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

A. GDP Growth

B. Price Index (2003=100)

C. Residential Investment/GDP

D. Land-sale Revenue/GDP

E. Infrastructure Investment/GDP

F. Capital Return
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 →
  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 $\rightarrow$ land-sale revenue $\uparrow \rightarrow$ infrastructure investment $\uparrow \rightarrow$ 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: $\text{GDP} = \text{Nonhousing output} + \text{Residential investment} + \text{Rents}$
## Supporting Evidence

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

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) growth_infr</th>
<th>(2) growth_capital</th>
<th>(3) growth_labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>growth_hp</td>
<td>0.0645*</td>
<td>−0.1832***</td>
<td>−0.0969**</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.043)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>growth_gdp</td>
<td>0.3278</td>
<td>1.2913***</td>
<td>0.1101</td>
</tr>
<tr>
<td></td>
<td>(0.288)</td>
<td>(0.183)</td>
<td>(0.195)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.1612***</td>
<td>0.0613**</td>
<td>0.0430</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.026)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>Observations</td>
<td>372</td>
<td>372</td>
<td>217</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.284</td>
<td>0.410</td>
<td>0.232</td>
</tr>
<tr>
<td>Province</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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

\[
\begin{align*}
\max & \quad \log(c_{1t}^w) + \beta \log(c_{2,t+1}^w) \\
\text{s.t.} & \quad c_{1t}^w + b_{t+1} = w_t, \\
& \quad c_{2,t+1}^w = R^f b_{t+1}
\end{align*}
\]
Entrepreneurs

• A young entrepreneur inherits wealth \( m_t \) from the old and invests in capital and houses

• He/she cannot borrow

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

• 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
  \[ y_{t+1} \equiv \hat{A}_{t+1}^\theta \dot{k}_{t+1}^\alpha n_{c,t+1}^{1-\alpha}, \]

- 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

\[ m_{t+1} = \psi ((1 - \tau)y_{t+1} - w_{t+1} n_{c,t+1}) . \]

- The remainder is capital return

\[ R_{t+1} k_{t+1} \equiv \max_{n_{c,t+1}} \left( 1 - \psi \right) \left( (1 - \tau) A_{t+1}^\theta k_{t+1}^\alpha n_{c,t+1}^{1-\alpha} - w_{t+1} n_{c,t+1} \right) . \]
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 $p_{Lt}$

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

- Exogenous land supply $L_t$

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

- Aggregate housing output

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

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

- Crowd in: Bubbly houses $Q_t > 0$ for all $t \rightarrow p_{Lt} > 0 \rightarrow$ collects land-sale revenues $\rightarrow$ 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, $\theta$
Transition

[Graphs showing various economic indicators over time, labeled A through L, with differentiation between 'Bubbly' and 'Bubbleless' scenarios.]
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

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

**Table:** Parameters estimated outside the model
### Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta = 0.999$</td>
<td>Discount factor</td>
<td>Average saving rate</td>
</tr>
<tr>
<td>$\psi = 0.42$</td>
<td>Wealth transfer share</td>
<td>Capital return in 2003</td>
</tr>
<tr>
<td>$\xi = 0.17$</td>
<td>Leverage ratio of firm</td>
<td>Average capital investment to GDP ratio</td>
</tr>
<tr>
<td>$g_e = 0.036$</td>
<td>Growth of labor efficiency</td>
<td>Average GDP growth rate</td>
</tr>
<tr>
<td>$g_l = 0.08$</td>
<td>Diminishing speed of land quality</td>
<td>Average residential investment to GDP ratio</td>
</tr>
<tr>
<td>$\rho_0 = 0.24$</td>
<td>Probability of bubble burst in 2003</td>
<td>Average housing price growth during 2003-2008</td>
</tr>
<tr>
<td>$\eta = 0.095$</td>
<td>Decay rate of burst probability</td>
<td>Average housing price growth during 2009-2013</td>
</tr>
<tr>
<td>$\zeta_y = 0.1$</td>
<td>Government expenditure/GDP ratio</td>
<td>Average infrastructure investment to GDP ratio</td>
</tr>
<tr>
<td>$\zeta_g(t) = 2.37$, if $t &lt; 7$</td>
<td>Leverage ratio of government</td>
<td>Average local government debt to GDP ratio during 2003-2008</td>
</tr>
<tr>
<td>$\zeta_g(t) = 3$, if $t \geq 7$</td>
<td>Leverage ratio of government</td>
<td>Average local government debt to GDP ratio during 2009-2013</td>
</tr>
<tr>
<td>$K_0 = 1$</td>
<td>Initial capital stock</td>
<td>Output to capital ratio in 2003</td>
</tr>
<tr>
<td>$A_0 = 0.37$</td>
<td>Initial infrastructure stock</td>
<td>Infrastructure to capital ratio in 2003</td>
</tr>
<tr>
<td>$H_0 = 0.15$</td>
<td>Initial housing stock</td>
<td>Housing stock to capital ratio in 2003</td>
</tr>
<tr>
<td>$r_0 = 0.01$</td>
<td>Initial rent</td>
<td>Residential investment to GDP ratio in 2003</td>
</tr>
</tbody>
</table>

