

Land Price, Export Shocks, and Investment in China: A Tale of Two Sectors

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Abstract

I construct the quarterly commercial land price series using land transaction data in China and document a negative correlation between land price and aggregate investment, as opposed to the positive correlation in the US. With sectoral productivity processes estimated, a real business cycle model with a manufacturing and a service sector is used to explain the negative correlation. A positive export (manufacturing good) price shock increases the demand for tradable manufacturing goods and attracts capital and labor from the non-tradable service sector, by which only land is used. Aggregate investment rises because the manufacturing sector is more capital intensive. Land price, on the other hand, falls as the return to land decreases.

JEL Classification: E13, E30, O18, P24, P25, R14

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1 Introduction

The relationships between real estate prices, investment, and macroeconomic fluctuations have been frequently discussed since the 2008 crisis. It is widely recognized that a collapse of the real estate market led to the great recession. [Liu, Wang, and Zha \(2013\)](#) study the influence of real estate prices on macroeconomic fluctuations through the positive correlation between land price and capital investment they documented (Figure 1a). They argue that the positive correlation is generated by a collateral constraint with the land as the collateral. This collateral constraint propagates shocks and amplifies macroeconomic fluctuations. In China, on the other hand, land price and capital investment negatively co-move (Figure 1b). What leads to this negative co-movement in China as opposed to that in the US, and how is it related to macroeconomic fluctuations?

In this paper, I construct the quarterly commercial land price series using land transaction data and document the negative correlation between (commercial) land price and investment on the aggregate and province levels. I also find the negative correlation to be related to movements in the ratio of manufacturing's GDP to service', as well as changes in China's export values. Based on these facts, I build and simulate a real business cycle model with two sectors—the manufacturing and the service. In this model, the commercial land is only used by the service sector, while the manufacturing sector is more capital-intensive than service. A negative export shock to the tradable manufacturing sector leads to the re-allocation of labor from manufacturing to the non-tradable service sector. This re-allocation, in turn, results in a rise in land prices due to a higher marginal return to land, and a fall in the aggregate capital investment because the service sector is less capital intensive.

My paper contributes to the literature on the relationship between the real estate market and investment ([Chaney et al., 2012](#); [Gan, 2007](#); [Liu et al., 2013](#)). In their papers, real estate shocks affect (corporate) investment through a collateral channel. In the presence of financial frictions, firms use real estate assets as collaterals to borrow for investment. A positive real estate shock raises the collateral values and in turn, boosts corporate investments, and vice versa. In my paper, the negative correlation between land price and investment originates from the institutional friction in China, i.e., the transformation of commercial lands to industrial lands is restricted by the government. This institutional friction prevents the re-allocation of land across sectors with capital and labor, which results in the negative co-movement between land prices and investment.

My paper is also related to the literature studying the negative correlation between land prices and investment in China. These papers document the negative correlation on the micro-level (e.g., [Chen et al., 2016](#); [Han and Lu, 2017](#)). [Chen, Liu, Xiong, and Zhou \(2016\)](#) combines the land transaction data with publicly listed firms' financial data and find that increases in (commercial)

