aligned} 8.6\% &\approx 0.882 * 7.7\% + 0.102 * 15.9\% + 0.016 * 13.1\% \\ &\approx 6.8\% + 1.6\% + 0.2\%. \end{aligned}$$

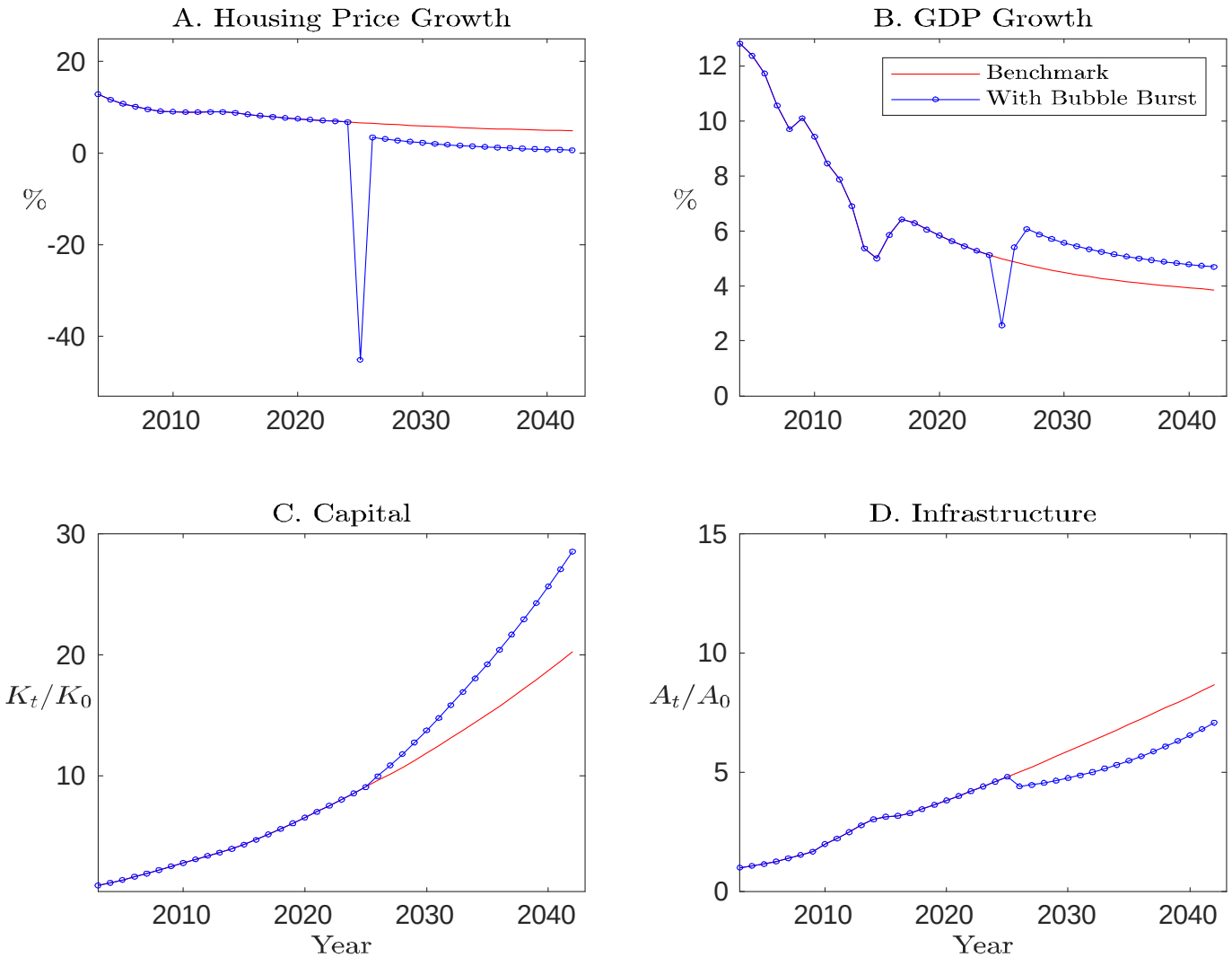
Why GDP Growth Declined?

