Slowdown, Stimulus and Real Estate Cycles of China

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Abstract

This paper constructs a DSGE model consistent with the China’s local government “land sale–debt financing–infrastructure investment” cycles. Policy triggered land price changes drive reallocation of capital and lands between private and public sectors which are heterogeneous in TFP and financial frictions. Collateral constraints amplify the responses to policy shocks as well as reallocations between sectors. The paper finds that if local government debt is restricted by land collateral, fiscal stimulus of government spending on public goods (e.g. infrastructure investment) has little impact on the land price, but crowd in the private sector output. If local government debt is not constrained, fiscal stimulus would cause resource misallocation, capital overcapacity, and negative fiscal multiplier. Moreover, given asymmetric TFP and financial frictions in two sectors, a relax in private borrowing constraint contributes more to growth in output and investment than a same percentage relax in public borrowing constraint. If bank looses lending constraint (i.e. required reserve ratio), private sector would be crowd out by public and there would result with an overcapacity of capital. The variance-decomposition shows that credit policy shocks to borrowing constraint and lending constraint are major sources of land price fluctuations.

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1 Introduction

The analysis of China’s 2014 GDP data released in the first quarter of 2015 has focused on the economy’s slowdown that is the weakest growth rate in the past 24 years (7.4%) and the first time this century that China has missed its official growth target (7.5%). It is not necessary to be pessimistic of a weaker growth rate because China’s economic size has been tremendous so that even slower growth now generates much larger additional output than before. However, after a long-term tremendous boom (2003-2009 and 2011-2013) in housing markets, China’s economy has observed a slump in fixed-asset investment, as well as a decline in land prices (Figure 3 and Figure 4).

Land is developed and sold by the local government to finance some off-budget infrastructure investment. As stated by Zhang and Barnett (2014)[26], infrastructure investment has become local governments’ main strategy to foster economy and countercyclical policy tool. The local infrastructure spending has mainly been financed either through land sales or Local Government Financing Vehicle (LGFV) borrowings, which is an implicit local government debt. Since land is a major input of infrastructure investment, the land sales-investment-growth cycle supports economy directly, as well as fluctuates the land prices. Figure 3 shows that the time series of GDP, land price and public expenditure move together during the last decade. A cross correlation test of macroeconomic variables shows that land price leads real estate development, local government investment and output, and lags public expenditure.

These facts and observations have raised questions to be answered:

(i) What impacts do local government land financing and debt financing models have on the Chinese economy?

(ii) Does the local government spending on the infrastructure investment help explain the Chinese real estate cycles and business cycles?
What effects do credit policies, i.e. changes in lending constraint and borrowing constraint, have on the real estate market, government finance, and macroeconomic dynamics?

Figure 1: The Structure of Markets and Government

This paper aims to answer the questions above in understanding the interplay between land market, local government policies and macroeconomic structure in China. Figure 1 displays the market structures and relationship between agents in the model. This paper has built a general equilibrium model in a closed economy with two production sectors which are heterogeneous in TFP and financial frictions. To match the model to reality, the public sector includes state owned enterprises (SOE) and infrastructure projects, which have lower TFP level and more access to financial market. By contrast, the private sector is mainly composed of domestic private enterprises (DPE), which have higher TFP level and less access to financial market. The explanation to these assumptions in heterogeneity of technology and financial frictions is provided in Chapter 3.

Both capitalists and local government face limited contract enforcement. Their debt is bound
by a Kiyotaki-Moore type of collateral constraint. The local governments invest in public sector production e.g. infrastructure investment, and finance government spending from land sale and government debt. Land, capital and labor can be reallocated between the two sectors as land prices change. The collateral constraints of borrowing could amplify the model dynamics to shocks as well as the resource reallocations between sectors. To explicitly describe the transmission of fiscal stimulus to real estate price and output, Figure 2 displays the mechanism of model.

The model is log-linearized near the deterministic steady states and calibrated to the annual Chinese data. Then simulation of model is hp filtered with annual smoothing parameter.

Credit policy shocks to lending constraint and borrowing constraint have been shown to be important sources of land price fluctuations in the shock decomposition. The model yields several predictions that have important policy implications:

(i) If local government faces limited contract enforcement so that local government debt is constrained by collateral value of land holdings, an expansion in government spending has little effect on the land price and crowd in private sector output.
(ii) A relax in private borrowing constraint contributes more to the output and investment than a same percentage relax in public borrowing constraint.

(iii) Private sector wins and public sector loses if tightening the lending constraint of financial intermediary. While if loosening the lending constraint, private sector would be crowd out by public and there would be an overcapacity of capital.

(iv) If local government debt is not constrained, an expansion in government expenditure will cause resource misallocation, capital overcapacity, and losses in GDP.

2 Literature

This paper is related to several strands of literature which covers topics in housing market and macroeconomy, monetary and fiscal stimulus, and capital misallocation and business cycles.

The recent housing boom and bust and financial crisis has renewed the curiosity of economists of all stripes about the interplay of housing, finance and macroeconomics. A booming literature has been produced on these topics to jointly explain business cycle facts and real estate prices during the great housing boom and bust of the 2000-2010 decade. This list contains Davis and Heathcote (2005) [7], Iacoviello (2005) [12], Kiyotaki, Michaelides and Nikolov (2011) [14], Liu, Wang and Zha (2013) [19]. Davis and Heathcote (2005) models shocks hitting the production of housing in the spirit of a simple two-sector model. Iacoviello (2005) follows the production section in Davis and Heathcote (2005) but feature a standard new Keynesian framework with an emphasis on the monetary policy transmission to housing markets. Liu, Wang and Zha (2013) capture the comovement between land price and business investments using a DSGE model with constraint of firm’s land collateral. Kiyotaki, Michaelides and Nikolov (2011) study the interaction between borrowing constraints, housing prices and economic activity. They use a general equilibrium life-cycle model to study the implications of an unexpected increase in land’s share of housing in an environment where interest rates are set outside of the model. Davis and Nieuwerburgh (2014) have made a very good survey of the recent literature in housing, finance and the macroeconomics.

Second strand of literature analyzes the impacts of financial frictions on the TFP. This list
includes Jermann and Quadrini (2007) [13], Buera, Kaboski and Shin (2012) [4], Miao and Wang (2012) [21], Buera and Shin (2013) [5], Liu and Wang (2014) [18]. Buera, Kaboski and Shin (2011) have two production sectors with heterogeneous productivity. They discover that financial frictions distort the allocation of capital across heterogeneous production units and also their entry/exit decisions, lowering aggregate and sector-level TFP. Miao and Wang (2012) assume an idiosyncratic productivity shocks attached to aggregate productivity level. They discover that bubbles allow firms to relax credit constraints and more capital is allocated to more productive firms, leading to a rise in total factor productivity (TFP). The collapse of bubbles tightens the credit constraints and worsens investment efficiency, leading to a recession and a fall of TFP. Liu and Wang (2014) study a model with productive and unproductive firms, the former of which face binding credit constraints. Thus, a drop in equity value tightens credit constraints and reallocates resources from productive to unproductive firms, generating a financial multiplier as well as self-fulfilling business cycles.

Third strand of literature analyzes government investment and fiscal multiplier. For example, Leeper, Walker and Yang (2010) [17] study the effect of government investment as a fiscal stimulus by modeling the government investment as building public capital in production technology. They find that the implementation delays in time-to-build model and the fiscal adjustment cost could make government investment contraction in the long run. Traum and Yang (2013) [25] use an estimated New Keynesian model with monetary and fiscal policy interactions to examine when government debt crowds out investment. They find that higher debt can crowd in investment for cutting capital tax rates or increasing government investment. Therefore whether investment is crowded in or out depends on which policy shocks triggers the debt expansions.

Last strand of literature is studies in the housing market of China after the financial crisis in the U.S.. For example, Deng et al (2011) [8] study the impacts of monetary and fiscal stimulus on housing market in China. Their data analysis finds that much of the public investment operated by SOEs was highly leveraged purchases of real estate. They argue that China’s stimulus package may well have fueled a real estate bubble and induced costly resource misallocation. Zhang and Barnett (2014) construct the augmented fiscal deficit and debt data of China and claim that
the model that local governments finance infrastructure investment from their off-balance land sales would increase fiscal vulnerabilities and risks. General equilibrium quantitative analysis in this field is scarce. Chang, Waggoner and Zha (2015) [6] construct a set of core macroeconomic time series for China to be as consistent with the NIPA as possible. Their econometric analysis show that monetary aggregates such as M2, as well as required reserves and the deposit rate, play a substantive role in both fluctuations and growth of aggregate output.