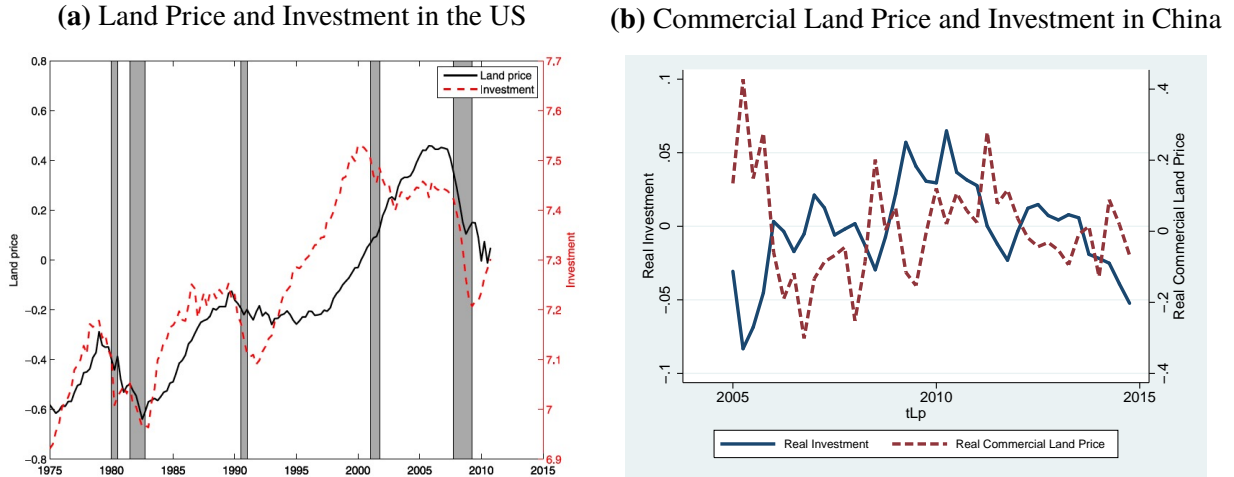


Figure 1: Real Land Price and Investment in US and China

Notes: Panel (a) plots the log real land price and investment in the US documented by Liu, Wang, and Zha (2013). The shaded bars mark the NBER recession dates. Panel (b) plots the log real commercial land price and investment in China documented in this paper. Both commercial land price and investment are hp-filtered.

land price discourage firms' investment.^{1 2} They explain this negative correlation with two channels. The first one is a speculation channel in line with Miao and Wang (2015) and Chen and Wen (2017). Encouraged by a rising land price (or expectation), firms re-allocate resources from core businesses (capital) to land purchases, leading to a negative correlation between the two. The second channel they argue is the crowding out channel, which is also associated with misallocation of resources. Due to the credit rationing policy in China, banks lend more to land-holders, which are more likely to be less efficient state-owned enterprises (SOEs). Compared to their papers, my paper documents the negative correlation between land prices and investment on the aggregate level. And I argue that the negative correlation is due to (efficient) re-allocation of resources between the manufacturing and service sectors.

My paper also contributes to the literature on estimating China's sectoral total factor productivities (TFPs). TFPs are important in my paper because they also lead to the re-allocation of resources across sectors. Most previous works estimate aggregate or manufacturing (industrial) TFPs (Bai and Zhang, 2015; Chen, 2011; Dong and Liang, 2013; Li and Zhu, 2005; Zhang and Shi, 2003), which reflects the focus of macroeconomic research on China, i.e., the manufacturing sector and misallocation within it (Chang et al., 2016; Hsieh and Song, 2016; Song et al., 2011). One reason

¹In their paper, land investment and non-land investment are distinguished, and a negative relationship between commercial land price and firms' non-land investment is found. Their non-land investment corresponds to the (capital) investment in my paper.

²Residential land and industrial land do not have this effect. This is one of the reasons why I focus on commercial land prices in this paper. Also, industrial land's price is often intentionally depressed by local governments to attract investment.

for this focus is the availability of both micro and macro data for the manufacturing instead of the service sector. However, at a point when manufacturing shrinks to less than 33% of the total GDP while the service sector counts for more than 50%, the importance of the service sector on the aggregate economy is worth attention. This motivates my study of the re-allocation between the manufacturing and service sectors. [Cheng \(2003\)](#), [Yang \(2008\)](#), and [Chen \(2011\)](#) study service sector's TFP in China. However, they do not look at the counterpart manufacturing TFP at the same time, and their TFP series are in annual frequency. Because China's macro time series is short, I need quarterly data to derive useful results. Thus, I construct the quarterly fixed asset investment (FAI) for both the manufacturing and the service sectors, based on which I estimate the factor income shares and TFPs for both sectors.