Variable (%)	$\Delta A/A$	$\Delta K_c/K_c$	$\Delta N_c/N_c$	$\Delta Q/Q$	$\Delta L/L - g_l$	$\Delta K_h/K_h$	$\Delta N_h/N_h$
2003-2008	8.8	17.5	0.3	11.0	-3.4	23.5	5.4
2009-2013	12.6	10.1	0.2	9.0	-0.3	18.4	7.8
2003-2013	10.7	13.8	0.3	10.0	-1.8	21.0	6.6

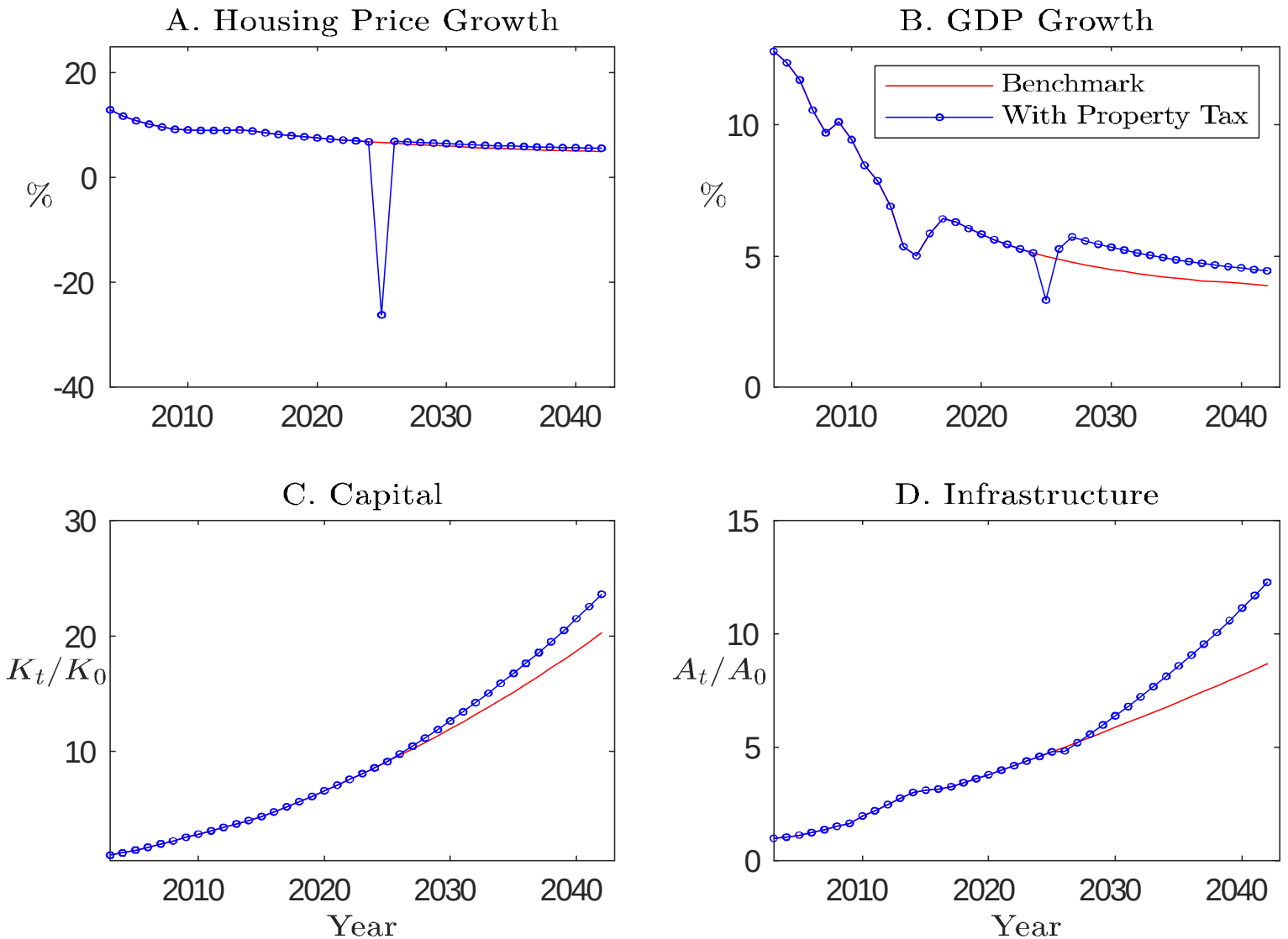
Table: Comparison between two periods

- Crowding out and reallocation effects of housing bubble

Bubble Burst

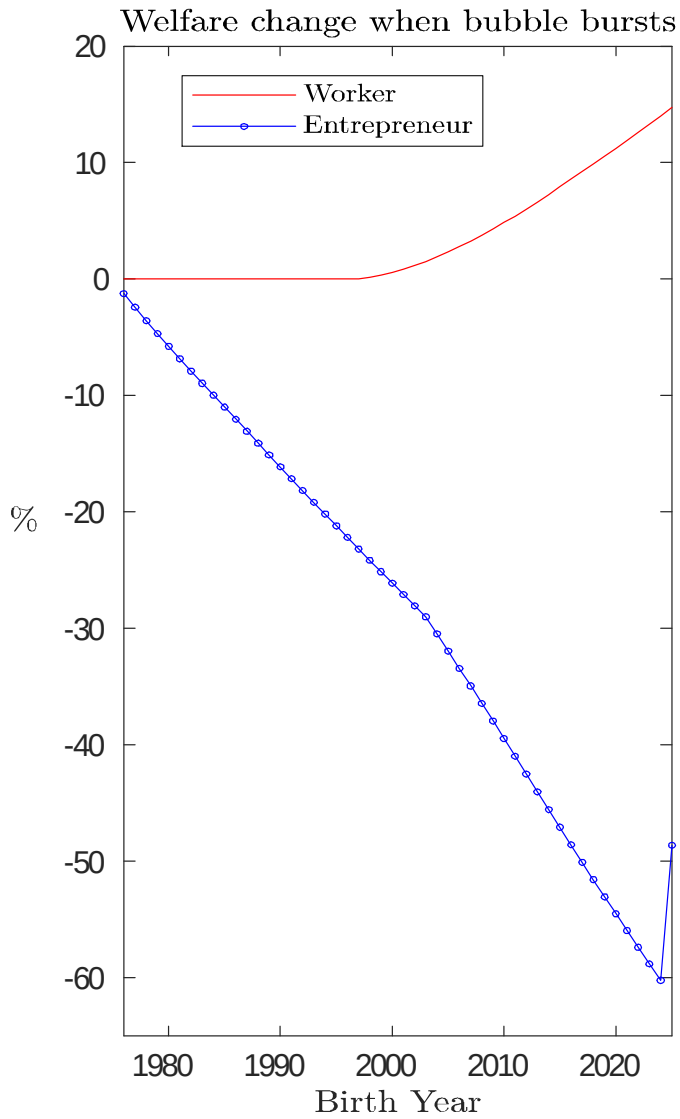


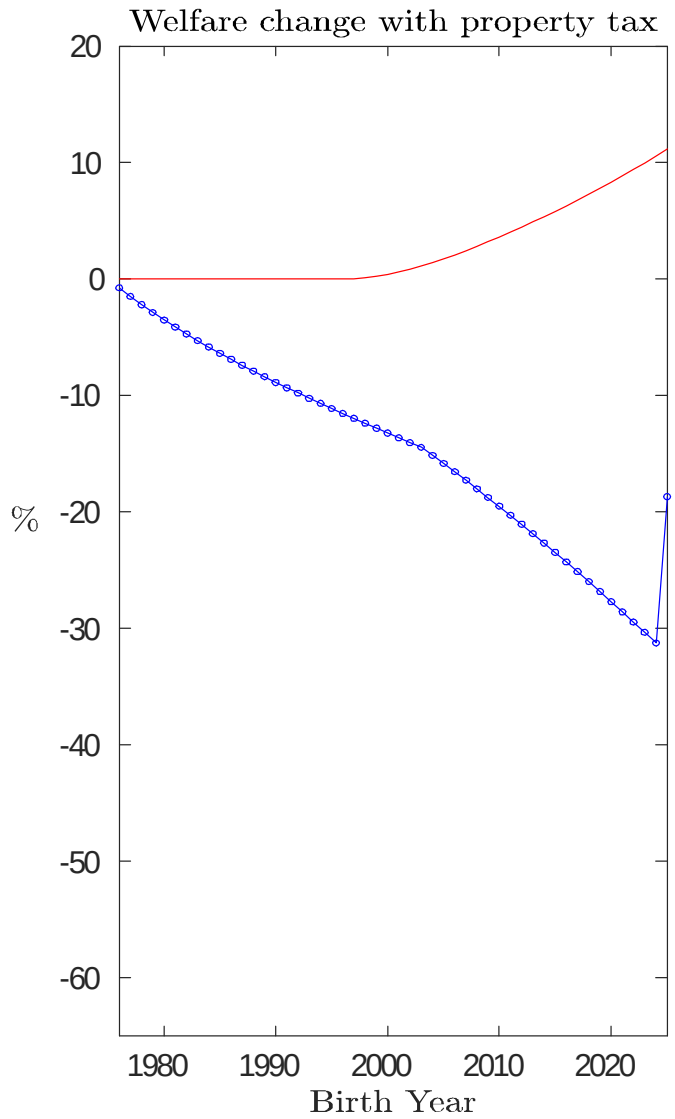
Property Tax



Welfare Effects

Consider workers and entrepreneurs alive in 2025





Conclusion

- We provide a two-sector OLG model to explain the Chinese stylized facts during 2003-2013
- Incorporate Chinese institution feature of land policy
- Housing bubble crowds in infrastructure investment, but crowds out capital investment
- Housing bubble and factor (resource) reallocation across the housing and non-housing sectors can explain stylized facts
- Counterfactual experiments show that bubble burst and property tax can reduce short-run GDP growth, but raise long-run GDP level