3 Background and Empirical Evidences

3.1 China’s Fiscal Stimulus

Although the recent financial crisis has generated substantial interest in understanding the links between the real estate market and the macroeconomy in the U.S., studies in case of China have been scant. One possible reason is that merely after the breakdown of the U.S. financial crisis in 2008 Q4, the Chinese central government reacted with an active fiscal stimulus package of 4 trillion-yuan ($586 billion) and a passive transformation in monetary policy from moderately tight to moderately loosen. As a response, China’s annualized growth rate of fixed-asset investment increased from 20.3% in 2008 Q4 to 29.4% and 38% in the Q1 and Q2 of 2009. Its annualized GDP growth rate reached 6.2%, 7.9%, 9.1% and 10.7% in the four quarters of 2009 respectively and 11.9% in 2010 Q1. The annualized growth rate of land price increase from -0.2% in 2008 Q4 to 14.9%, -11.1%, 65.7%, 35.9% in the four quarters of 2009 and 23.6%, 71.1% in 2010 Q1 and Q2. Therefore the booms in housing market and fixed-asset investment by fiscal stimulus might vague the question that to what extent are these housing market boom-and-bust cycles consistent with fundamental conditions in China, until the recent slowdown in China’s economy.

1The numbers of growth rate are from the estimates in Deng et al (2011)[8].
3.2 Chinese Land Ownership and Local Government Land Financing Model

Land in modern China belongs to the local government. The revenue of sales of land use right belongs to the local government and has become a key source of revenue for the local government as urbanization advanced. For example, according to estimates of Zhang and Barnett (2014)[26], the local government earned a gross land sales of 3.3 trillion Yuan ($520 billion) out of the 3.8 trillion Yuan in government managed funds revenue. The land sales revenues were then used to finance infrastructure investment to further support the urbanization process. However, as land is a major input of infrastructure investment, higher infrastructure spending supported investment directly as well as propagated land price indirectly. Thus, the land sales-investment-growth cycle not only foster economy strongly but also raised concerns that whether infrastructure investments crowd out other investments which use land as input.

3.3 Local Government Debt Financing Model

As stated by Zhang and Barnett (2014)[26], Chinese local governments are not allowed to issue bond directly unless approved by the State Council. Thus, in order to finance the off-budget government spending, local governments made recourse to local government financing vehicles (LGFVs) which are government-related entities to borrow from banks and corporate bond market. Local governments injected land or property to provide capital to LGFVs, which is used as collateral for borrowing. Lu and Sun (2013)[20] discuss the function and risks of the local government financing vehicles in China. They find that local governments transfer land as collateral to help LGFVs to secure loans. Land could also provide future operating revenue for LGFPs when the land use rights are sold in the future.

3.4 Heterogeneity in Productivity and Borrowing Constraints

There are an extensive literature have documented a higher TFP in domestic private enterprises (DPE) than in state owned enterprises (SOE). For example, Song, Storesletten and Zilibotti

\[ \text{A land user obtains the land use right only, not the land or any resources in or below the land. Source: Land Administrative Law of the People’s Republic of China: Chapter II Article 8. To obtain the land use right, land user must sign a land grant contract with the land administration department of the state. Source: China Real Estate Law: Part 1: land use right.} \]
estimate a small average TFP gap between DPE and SOE about 9 percent per year. Hsieh and Klenow (2009) estimate a gap of 1.42, which is similar to the estimate of 1.4952 in this paper. Brandt and Zhu (2010) document persistent differences in returns to capital and labor between the state and the non-state sectors. Brandt, Tombe and Zhu (2013) examine the effect of resource misallocation in China. They find that TFP losses associated with factor market distortions are still high in China and have increased sharply since the mid-1990s. The rising TFP losses are mainly due to capital misallocation between the SOE and non SOE sectors.

Financial frictions are also documented that private firms are subject to strong discrimination in credit markets. The commercial banks most of which are state owned, tend to offer easier credit to SOE (Genevieve Boyreau-Debray and Wei, 2005). Song, Storesletten and Zilibotti (2011) shows that SOE finance more than 30 percent of their investments through bank loans compared to less than 10 percent for DPE. Dollar and Wei (2007) and Riedel, Jin and Gao (2007) report that DPE rely less on bank loans and more on retained earnings and other sources to finance investments. In case of Egypt and Turkey where government investment take large share in some industries, private TFP is about twice relative to government TFP (Schmitz, 2001).

3.5 Macroeconomic Dynamics

Table 1 displays the data moments of land market variables, fiscal variables and macroeconomic variables. All series are hp-filtered. Column 1 to 3 of upper panel are standard deviation, relative standard deviation to GDP, and first-order autocorrelation. Figure 3 displays the output, public expenditure and land price after 1990. These time series data is the log-deviation from the last period.

Figure 4 displays the land market variables and government investments. All time series data are log-deviation from last period. Figure 4c is the average price of land sale derived from 4a and 4b. The land price in China has experienced a slump in 2011, then a rebound in 2012. Figure 4d and 4g display fixed-asset investment and investment of real estate development enterprise, both of which display a contraction since 2010. Figure 4e and 4f display investment by state-owned enterprises (SOEs) and local government. It is noticeable that local government
Table 1: Moments of Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Std.Dev.</th>
<th>Rel.Std.Dev. to GDP</th>
<th>ACF(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Sale Space</td>
<td>0.089</td>
<td>1.832</td>
<td>-0.254</td>
</tr>
<tr>
<td>Land Sale Revenue</td>
<td>0.108</td>
<td>2.218</td>
<td>-0.188</td>
</tr>
<tr>
<td>Average Land Price</td>
<td>0.084</td>
<td>1.717</td>
<td>-0.078</td>
</tr>
<tr>
<td>Fixed-asset Investment</td>
<td>0.039</td>
<td>0.792</td>
<td>0.409</td>
</tr>
<tr>
<td>SOEs Investment</td>
<td>0.059</td>
<td>1.201</td>
<td>0.433</td>
</tr>
<tr>
<td>Real Estate Development</td>
<td>0.047</td>
<td>0.954</td>
<td>0.173</td>
</tr>
<tr>
<td>Local Government Investment</td>
<td>0.039</td>
<td>0.791</td>
<td>0.380</td>
</tr>
<tr>
<td>Residential Investment Fund</td>
<td>0.054</td>
<td>1.115</td>
<td>-0.178</td>
</tr>
<tr>
<td>GDP</td>
<td>0.049</td>
<td>1.000</td>
<td>0.790</td>
</tr>
<tr>
<td>Public Expenditure</td>
<td>0.082</td>
<td>2.055</td>
<td>0.289</td>
</tr>
<tr>
<td>Tax</td>
<td>0.107</td>
<td>2.183</td>
<td>0.228</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlation with Land Price</th>
<th>contemp. corr</th>
<th>corr with $Q_{t-1}$</th>
<th>corr with $Q_{t+1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corr(land price, fix inv)</td>
<td>0.151</td>
<td>0.297</td>
<td>0.112</td>
</tr>
<tr>
<td>Corr(land price, SOE inv)</td>
<td>0.584</td>
<td>0.130</td>
<td>0.265</td>
</tr>
<tr>
<td>Corr(land price, real estate develop)</td>
<td>-0.081</td>
<td>0.582</td>
<td>-0.509</td>
</tr>
<tr>
<td>Corr(land price, local gov inv)</td>
<td>0.074</td>
<td>0.337</td>
<td>-0.035</td>
</tr>
<tr>
<td>Corr(land price, funds)</td>
<td>-0.484</td>
<td>0.578</td>
<td>-0.312</td>
</tr>
<tr>
<td>Corr(land price, GDP)</td>
<td>-0.060</td>
<td>0.436</td>
<td>-0.008</td>
</tr>
<tr>
<td>Corr(land price, public exp)</td>
<td>0.163</td>
<td>-0.140</td>
<td>0.699</td>
</tr>
</tbody>
</table>

Note: The frequency of data is annual. The data has been detrended using the Hodrick-Prescott filter with smoothing parameter $\lambda = 100$. Sources of data are National Bureau of Statistics of China and WIND.

investment (4f) comoves with fixed-asset investment (4d). This is because a large portion of local government investment is on fixed asset. Also, the real estate development investment (4g) comoves with land price indicating that land price is a key factor that affects the real estate development activities.