Finally, my paper is related to recent works on China's real estate and land prices. [Fang, Gu, Xiong, and Zhou \(2016\)](#) used a comprehensive data set of mortgage loans issued by major Chinese commercial banks to evaluate the risk in China's housing market. [Cai, Wang, and Zhang \(2016\)](#) studies the implementation of land use regulations in urban China, particularly the floor-to-area ratio (FAR) regulations. [Glaeser, Huang, Ma, and Shleifer \(2017\)](#) compares the housing booms in China and in the US from various aspects. They conclude that whether the housing market in China crashes or not depends on how the Chinese government reacts. [Du and Peiser \(2014\)](#) studies the supply side of the land. In particular, they focus on the land hoarding behavior of China's local governments.

The paper is organized as follows. [Section 2](#) introduces the construction of China's quarterly (commercial) land price series. In this section, I document the negative correlation between land price and investment, and show this negative correlation is associated with movements in China's export value. [Section 3](#) describes the real business cycle model with two sectors, followed by [Section 4](#), where efforts on estimating sectoral TFPs are shown. [Section 5](#) describes the calibration of the model and discusses the results, including possible explanations for unmatched moments. In [Section 6](#), I extend the model to include two different types of capital adjustment costs and briefly discuss their effects. [Section 7](#) concludes the paper.

2 Land Price, Investment, and Export in China

In this section, evidence of a negative correlation between real (commercial) land price and investment is documented. First, I introduce the quarterly land price series of China based on land transactions from 2005 to 2015, as well as the export value data. Second, I show that the real land price and capital investment are negatively correlated on both the aggregate and the province level.

Third, I show this negative correlation may be caused by a third factor, the export demand from the outside world.

2.1 Transaction-Based Commercial Land Price Series of China

Since 2004, the Ministry of Land and Resources of China (MLR) publishes quarterly commercial land prices of 35 major cities (CEIC ticker CRKAMRG). However, these prices are much higher than the nation-wide average (more than four times the prices I found in nation-wide transactions) and doubled suddenly in 2008. In the third quarter of 2008, the MLR expanded the land price monitoring cities from 35 to 105 (CEIC ticker CRKAMA). Nonetheless, the prices published are still higher than the national average, and the sequence is too short for quantitative analysis. What is worse, it is hard to argue that evidence found using data after 2008 are not due to the financial crisis. Besides the official data, the Wharton/NUS/Tsinghua Chinese Residential Land Price Indexes (CRLPI) reports real residential land price indexes with high quality (Wu et al., 2012). Their price indexes, however, again only covers 35 major cities and are of residential lands.

As a result, I constructed quarterly commercial land prices from the public land transaction database online.³ This database is so far the most frequently used and completest record of land transactions in China.⁴ I hand-collected more than 64,470 land transactions (including bid invitation, auction, or listing for sale) in 2,708 counties from 2005 to 2016 from the online database. For each land transaction entry, there is information on land transaction date, value, area, sale type⁵, and the type of land⁶. I calculated the price of each transaction as the ratio of its land transaction value over its area. The top and bottom 0.5% transactions regarding price were dropped to exclude outliers due to input errors when uploaded online.

I divided each quarters' total land sale value by total land sale area to construct the nominal quarterly land price series in Yuan/Square meters. The series is then deflated using China's quarterly GDP deflator from the database "China's Macroeconomy: Time Series Data" (CMTSD) of FRB of Atlanta maintained by Chang, Chen, Waggoner, and Zha (2016).⁷ Finally, the series is seasonally adjusted to obtain the real commercial land price series $Land\ price_{y,q}$.⁸

³www.landchina.com

⁴Other sources include <http://land.fang.com/>, etc.

⁵Bid invitation, auction, or listing.

⁶Manufacturing, commercial, transportation, or residential, etc.

⁷<https://www.frbatlanta.org/cqer/research/china-macroeconomy.aspx?panel=1>, version September 17, 2016.