**Table:** Parameters calibrated in the model
Results

A. GDP Growth

B. Capital Return

C. Housing Price Index (2003=100)

D. Residential Investment/GDP

E. Infrastructure/GDP

F. Land-sale Revenue/GDP
Government Debt/GDP

Local Government Debt/GDP

- Data
- Model

Year


%
Growth Accounting for 2003-2013

- GDP growth

\[ \begin{align*}
GDP_t &= Y_t + Q_t Y_{ht} + r_t H_t \\
\frac{\Delta GDP_t}{GDP_t} &\approx \frac{Y_t}{GDP_t} \Delta Y_t + \frac{Q_t Y_{ht}}{GDP_t} \Delta (Q_t Y_{ht}) + \frac{r_t H_t}{GDP_t} \Delta (r_t H_t) \\
10\% &\approx 0.9 \times 9.3\% + 0.086 \times 16.2\% + 0.014 \times 17.1\% \\
&\approx 8.4\% + 1.4\% + 0.2\%.
\end{align*} \]
Growth Accounting for 2003-2013

- Nonhousing output

\[
Y_t = A_t^\theta K_{ct}^{\alpha - \rho \theta} (e_t N_{ct})^{1 - \alpha - (1 - \rho) \theta}
\]

\[
\frac{\Delta Y_t}{Y_t} \approx \frac{\theta}{A_t} \frac{\Delta A_t}{A_t} + (\alpha - \rho \theta) \frac{\Delta K_{ct}}{K_{ct}} + (1 - \alpha - (1 - \rho) \theta) \frac{\Delta e_t}{e_t}
\]

\[
+(1 - \alpha - (1 - \rho) \theta) \frac{\Delta N_{ct}}{N_{ct}}
\]

9.3% \approx 0.1 \times 10.7% + 0.49 \times 13.8% + 0.41 \times 3.6% + 0.41 \times 0.3%

\approx 1.1% + 6.7% + 1.5% + 0.1%
Growth Accounting

- Residential investment

\[
Q_t Y_{ht} = Q_t L_t^{\alpha_l} K_{ht}^{\alpha_k} (e_t N_{ht})^{1-\alpha_l-\alpha_k}
\]

\[
\frac{\Delta (Q_t Y_{ht})}{Q_t Y_{ht}} \approx \frac{\Delta Q_t}{Q_t} + \alpha_l \left( \frac{\Delta L_t}{L_t} - g_l \right) + \alpha_k \frac{\Delta K_{h,t}}{K_{h,t}} + (1 - \alpha_l - \alpha_k) \frac{\Delta e_t}{e_t} + (1 - \alpha_l - \alpha_k) \frac{\Delta N_{ht}}{N_{ht}}
\]

16.2% \approx 10.0% + 0.56 \times (-1.7\%) + 0.24 \times 21\%
+ 0.2 \times 3.6\% + 0.2 \times 6.6\%
\approx 10.0\% + (-1\%) + 5\% + 0.7\% + 1.3\%
Why GDP Growth Declined?

- For 2003-2008

  \[ 11.4\% \approx 0.916 \times 10.9\% + 0.072 \times 16.6\% + 0.012 \times 21.2\% \]
  \[ \approx 10\% + 1.2\% + 0.3\%, \]

- For 2009-2013

  \[ 8.6\% \approx 0.882 \times 7.7\% + 0.102 \times 15.9\% + 0.016 \times 13.1\% \]
  \[ \approx 6.8\% + 1.6\% + 0.2\%. \]
Why GDP Growth Declined?

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

Table: Comparison between two periods

- Crowding out and reallocation effects of housing bubble
Bubble Burst

A. Housing Price Growth

B. GDP Growth

C. Capital

D. Infrastructure
Property Tax

A. Housing Price Growth

B. GDP Growth

C. Capital

D. Infrastructure
Welfare Effects

Consider workers and entrepreneurs alive in 2025

Welfare change when bubble bursts

Welfare change with property tax
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