Volatility

As shown in Figure 3, the land price and public expenditure have displayed a higher volatility than that of GDP. In Table 1, we observe that public expenditure is more volatile than output while investment variables are less volatile. The land sale space, revenue, and land price are about twice volatile as output. Therefore how to generate the observed large volatility in government and lands market variables is key to the model.
Figure 3: Log-deviations of Output and Public Expenditures


Note: The annual data is constructed from the accumulated monthly data by the WIND.

Comovement

The time series in Figure 3 have observed a dynamic comovement between land price and public expenditure. For example, the fall in public expenditure after 2008 is followed by a fall in land price since 2009. The expansionary public expenditure in 2010 is followed by increase in land price since 2011. The correlations between lands price and other variables have been tested in Table 1.

The lower panel of Table 1 reports the variables' contemporaneous correlation with land price and their cross correlation with one lead and one lag in land price. We can see that the land price leads real estate development, local government investment and output. The state-
owned enterprises’ investment is positively correlated with the contemporaneous land price. The fixed-asset investment and land price are weakly correlated. The cross correlation between public expenditure and lagging land price is 0.699 while is 0.163 with contemporaneous land price and is -0.140 with leading land price. This indicates the public expenditures leads the land price as shown in Figure 3.

Figure 5 displays the cross correlations between land price and other variables.

**Persistence**

From the third column, we observe that the output is most persistent in the sense of having a large first order autocorrelation coefficient. The investment variables are less persistent than output, but their least correlation is still 0.38 (local government investment). The land market variables are least persistent and their autocorrelation are negative. 3

4 Model

The economy is populated by two agents: workers and capitalists, and two production sectors: private and public. The capitalists own private sector firms and the government owns public sector firms. All firms own technology that uses land, capital and labor to produce. Land is owned, developed by government and sold to capitalists. Both capitalists and government use the land as collateral for external financing. The imperfect contract enforcement implies that the amount of loan is constrained by the value of collateral. The monetary policy is represented by an exogenous credit injection into the loanable funds market. The fiscal policies are fiscal rules of government consumption, land development and taxes.

4.1 Agents: Capitalists and Workers

The agents are composed by capitalists and workers.

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3The volatility and autocorrelation can change with smoothing parameter and frequency of data. So these observations might be updated.
Note: The annual data is constructed by the author from the accumulated monthly data by the National Bureau of Statistics of China.

4.1.1 Workers

The representative worker has the utility function

\[
E \sum_{t=0}^{\infty} \beta_t^t (\ln c_{h,t} - \psi \ln N_{h,t})
\]

(1)

where \( \beta_t^t \) is worker’s discount factor, \( c_{h,t} \) is worker’s consumption, \( \psi \) is parameter for disutility of labor, and \( N_{h,t} \) is worker’s labor supply.

The representative workers maximize utility subject to

\[
\frac{c_{h,t}}{R_t} + \frac{B_{h,t}}{R_t} = B_{h,t-1} + w_t N_{h,t} - T_t
\]

(2)
where $B_{h,t}$ is worker’s saving, $R_t$ is gross rate of return (discount rate) of saving, $w_t$ is wage and $T_t$ is a lump-sum transfer. The workers are free to work in either sector thus $N_{h,t}$ is the total supply of labor.

4.1.2 Capitalists

The capitalists own (non-residential) capital and receive rental of capital from both sectors. The representative capitalist owns all private sector firms and retains the profit. Capitalist finances its consumption, investment, and land acquisition from internal and external financing.

The representative capitalist has the utility function

$$E \sum_{t=0}^{\infty} \beta^t_c \ln c_{c,t}$$

where $\beta^t_c$ is capitalist’s discount factor and $c_{c,t}$ is capitalist’s consumption. I assume that $\beta^t_c < \beta^t_h$ to ensure that the borrowing constraint for the capitalist binds in a neighborhood of the deterministic steady state.

The representative capitalist maximizes utility subject to

$$c_{c,t} + Q_{l,t}(L_{c,t} - L_{c,t-1}) + I_t + \Psi(e_t)K_{t-1} + B_{c,t-1} = \frac{B_{c,t}}{R_t} + R_{k,t}e_tK_{t-1} + R_{l,t}L_{c,t-1} + \Pi_t$$

where $Q_{l,t}$ is land price, $L_{c,t}$ is land holding of capitalist, $I_t$ is capital investment, $e_t$ and $\Psi(e_t)$ are capacity utilization and its adjustment cost, $B_{c,t}$ is loan from external financing, and $R_{k,t}$, $R_{l,t}$ are rental prices of capital and land, $\Pi_t$ is the profit of private sector firms. $L_{c,t} - L_{c,t-1}$ represents the investment of land by capitalist as well as the space of land sold by government.

The cost of capital capacity utilization $\Psi(e_t)$ is an increasing and convex function:

$$\Psi(e_t) = \gamma_1 (e_t - 1) + \frac{\gamma_2}{2} (e_t - 1)^2$$

The law of motion for capital evolves as

$$K_t = (1 - \delta)K_{t-1} + \Omega(I_t)$$
where $\Omega(I_t)$ is investment with adjustment cost of capital

$$\Omega(I_t) = \left[ 1 - \frac{\Omega}{2} (\frac{I_t}{I_{t-1}} - \gamma_t)^2 \right] I_t$$  \hspace{1cm} (7)

### 4.2 Production and Firm’s Problem

The economy has two production sectors: a public production sector with a larger share of land in production and a lower productivity, a private production sector with a smaller share of land in production and a higher productivity. Examples of the public production sector include low-rent housing, infrastructures, as well as roads, railways and airports, which take a major part of fiscal investment in China and are mainly operated by the state-owned enterprises (SOEs). Examples of the private production sector are manufactures, commercial and residential housing constructions, etc.


Thus, the representative private sector firm’s production is

$$y_t = A_t(L_{c_t}^\phi k_t^{1-\phi} n_t^{1-\alpha} Y_t^{\gamma'})$$  \hspace{1cm} (8)

where $y_t$ is private sector output, $A_t$ is technology shock of private sector, $\phi$ is land input elasticity, $1 - \alpha$ is share of labor input in production, $Y_t'$ is infrastructure stock, $\gamma'$ is elasticity
of private output with regard to the infrastructure stock. The $A_t$ follows the AR(1) process

$$\log(A_t) = \rho_A \log(A_{t-1}) + (1 - \rho_A) \log(A) + \epsilon_{A,t} \tag{9}$$

where $\rho_A$ is degree of persistence and $\epsilon_{A,t}$ is i.i.d. mean zero normal process with standard deviation $\sigma_A$.

The law of motion of infrastructure stock $Y_t'$ is

$$Y_t' = (1 - \delta_y)Y_{t-1}' + y_t' \tag{10}$$

Similar to capital stock, the value of infrastructure stock could depreciate over. $\delta_y$ is depreciation rate of infrastructure stock.

The representative public sector firm’s production is

$$y_t' = A_t'((L_{t-1}')^{1-\phi'}(k_t')^{\phi'})^{\alpha}(n_t')^{1-\alpha} \tag{11}$$

where $'$ represents that parameter is specific to public sector. The $A_t'$ follows the AR(1) process

$$\log(A_t') = \rho_A' \log(A_{t-1}') + (1 - \rho_A') \log(A') + \epsilon_{A',t} \tag{12}$$

where $\rho_A'$ is degree of persistence and $\epsilon_{A',t}$ is i.i.d. mean zero normal process with standard deviation $\sigma_A'$.

Empirical evidences suggest $A \geq A'$ and $\phi \leq \phi'$ which imply that private sector has a higher productivity and public sector production technology requires a larger share of land input.

The representative private sector firm maximizes the profit by solving the firm’s problems

$$\Pi_t = \max_{k_t, l_{c,t}, n_t} y_t - R_{k,t}k_t - R_{l,t}L_{c,t-1} - w_t n_t \tag{13}$$

where the rental price $R_{k,t}$ and $R_{l,t}$ and the wage $w_t$ are taken as given.