⁸I used SAS procedure "proc X12", which was applied to other seasonal adjustments in this paper.

2.2 China's Export Value Index Series

Since 2005, China's General Administration of Customs publishes monthly year-on-year export value, quantity, and price indexes of the manufacturing sector, $ExV_{yoy, y, m}$ (CEIC tickers *CJAOXV*, *CJAOXT*, and *CJAOXR*).⁹ Besides, month-to-month indexes can be found for (and only for) 2006, $ExV_{mom, 2006, m}$.^{10,11} These indexes are Fisher indexes, so multiplicity can only be applied to value indexes instead of quantity and price indexes.

Firstly, I multiplied month-to-month value indexes to obtain the monthly value indexes of 2006, $ExV_{2006, m, M}$.

$$ExV_{2006, m, M} = \frac{ExV_{mom, 2006, m} * ExV_{mom, 2006, m-1}}{100} \quad \forall m = 2, \dots, 12 \quad (1)$$

Then the year-on-year value indexes allow me to further construct the whole monthly series of export value index from 2005 to 2015, $ExV_{y, m, M}$.

$$ExV_{2005, m, M} = \frac{ExV_{2006, m, M}}{ExV_{yoy, 2006, m} * 100} \quad \forall m = 1, \dots, 12 \quad (2)$$

$$ExV_{y, m, M} = \frac{ExV_{yoy, y, m} * ExV_{y-1, m, M}}{100} \quad \forall y \geq 2007 \ \& \ m = 1, \dots, 12 \quad (3)$$

Quarterly export value indexes $ExV_{y, q, Q}$ are the last month's monthly indexes of each quarter, i.e.

$$ExV_{y, q, Q} = ExV_{y, (3*q), M} \quad (4)$$

As all the value indexes are in US dollars, the quarterly indexes are multiplied by the quarterly US Dollar/Chinese Yuan exchange rate, deflated by the GDP deflator, and seasonally adjusted to obtain the real quarterly export value indexes $Export\ value_{y, q, Q}$.

2.3 Real Land Price and Investment in China

The aggregate investment series I use also comes from the CMTSD, which has already been seasonally adjusted. The quarterly nominal gross fixed capital formation (NGFCF) for state-

⁹The same month of last year=100.

¹⁰Last month=100.

¹¹2006 "China's External Trade Indices Monthly" journal published by China's General Administration of Customs.

owned enterprises (SOE) excluding government, private enterprises, and other non-SOE enterprises (CMTSD tickers *NominalSOEexGovtGFCF*, *NominalPrivGFCF*, and *NominalNonSOEGFCF*) are added up to construct the nominal quarterly aggregate investment series $NomInv_{y,q}$. The series is then deflated using the GFCF price index (CMTSD ticker *GFCFPriceIndex*) to obtain the real quarterly aggregate investment series $Investment_{y,q}$ from 2005 to 2015.

In Table 1, OLS regression results further show that land price and investment moves in opposite directions in China. A one percent increase in real land price is associated with a 0.0898 percent decrease in aggregate real investment (column 1). The result is robust to controlling for the four trillion yuan stimulus package from 2009 to 2011 by the Chinese government in response to the 2008 crisis (column 2).

Table 1: Real Land Price and Investment in China

Dependent Variables	(1) Investment	(2) Investment
<i>Land price</i>	-0.0898** (0.0347)	-0.0931*** (0.0246)
<i>Crisis dummy</i>		0.0555*** (0.00897)
Observations	40	40
R-squared	0.150	0.582

Notes: Data are quarterly from 2006 to 2015. The dependent variables are investment (real capital formation). *Land price* is the commercial land price deflated by the GDP deflator. *Crisis dummy* is equal to 1 from 2009Q1 to 2011Q4 and 0 otherwise, which controls for the four trillion yuan stimulus package from 2009 to 2011 by the Chinese government after the 2008 crisis. Both *investment* and *Land price* are logged and hp-filtered. Standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