The government owns the public sector firms (e.g. SOEs and public investment projects) and their lands. The government leases land $L_t'$ to the public sector production and retain the
profits. The representative public sector firm maximizes the profit

$$\Pi'_{t} = \max_{k'_t, n'_t} \left( p^G_t y'_t - R_{k,t} k'_t - R_{l,t} L'_{t-1} - w_t n'_t \right)$$

where $p^G_t$ is the relative price of public goods.

### 4.3 Local Government

Land is owned and developed by the local government. The local government sells part of the developed land in order to raise revenue. The government spends on consumption of public goods and land development. The government finance spending through land sale revenue, lump-sum taxes, profits in public sector, and government debt from loanable funds market. The government budget constraint is

$$Q_{l,t}(L_{c,t} - L_{c,t-1}) + T_t + \Pi'_t + R_{l,t} L'_{t-1} + \frac{B_{g,t}}{R_t} = B_{g,t-1} + p^G_t G^c_t + G^I_t$$

where $B_{g,t}$ is government debt, $p^G_t G^c_t$ and $G^I_t$ denote government consumption of public goods and investment in land development, respectively.

There are two fiscal policy shocks: $\{\epsilon_{g,t}, \epsilon_{g,t}\}$, which are shocks to government purchase of public sector goods and to land development investment.

Assume that the government consumption of goods $G^c_t$ follows AR(1) processes and the fiscal policy shock $\epsilon_{g,t}$ is i.i.d. mean zero normal processes.

$$\log G^c_t = \rho_{g,c} \log G^c_{t-1} + (1 - \rho_{g,c}) \log G^c_t + \epsilon_{g,t}^c$$

In this model, government investment is to develop the land in order to use in process of production. The government investment expands the stock of land

$$F(G^I_t) = Q^I_t (L_t - (1 - \delta_L) L_{t-1})$$

where $F(\cdot)$ is a linear function such like $F(x) = \eta x$ with $\eta \in (0, 1)$. Since land market clears,
the government investment of land development $G_I$ is an endogenous variable of land demand and land price.

### 4.4 Borrowing Constraint

Both production sectors use land as collateral for external financing in order to invest and to pay wage bill. I assume an imperfect contract enforcement that limits the amount of loans by capitalists and governments’ land value (Kiyotaki and Moore, 1995[15]; Iacoviello, 2005[12]; Liu, Wang, and Zha, 2013[19]). So that capitalists and governments face collateral constraints that mean they can only borrow up to a limit of their land collateral value.

The collateral constraint for representative capitalists is:

$$B_{c,t} \leq \theta_t Q_{t,t} L_{c,t} \tag{18}$$

where $\theta_t$ is the loan-to-value ratio for capitalist. The imperfect contract enforcement implies that the lender can recoup up to a fraction $\theta_t$ of the value of collateral assets if the borrower fails to repay the loan. Although $\theta_t$ might be thought as varieties of borrowing constraint, in this paper I will be especially concerned with the effect of shocks to $\theta_t$, which is identified as a collateral shock. As in Kiyotaki and Moore (2012)[16], I take $\theta_t$ as exogenous, which follows an AR(1) process

$$\ln \theta_t = \rho_\theta \ln \theta_{t-1} + (1 - \rho_\theta) \ln \theta + \epsilon_{\theta,t} \tag{19}$$

where $\epsilon_{\theta,t}$ denotes the collateral shock which follows an i.i.d. zero mean normal process.

The collateral constraint for the government is:

$$B_{g,t} \leq \theta'_t Q_{t,t} L'_t \tag{20}$$

where $\theta'_t$ is the loan-to-value ratio for projects in public sector. $\theta'_t$ follows an AR(1) process where $\epsilon'_{\theta,t}$ represents the collateral shock to public sector.

$$\ln \theta'_t = \rho'_\theta \ln \theta'_{t-1} + (1 - \rho'_\theta) \ln \theta' + \epsilon'_{\theta,t} \tag{21}$$
4.5 Bank and Lending Constraint

The financial intermediary in model is a bank, which finances loans from workers’ savings $B_{h,t}$ and an exogenous monetary reserve $X_t$. The financial market is perfectly competitive thus the profit of financial intermediary is zero. The FI’s balance sheet implies that its liabilities cannot be more than its asset. So the deposits minus required reserve cannot be lower than the loans. The FI’s balance sheet constraint is given by:

$$B_{h,t}(1 - X_t) \leq B_{c,t} + B_{g,t}$$  \hspace{1cm} (22)$$

where $X_t$ is the RRR required by the central bank.

The credit policy of lending constraint in this model is implemented by a reserve requirement ratio (RRR) policy. He and Wang (2012)[10] show that deposit rate and RRR are policy tools most frequently used by the People’s Bank of China (PBC). They find that market interest rates are most sensitive to changes in deposit interest rates and significantly responsive to changes in reserve requirements. As deposit rate in my model is determined by the debt market equilibrium, the credit policy is implemented by exogenous injections of liquidity into the financial intermediary through RRR policy. So that the central bank is nothing more than a liquidity provider.  

The RRR $X_t$ follows an AR(1) process:

$$\ln X_t = \rho_x \ln X_{t-1} + (1 - \rho_x) \ln X + \epsilon_{x,t}$$  \hspace{1cm} (23)$$

where $\epsilon_{x,t}$ is the RRR policy shock that directs to exogenous injections (extraction) of liquidity into (from) the financial intermediary.

---

4The People’s Bank of China (PBC) highly regulates the lending operations of the four largest state-owned banks. Therefore the financial market liquidity is highly dependent on the central bank credit policy. Modeling the central bank as a liquidity provider in this paper is to simplify the monetary policy as a credit policy that is operated by the PBOC.
4.6 Equilibrium

Given the initial conditions and a sequence of exogenous variables, an equilibrium consists of a sequence of state-contingent allocations and prices such that (1) the allocations solve the first order problems of agents and firms; (2) the capital market, goods market, lands market, and labor market all clear; (3) government constraints and financial market constraints have been balanced.

4.6.1 Optimal Conditions

The optimal conditions are first order conditions of workers’, capitalists’, private and public production sectors’ problems.

Workers

The workers maximize their expected lifetime utility subject to budget constraint.

\[
\frac{\partial}{\partial c_{h,t}} : \frac{1}{c_{h,t}} = \lambda_{h,t} \tag{24}
\]

\[
\frac{\partial}{\partial B_{h,t}} : \frac{\lambda_{h,t}}{R_t} = \beta_h \lambda_{h,t+1} \tag{25}
\]

\[
\frac{\partial}{\partial N_{h,t}} : \frac{\psi}{N_{h,t}} = \lambda_{h,t} w_t \tag{26}
\]

where \(\lambda_{h,t}\) is multiplier to budget constraint.
Capitalists

\[
\begin{align*}
\frac{\partial}{\partial c_{c,t}} : & \quad \frac{1}{c_{c,t}} = \lambda_{c,t} \\
\frac{\partial}{\partial I_t} : & \quad \lambda_{c,t} = \mu_{c,t} \frac{\partial \Omega(I_t)}{\partial I_t} + \beta_c \mu_{c,t+1} \frac{\partial \Omega(I_{t+1})}{\partial I_t} \\
\frac{\partial}{\partial K_t} : & \quad -\mu_{c,t} + \beta_c \mu_{c,t+1}(1 - \delta) + \lambda_{c,t+1}(R_{k,t+1}e_{t+1} - \Psi(e_{t+1})) = 0 \\
\frac{\partial}{\partial e_t} : & \quad \Psi'(e_t) = R_{k,t} \\
\frac{\partial}{\partial L_{c,t}} : & \quad -\lambda_{c,t}Q_{l,t} + \nu_{c,t}\theta_{l,t} Q_{l,t} + \beta_c \lambda_{c,t+1}(R_{l,t+1} + Q_{l,t+1}) = 0 \\
\frac{\partial}{\partial B_{c,t}} : & \quad \frac{\lambda_{c,t}}{R_t} = \nu_{c,t} + \beta_c \lambda_{c,t+1}
\end{align*}
\]

where \(\{\lambda_{c,t}, \mu_{c,t}, \nu_{c,t}\}\) are multipliers to budget constraint, capital accumulation and collateral constraint, respectively. The \(\frac{\partial \Omega(I_t)}{\partial I_t}\) and \(\frac{\partial \Omega(I_{t+1})}{\partial I_t}\) in the first order condition of \(I_t\) are

\[
\begin{align*}
\frac{\partial \Omega(I_t)}{\partial I_t} &= 1 - \frac{\Omega}{2} \left[\frac{I_t}{I_{t-1}} - \gamma_l\right] \left(\frac{I_t}{I_{t-1}}\right) + \left(\frac{I_t}{I_{t-1}}\right)^2 \\
\frac{\partial \Omega(I_{t+1})}{\partial I_t} &= \frac{\Omega}{2} \left(\frac{I_{t+1}}{I_t} - \gamma_l\right) \left(\frac{I_{t+1}}{I_t}\right)^2
\end{align*}
\]

Private Sector

\[
\begin{align*}
\frac{\partial}{\partial l_t} : & \quad \frac{\alpha \phi y_t}{L_{c,t-1}} = R_{l,t} \\
\frac{\partial}{\partial k_t} : & \quad \frac{\alpha (1 - \phi) y_t}{k_t} = R_{k,t} \\
\frac{\partial}{\partial n_t} : & \quad \frac{(1 - \alpha) y_t}{n_t} = w_t \\
\Pi_t &= \max(y_t - R_{k,t}b_t - R_{l,t}L_{c,t-1} - w_t n_t)
\end{align*}
\]

The land input in private sector is provided by capitalists so that \(l_t = L_{c,t}\).
Public Sector

The public sector receives land input from the governments so that $L_t'$ is given.

\[
\frac{\partial}{\partial L_t'} \frac{\alpha \phi' p_t^G y_t'}{L_{t-1}} = R_{t,t}
\] (39)

\[
\frac{\partial}{\partial k_t'} \frac{\alpha (1 - \phi') p_t^G y_t'}{k_t'} = R_{k,t}
\] (40)

\[
\frac{\partial}{\partial n_t'} \frac{(1 - \alpha) p_t^G y_t'}{n_t'} = w_t
\] (41)

\[
\Pi_t' = \max(p_t^G y_t' - R_{k,t} k_t' - R_{t,t} L_{t-1}' - w_t n_t')
\] (42)

Market Clearing Conditions

The aggregate resource constraint clears the private goods market and public goods market:

\[
e_{h,t} + c_{c,t} + I_t + \Psi(e_t) K_{t-1} + G_t^c = y_t
\] (43)

\[
G_t^c = y_t'
\] (44)

The land market clearing condition is:

\[
L_{c,t} + L_t' = L_t
\] (45)

The capital market clearing condition is:

\[
k_t + k_t' = \epsilon_t K_{t-1}
\] (46)

The labor market clearing condition is:

\[
n_t + n_t' = N_t
\] (47)
GDP

The aggregate output of two sectors is:

\[ Y_t = y_t + p_t^G y_t' \]  \hspace{1cm} (48)

5 Calibration and Simulation

To solve the model and fit it to the data, I first log linearize the stationary equilibrium conditions around the deterministic steady state in which the collateral constraints of private and public sectors are binding. There are eight structural shocks in the model: productivity shocks to \( \{A_t, A_t'\} \), fiscal policy shocks to \( \{G_t^c, G_t^I, T_t\} \), and credit policy shocks to \( \{\theta_t, \theta_t', X_t\} \). I first calibrate the parameters to the data and existing literature. Then I simulate the model to obtain the theoretical impulse response functions and simulated moments. The standard convention of model evaluation is to compare moments from the data and from the model based on the same transformation.

5.1 Calibration

I categorize the parameters into two groups. The first group of parameters are standard so that they are calibrated from the literature. The second group of parameters are model specific so that they are determined by the moments of data. The third group of parameters are estimated in a VAR model.

Table 2 summarizes the first and second groups of parameters. The calibration table is based on the annual data in China from 2004 to 2014.

It is notable that the labor supply aversion \( \psi \) is calibrated to the steady state of marginal utility of consumption for workers.\(^5\) The annual capital depreciation rate is 0.03 so that quarterly rate is 0.0075. The land share in the private sector of consumption goods \( \phi \) is calibrated from steady state of (38). Here it is approximated to estimates by Liu, Wang and Zha (2013)[19] and Iacoviello (2005)[12]. The land share in public sector of public goods \( \phi' \) is from steady

\(^5\)This steady state representation is in appendix. \( \psi = w^{Nybar}/ch^{ybar} \) where \( w^{Nybar} \) and \( ch^{ybar} \) are two steady states solved by model.
Table 2: Calibrated Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker’s discount factor</td>
<td>$\beta_h$</td>
<td>0.99</td>
</tr>
<tr>
<td>Capitalist’s discount factor</td>
<td>$\beta_c$</td>
<td>0.95</td>
</tr>
<tr>
<td>Labor supply aversion</td>
<td>$\psi$</td>
<td>1.1009</td>
</tr>
<tr>
<td>Capital:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital depreciation rate</td>
<td>$\delta$</td>
<td>0.03</td>
</tr>
<tr>
<td>Investment adjustment cost</td>
<td>$\Omega$</td>
<td>2</td>
</tr>
<tr>
<td>Investment adjustment cost (slope)</td>
<td>$\gamma_1$</td>
<td>1</td>
</tr>
<tr>
<td>Capital utilization (slope)</td>
<td>$\gamma_1$</td>
<td>0.063</td>
</tr>
<tr>
<td>Capital utilization (curvature)</td>
<td>$\gamma_2$</td>
<td>1.009</td>
</tr>
<tr>
<td>Technology:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor share</td>
<td>$1 - \alpha$</td>
<td>0.7</td>
</tr>
<tr>
<td>Land share in private sector</td>
<td>$\phi$</td>
<td>1/20</td>
</tr>
<tr>
<td>Land share in public sector</td>
<td>$\phi'$</td>
<td>1/6</td>
</tr>
<tr>
<td>Land development</td>
<td>$\eta$</td>
<td>0.3737</td>
</tr>
<tr>
<td>Land depreciation rate</td>
<td>$\delta_L$</td>
<td>0.03</td>
</tr>
<tr>
<td>Productivity ratio</td>
<td>$A'/A$</td>
<td>0.6796</td>
</tr>
<tr>
<td>Infrastructure stock elasticity to private output</td>
<td>$\gamma'$</td>
<td>0.10</td>
</tr>
<tr>
<td>Infrastructure depreciation rate</td>
<td>$\delta_y$</td>
<td>0.03</td>
</tr>
<tr>
<td>Financial:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan-to-value ratio for Private</td>
<td>$\theta$</td>
<td>0.60</td>
</tr>
<tr>
<td>Loan-to-value ratio for Public</td>
<td>$\theta'$</td>
<td>0.72</td>
</tr>
</tbody>
</table>

state of (41). Here I use the data of share of land acquisition cost to real estate investment to approximate the land share in public sector. The elasticity of infrastructure stock to private output is 0.10 in empirical studies of effects of public infrastructure investment on economic growth (Lau and Sin, 1997). The land development parameter $\eta$ is derived from the steady state of land development equation (17). So that in steady state $\eta = (Q^L/L/\delta L/(G^I/y))$ where $Q^L/y$ and $G^I/y$ are steady states and $\delta L$ is depreciation rate of land. From the steady states of (33) and (34), we can derive the steady state of private sector loan-to-value ratio $\theta$ if given the first order moment of rent-price ratio of land $R_L/Q_L$. Typically the loan-to-value ratio in the land financing market of China ranges from 50% to 70%. The ratio of public sector productivity to private sector productivity is calibrated from production functions of two sectors given public goods clearing condition and $G^c/y$ at steady state.
The third group of parameters includes autocorrelation and standard deviation parameters of structural shocks. To compare the theoretical impulse responses of model variables to same percentage deviation of shocks, I begin with all autocorrelation parameters of shocks are 0.9 and standard deviations of shocks are 0.01. While in the other version of calibration, these parameters are estimated in VAR with variables of interest. Table 3 summarizes the shock parameters including persistence and volatility.

### Table 3: Shock Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autocorrelation of shocks:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>( \rho_A )</td>
<td>0.9</td>
</tr>
<tr>
<td>Government consumption</td>
<td>( \rho_G )</td>
<td>0.9</td>
</tr>
<tr>
<td>Collateral constraint for private</td>
<td>( \rho_{\theta} )</td>
<td>0.9</td>
</tr>
<tr>
<td>Collateral constraint for public</td>
<td>( \rho'_{\theta} )</td>
<td>0.9</td>
</tr>
<tr>
<td>Credit policy</td>
<td>( \rho_X )</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Standard deviation of shocks:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>( \sigma_A )</td>
<td>0.01</td>
</tr>
<tr>
<td>Government consumption</td>
<td>( \sigma_G )</td>
<td>0.01</td>
</tr>
<tr>
<td>Collateral constraint for private</td>
<td>( \sigma_{\theta} )</td>
<td>0.01</td>
</tr>
<tr>
<td>Collateral constraint for public</td>
<td>( \sigma'_{\theta} )</td>
<td>0.01</td>
</tr>
<tr>
<td>Credit policy</td>
<td>( \sigma_X )</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### 6 Quantitative Analysis and Economic Implications

In this section I discuss the quantitative implications of model based on the shock decomposition and theoretical impulse responses.

#### 6.1 Relative Importance of Shocks

Table 4 reports the shock decompositions for investment, land, interest rate, land price and GDP across six structural shocks. Variance decompositions show that shocks to technology in the two sectors (ea, eaprive), do not explain much of the fluctuations in land, land price and interest rate. The technology shocks contribute relatively more to fluctuations in investment and GDP.
Similar to technology shocks, government consumption shock (egc) contributes little to land market variables. It contributes to investment and GDP in similar magnitude as technology shocks.

In contrast, a borrowing constraint shock (loan-to-value ratio) for capitalist (eth) drives most of the land space ($L$) and a large fraction of land price fluctuations ($Q^l$). The borrowing constraint is directly related to capitalist’s investment decisions so that the shock contributes to considerable fraction of fluctuations in investment and capital as well. However, land market variables are less sensitive to borrowing constraint shock for government because the economy of public sector is relatively smaller than private sector as calibrated in the model.

A shock to lending constraint (reserve ratio requirement) for bank (ex) accounts for a substantial fraction of land price fluctuations (40%). The shock in lending constraint directly affects the interest rate (R) thus affects the borrowing capacity of capitalist and government.

### 6.2 Which shocks drive land price fluctuations?

The land price fluctuation is mainly driven by shocks to borrowing constraint for capitalists (eth) and to lending constraint for bank (ex).

A relax in borrowing constraint for capitalists would increase demand of land. While a tighten in borrowing constraint would push capitalists to sell their land stock to meet collateral constraint. The borrowing constraint shock is propagated through the collateral constraint thus...
explains a sizable fraction of fluctuations in land market variables.

A lending constraint shock is related to borrowing capacity of capitalist and government thus is amplified through the collateral constraint and generates sizable fluctuation in land prices.

Not surprisingly, the shocks to technology and government consumption, both of which are demand shocks of land, are not driven forces of land price fluctuation. Land is a predetermined variable. Positive technology and government consumption shocks at $t$ increases rental price of land at $t$ but land demand at $t + 1$. Since land is not fixed in this model, land development by government would contemporaneously increase in response to increase in land demand at $t + 1$. Thus the demand side effect of land from production is canceled by the supply side effect of land from land development contemporaneously. These findings are consistent with Liu, Wang and Zha (2012) who find that technology shock contributes little to land price fluctuations.

6.3 Impacts of Government Spending Shock with Government Debt Constrained

Figure 8 displays the impulse responses of several variables to a positive government spending shock. An expansion in government spending on public goods (e.g. infrastructure) has very little effect on the land price. This is because the increase in land demand has been diminished by increase in land sale and increase in total land supply. Since government debt is constrained by land collateral value and cannot borrow over the limit, government has to sell part of land holdings to finance the expansion in purchase of public goods. Also, the increase in public sector land demand inspires new investment in land development. Therefore both land sale to capitalist and total land supply increase.

However, the government spending shock has real effect on investment and output. A positive shock pushes up the rental price of land because of an increase in demand of land in public sector. Both investment in capital and capital utilization rate increase in response to a growing demand of capital. Labor wage falls as the marginal productivity of labor decreases with more labor input. As a result, private sector benefits from positive government spending shock because it drives higher demand of capital investment and consumption goods. Also there is hump shape in the impulse responses of variables. The land price firstly drops after the shock
but then grows back. This is because government is able to adjust the land development in response to the changes in land price so that land supply is elastic to land price.

Figure 8 shows a crowd in effect of public spending to private sector. The key issue is that the government debt must be constrained by their land collateral value. What if there is no imperfect contract enforcement on government debt? I would discuss in next chapter.

6.4 Impacts of Relax in Borrowing Constraints: Capitalist vs Government

Figure 9 and 10 report the impulse responses of land and macroeconomic variables to relaxes in borrowing constraints for capitalist and government. Comparing impulse responses to one-percent deviation change in eth and ethprime, relaxation in capitalist’s collateral constraint has greater effect on stimulating GDP, investment and consumption than relaxing government debt constraint. Even though increasing the portion of public sector output in total GDP, the borrowing constraint shock to capitalist is still able to account for more fluctuations in output and investment.

The mechanism is as follows. Since capitalist’s collateral constraint is directly related to their capital investment decision, relax in capitalist’s collateral constraint would have a direct effect on the investment. As land is used as collateral asset, relax in capitalist collateral constraint would increase their land demand as well. Then capitalists would invest their new adding land in the private sector, which has higher productivity. Thus same percent change in capitalist’s borrowing constraint has greater effect on output.

6.5 Impacts of Tightening Lending Constraint: Private Wins, Public Loses

Increasing the required reserve ratio (RRR) by financial intermediary has complex yet interesting consequences. Figure 11 reports the impulse responses of model variables to a negative lending constraint shock, i.e. increase RRR. The model predicts that tightening lending constraint would inspire the private sector economy much more than the public. This is due to a reallocation of land between private and public sectors driven by land price change. An increase in reserve requirement ratio would drive up the interest rate. As government debt is constrained by collateral value of land, higher interest rate would increase the borrowing cost and push the
government to sell part of land holdings to finance alternatively. This results in a lower land price. Though capitalists are facing a higher borrowing cost as well, instead of selling their land holdings, they would cut their capital investment and increase the capital utilization rate. Also, the capitalists would buy more land in response to a cheaper land price. Therefore, the private sector would benefit from a lower land price that is driven by the tightening lending constraint shock.

6.6 Impacts of Loosening Lending Constraint: Private Crowd-out and Capital Overcapacity

If financial intermediary looses lending constraint by reducing the required reserve ratio, interest rate falls. Both capitalists and government would have more incentive to borrow as to finance investment in both production. However, since both parties face collateral constrains on their land holding, they have to acquire more land to borrow more. The demand of land increase thus land price hikes, as displayed in Figure 12. As to acquire more land as collateral, government cuts the land sale to capitalists and inputs the land into public sector production. As a result, private sector is facing a shortage of land input and a higher land price. In response to shortage of land input, capitalist has to reduce the capital utilization rate, which results in the overcapacity of capital. Therefore, the private sector output is crowd out by the public after FI looses lending constraint.

6.7 Does Technology Shock to Public Sector Crowd-out Private Sector?

Figure 7 displays the impulse response of positive public sector technology shock. Not surprisingly, a positive technology shock to public sector results in a higher land price and lower output in private sector. The shock would drive up government’s incentive to invest in public sector. As to finance public investment, government would raise debt and cut land sale to push up the collateral constraint.
7 Key Issues

7.1 What if local government debt is not constrained by land collateral?

From the last chapter, we can tell that the assumption that local government debt is constrained by collateral value of their land holdings is very important to the model dynamics. One may ask that what if there is no limited contract enforcement so that the government debt is not constrained by land collateral. Would there be crowd-out effect on private sector if there is an expansion in government spending?

To answer this question, I consider an alternative model in which local government debt is not constrained by land collateral. Government debt is determined in government budget constraint with deficit. The lump-sum tax (transfer) follows a second fiscal rule:

\[
\log T_t = \rho T \log T_{t-1} + (1 - \rho T) \log T + \epsilon_{g,t}^T
\]

(49)

where \( T_t \) is lump-sum taxes (transfers) and \( \epsilon_{g,t}^T \) is shock to lump-sum taxes which is i.i.d. mean zero normal process.

Figure 13 reports the impulse responses of variables to an expansion in government spending if the government debt is not constrained by land collateral. The alternative model has shown two significant results.

First, when government debt is not constrained by their land collateral, the model generates much higher volatility of land price. Simulated moments of alternative model show that relative volatility of land price to GDP is 1.607, which nearly equal to the data moment 1.717. Thus the moment matching of model improves when the local government debt is not constrained by their land collateral. This indicates that the Chinese local government debt in reality is not strictly constrained by their collateral asset when they are motivated to sell the land to finance investment.

Second, the alternative model predicts that an increase in the government expenditure on public goods would drive up in land price and wage; then cause a reallocation of capital, land and labor between private and public sectors. As a result, private sector is crowded out by public
sector after an expansion in public spending. This crowding out effect on private sector production further reduces capital investment, reduces consumption, and causes capital overcapacity. Therefore, for a local government whose debt is not constrained, an expansion in government expenditure reallocates resources from high-productive sector to low-productive sector, which causes resource misallocations and GDP losses.

7.2 What if total land supply is fixed?

The benchmark and analysis in last chapter are based on an assumption that the land supply is elastic to the land price so that local government could determine land development in response to land price changes. This assumption secures relatively smooth land price fluctuation since any time when land price is driven up by land demand the land supply could increase to cancel off the demand side effect. The land development model is realistic for many urban cities in China. However, in some cities or rural area where land is not completely owned and developed by the government or where there is relatively high adjustment cost associated to the land supply, the effect of government investment in infrastructure on land price and other model dynamics may change. Therefore to figure out the relationship between fiscal spending and real estate cycles and macroeconomic variables, I construct an alternative model in which total land supply is fixed. Then this model is consistent with the land supply assumption in Iacoviello (2005) and a series of following paper which assumes fixed land supply in the US economy. Since total land supply is fixed, local government cannot develop more land so that there is no government land development investment ($G^l$). Then land holding of government is determined by land price only (not land price and land rental price in elastic land supply model).

Figure 14 shows the impulse response to government spending expansion if land is fixed and government debt is constrained by land collateral value. Comparing Figure 14 with Figure 8 in which land is elastic and government debt is constrained, land price drops faster and deeper but causes more crowding in of private sector output if the total land supply is fixed. The simulated moments of alternative model predict that the relative volatility of land price to GDP is 0.578, which is smaller than that of data, 1.717. The logic of land price drop is same as in previous chapter. Local government debt is constrained so that the government has to sell more
land to finance the increase in public spending. Since land supply is fixed so that government
cannot adjust land development to smooth changes in land prices, the fluctuations of land price,
investment and output are larger. The crowd in effect of government spending to private sector
is stronger. And there is not hump shape in the impulse responses of variables because land
prices fluctuation driven by demand side cannot be canceled off by the supply change.

7.3 What if land supply is fixed and local government debt is unconstrained?

Figure 15 reports the impulse response to government spending expansion if land is fixed and
local government debt is unconstrained. Comparing Figure 15 with Figure 14 in which land is
fixed and government debt is constrained, we can see that an unconstrained-debt government
spending would crowd out private investment and output, and push up the land price. Com-
paring Figure 15 with Figure 13 in which government debt is unconstrained and land supply is
elastic, fixed land supply (or increase land supply elasticity to infinity) would not only increase
the fluctuations of land price but also crowd out private investment and output more than the
case with elastic land supply. Therefore, relaxing the local government debt from collateral con-
straint would crowd out private investment and output, increase land price, and cause GDP loss;
while fixing the land supply would increase the fluctuations of land price and other variables.

8 Sensitivity Analysis

8.1 Adjustment cost

Figure 16 compares the impulse responses to expansion in government spending. Parameteriza-
tion is with three different values of investment growth rate at steady state, $\gamma_I$: 1.01, 1.05, 1.10,
while $\Omega = 2$. The impulse responses of investment, capital stock and capital utilization rate if
$\gamma_I = 1.10$ are smaller than the case if $\gamma_I = 1.01, 1.05$. A higher steady state investment growth
rate is associate with a higher adjustment cost of investment so that responses of capitalist’s
investment decision are smaller.
8.2 Land share

The calibration values of private land input share ($\phi$) and public land input share ($\phi'$) in benchmark model are $1/10$ and $1/6$. Figure 17 compares the impulse responses between models with different private land input share, $\phi$: $1/10$, $1/11$, $1/12$. If local government debt is constrained, higher land input share in private sector would result in higher land price and land rental price. As the private sector would benefit from the land price drop and land supply increase, higher private sector land input share would cause more crowd in of the private output. Figure 18 compares the impulse responses between models with different public land input share, $\phi'$: $1/6$, $1/5$, $1/4$. In contrast with Figure 17, the higher public sector land share, the more land would need to be inputted in public sector production and the less crowd in effect on the private sector. Both Figure 17 and Figure 18 indicate that land share in private and public sector production would change the impacts of government spending on land market and output.

9 Conclusion

This paper contributes to the literature by studying the macro effects of local government land sale and infrastructure investment cycles, as well as multiple policy implications on the real estate market and macroeconomy. The paper predicts that land price fluctuations are mainly driven by credit shocks, i.e. borrowing constraint shocks and lending constraints shocks. While impacts of technology and government spending shocks on land price fluctuations are modest. The paper suggests that to generate a positive effect of land sale financing infrastructure investment on the economy, local government debt must be constrained by asset value. Otherwise, infrastructure investment would drive up land price, crowd out private investment and output, and cause capital overcapacity and capital misallocation.

The paper abstracts from endogenous growth factor in the model for two reasons: it is extensively discussed in literature that how infrastructure may foster growth endogenously by public goods spill-over and/or productivity growth; this paper focuses on Chinese business cycles and real estate cycles, i.e. comovement and fluctuations in the short run, other than growth in longer time span. Also, PBC is simplified as a liquidity provider and conducting a single
monetary policy target as the required reserve ratio. In future study, I will discuss the impacts of local government debt financing on the economy in a nominal model in which monetary policy has multiple targets including real estate price.
Figure 5: Cross Correlation of Variables

land price vs fix inv

land price vs soe inv

land price vs res inv

land price vs local gov inv

land price vs res fund

land price vs GDP
Figure 6: IRF to private productivity shock (ea)
Figure 7: IRF to public productivity shock (eaprime)
Figure 8: IRF to government consumption shock (egc)
Figure 9: IRF to private borrowing constraint shock (eth)
Figure 10: IRF to public borrowing constraint shock (ethprime)
Figure 11: IRF to tightening lending constraint shock (ex)
Figure 12: IRF to loosening lending constraint shock (e-x)
Figure 13: IRF to government consumption shock if government debt is not constrained (egc)
Figure 14: IRF to government consumption shock if total land supply is fixed (egc)
Figure 15: IRF to government consumption shock if government debt is not constrained and total land supply is fixed (egc)
Figure 16: IRF to government consumption shock with different investment growth parameter ($\gamma_I$) in adjustment cost (egc)
Figure 17: IRF to government consumption shock with different private land share ($\phi$) (egc)
Figure 18: IRF to government consumption shock with different public land share ($\phi'$) (egc)
A Log-Linearized System

I log-linearize the model in the preceding appendix around the deterministic steady state.

[1] Agents

\[
\begin{align*}
-c_{h,t} = & \lambda_{h,t} \\
\hat{\lambda}_{h,t} - \hat{R}_t = & \lambda_{h,t+1} \\
-N_{h,t} = & \lambda_{h,t} + \bar{w}_t \\
-\hat{c}_{c,t} = & \lambda_{c,t} \\
\lambda_{c}\hat{\lambda}_{c,t} = & \mu_c\Omega'(I_t)(\mu_{c,t} + \Omega'(I_t)) + \beta_c\lambda_cR_k\epsilon(\lambda_{c,t+1} + R_{k,t+1} + e_{t+1}) - \beta_c\lambda_c\Psi(\lambda_{c,t+1} + \Psi(e_{t+1})) \\
\mu_{c}\hat{\mu}_{c,t} = & \beta_c(1 - \delta)\mu_c\mu_{c,t+1} + \beta_c\lambda_cR_k\epsilon(\lambda_{c,t+1} + R_{k,t+1} + e_{t+1}) - \beta_c\lambda_c\Psi(\lambda_{c,t+1} + \Psi(e_{t+1})) \\
\gamma_2\hat{e}_t = & R_k\hat{R}_k \\
\lambda_{c}Q_l(\hat{\lambda}_{c,t} + \hat{Q}_{l,t}) = & \nu_c\theta Q_l(\nu_{c,t} + \hat{\theta}_t + \hat{Q}_{l,t}) + \beta_c\lambda_cR_l(\lambda_{c,t+1} + R_{l,t+1} + Q_l(\lambda_{c,t+1} + \Omega'(I_t))) \\
\lambda_{c}\hat{\lambda}_{c,t} = & \nu_cR(\nu_{c,t} + \hat{R}_t) + \beta_c\lambda_cR(\lambda_{c,t+1} + \hat{R}_t) \\
\Omega'(I_t) = & 1 - \frac{\Omega}{2}(2(1 - \gamma_I) + (1 - \gamma_I)^2) \\
\Omega'(I_{t+1}) = & \Omega(1 - \gamma_I) \\
\Omega'(I_t)\Omega'(I_t) = & \Omega(-3 + 2\gamma_I)(I_t - \hat{I}_{t-1}) \\
\Omega'(I_{t+1})\Omega'(I_{t+1}) = & \Omega(3 - 2\gamma_I)(I_{t+1} - \hat{I}_t) \\
K\hat{K}_t = & (1 - \delta)KK_{t-1} + \Omega\hat{\Omega}_t \\
\Omega\hat{\Omega}_t = & [1 - \frac{\Omega}{2}(1 - \gamma_I)^2]I\hat{I}_t - \Omega(1 - \gamma_I)I(I_t - \hat{I}_{t-1})
\end{align*}
\]
Firms

\[ \hat{y}_t = \hat{A}_t + \alpha(\phi\hat{L}_{c,t} + (1 - \phi)\hat{k}_t) + (1 - \alpha)\hat{n}_t + \gamma'\hat{Y}_t' \]  
(A.14)

\[ Y'\hat{y}_t' = (1 - \delta_y)Y'Y_{t-1} + y'\hat{y}_t' \]  
(A.15)

\[ \hat{y}_t' = \hat{A}_t' + \alpha(\phi'\hat{L}_{c,t}' + (1 - \phi')\hat{k}_t') + (1 - \alpha)\hat{n}_t' \]  
(A.16)

\[ \hat{y}_t - \hat{L}_{c,t} = \hat{R}_{t,t} \]  
(A.17)

\[ \hat{y}_t - \hat{k}_t = \hat{R}_{k,t} \]  
(A.18)

\[ \hat{y}_t - \hat{n}_t = \hat{w}_t \]  
(A.19)

\[ \Pi\Pi_t = yy_t - \hat{R}_k k(\hat{R}_{k,t} + \hat{k}_t) - \hat{R}_l L_c(\hat{R}_{l,t} + \hat{L}_{c,t}) - wn(\hat{w}_t + \hat{n}_t) \]  
(A.20)

\[ \hat{p}_G' + \hat{y}_t' - \hat{k}_t' = \hat{R}_{k,t} \]  
(A.21)

\[ \hat{p}_G' + \hat{y}_t - \hat{n}_t' = \hat{w}_t \]  
(A.22)

\[ \Pi'\Pi_t = p^G y'(\hat{p}_G' + \hat{y}_t') - \hat{R}_k k'(\hat{R}_{k,t} + \hat{k}_t') - wn'(\hat{w}_t + \hat{n}_t') \]  
(A.23)

\[ \Psi(e)\Psi(e_t) = \gamma_1 e\hat{e}_t + \gamma_2 (e^2\hat{e}_t - e\hat{e}_t) \]  
(A.24)

[3] market clearing conditions

\[ c_h c_{h,t} + c_c c_{c,t} + I\hat{I}_t + \Psi(e)K(\Psi(e_t) + K_{t-1}) + G^l \hat{G}_t^l = yy_t \]  
(A.25)

\[ \hat{G}_t^l = \hat{y}_t' \]  
(A.26)

\[ L_c\hat{L}_{c,t} + L'\hat{L}_t = LL_t \]  
(A.27)

\[ k\hat{k}_t + k'\hat{k}_t' = eK(\hat{e}_t + \hat{K}_{t-1}) \]  
(A.28)

\[ n\hat{n}_t + n'\hat{n}_t' = NN_t \]  
(A.29)

[4] government budget constraint

\[ Q_l L_c(L_{c,t} - L_{c,t-1}) + T\hat{T}_t + \Pi'\Pi_t + \frac{B_g}{R}(\hat{B}_{g,t} - \hat{R}_t) = B_g B_g t_{t-1} + p^G G^c(\hat{p}_G' + \hat{G}_t^c) + G^l \hat{G}_t^l \]  
(A.30)

\[ \eta\delta_L \hat{G}_t^l = (\hat{Q}_t^l + \hat{L}_t) - (1 - \delta_L)(\hat{Q}_t^l + L_{t-1}) \]  
(A.31)
financial intermediary

\[ B_h \dot{B}_{h,t} + X \dot{X}_t = B_c \dot{B}_{c,t} + B_g \dot{B}_{g,t} \]  
(A.32)

\[ \dot{B}_{c,t} = \dot{\theta}_t + \dot{Q}_{l,t} + L_{c,t} \]  
(A.33)

\[ \dot{B}_{g,t} = \dot{\theta}^t_t + \dot{Q}_{l,t} + \dot{L}^t_t \]  
(A.34)

shocks

\[ \dot{A}_t = \rho_A \dot{A}_{t-1} + \epsilon_{A,t} \]  
(A.35)

\[ \dot{A}'_t = \rho'_A \dot{A}'_{t-1} + \epsilon'_{A,t} \]  
(A.36)

\[ \dot{G}^c_t = \rho_{g,c} \dot{G}^c_{t-1} + \epsilon_{g,t} \]  
(A.37)

\[ \dot{G}^I_t = \rho_{g,I} \dot{G}^I_{t-1} + \epsilon_{g,t} \]  
(A.38)

\[ \dot{T}_t = \rho_T \dot{T}_{t-1} + \epsilon_{T,t} \]  
(A.39)

\[ \dot{\theta}_t = \rho_{\theta} \dot{\theta}_{t-1} + \epsilon_{\theta,t} \]  
(A.40)

\[ \dot{\theta}'_t = \rho'_\theta \dot{\theta}'_{t-1} + \epsilon'_{\theta,t} \]  
(A.41)

\[ \dot{X}_t = \rho_X \dot{X}_{t-1} + \epsilon_{x,t} \]  
(A.42)
B Steady States of System

In this section, I solve the system of model at steady state.

\[
\begin{align*}
\lambda_h &= 1/c_h \\
R &= 1/\beta_h \\
N_h &= \frac{\Psi}{\lambda_h w} \\
\lambda_c &= 1/c_c \\
\lambda_c &= \mu_c(1 - \frac{\Omega}{2}(2(1 - \gamma_l) + (1 - \gamma_l)^2)) + \beta_c\mu_c\Omega(1 - \gamma_l)^2 \\
\beta_c((1 - \delta) + \frac{\lambda_c}{\mu_c}(R_k e - \Psi(e))) &= 1 \\
\gamma_1 + \gamma_2(e - 1) &= R_k \\
-\lambda_cQ_l + \nu_c\theta Q_l + \beta_c\lambda_c(R_l + Q_l) &= 0 \\
\frac{\lambda_c}{R} &= \nu_c + \beta_c\lambda_c \\
R_l &= \alpha\phi \frac{y}{k} \\
R_k &= \alpha(1 - \phi) \frac{y}{k} \\
w &= (1 - \alpha) \frac{y}{n} \\
R_k &= \alpha(1 - \phi') \frac{pG' y'}{k'} \\
w &= (1 - \alpha) \frac{pG' y'}{n'} \\
L' &= L - L_c \\
eK &= k + k' \\
N &= n + n' \\
B_c &= \theta Q_l L_c \\
B_g &= \theta' Q_l L' \\
B_h - B_c - B_g &= 0 \\
\Delta L &= F(G') \\
X &= 0.2
\end{align*}
\]
References