2.4 Export, Service Employment, Land Price, and Investment

In Table 2, OLS regression results reveal the relationships among export value, service employment share, land price, and investment. Columns (1) and (2) show that a one percent increase in service employment share is associated with an 11.8 percent increase in real commercial land price and a 1.8 percent decrease in real aggregate investment. A one percent increase in the real export value index, on the other hand, is associated with a 4.3 percent decrease in service employment share, which column (3) indicates. Finally, columns (4) and (5) show that the direct correlation between real export value and real investment is positive, while the correlation between export value and land price is negative.

Combining these results, I argue that the real export value increase leads to increased demand for manufacturing (industrial) goods¹² and decreased demand for services. As a result, resources such as labor move towards the manufacturing sector from the service sector. Because the commercial land is mainly used by the service sector, decreased demand for service goods and other inputs reduces the return to land, thus the land price. On the other hand, because the manufacturing sector is more capital intensive, higher demand and other inputs result in an increase in aggregate capital demand and investment. Vice versa, when the export value decreases.

Table 2: Export, Service Employment, Land Price, and Investment in China

Dependent Variables	(1) Land price	(2) Investment	(3) Service emp share	(4) Investment	(5) Land price
<i>Service emp share</i>	11.82*** (3.744)	-1.800*** (0.652)			
<i>Export value</i>			-0.0428*** (0.0112)	0.157* (0.0848)	-0.951** (0.431)
<i>Crisis dummy</i> ₁	0.0488 (0.0710)	0.0654*** (0.0104)		0.0620*** (0.0141)	
<i>Crisis dummy</i> ₂	-0.222** (0.0987)			0.0242 (0.0231)	-0.247** (0.112)
Observations	40	40	40	40	40
R-squared	0.247	0.520	0.278	0.471	0.116

Notes: Data are quarterly from 2006 to 2015. The dependent variables are investment (real gross capital formation), real commercial land price *Land price*, and the share of service employment in the total employment of service and manufacturing *Service emp share*. *Land price* is deflated by the GDP deflator. *Export value* is the export value deflated by the GDP deflator. *Crisis dummy*₁ is equal to 1 from 2009Q1 to 2011Q4 and 0 otherwise, which controls for the four trillion yuan stimulus package from 2009 to 2011 by the Chinese government after the 2008 crisis. *Crisis dummy*₂ equal to 1 from 2009Q1 to 2010Q4 and 0 otherwise to control for the unexpected land price drop in crisis. *investment*, *Land price*, and *Export value* are logged. All variables are hp-filtered. Standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table 3 further shows that the negative correlation between land price and investment also exists on the province level. Furthermore, export values and the share of manufacturing in production are still associated with the negative correlation. Column (1) shows that a 1 percent increase in commercial land price is associated with a -0.078 percent decrease in investment (real gross capital formation), which is close to that on the aggregate level. Columns (2) and (3) show that a 1 percent increase in the share of manufacturing GDP in total GDP (of service and manufacturing) is associated with a 0.5 percent increase in investment, and a -1.9 percent decrease in the land price. At the same time, columns (4) and (5) find that a 1 percent increase real export value is associated with 0.04 and 0.09 percent increases in manufacturing's GDP and FAI shares, respectively. Columns (2)

¹²Manufacturing is the major part of industrial, accounting for 80% of the total industrial GDP.

Table 3: Land Price, Investment, Manufacturing Share, and Export by Province

VARIABLES	(1) Investment	(2) Land price	(3) Investment	(4) $Share_{Man,GDP}$	(5) $Share_{Man,FAI}$	(6) Land price
<i>Land price</i>	-0.0777** (0.0333)					
$Share_{Man,GDP}$		-1.932*** (0.345)	0.523*** (0.139)			-3.393*** (0.518)
<i>Export value</i>				0.0467*** (0.0119)	0.0855* (0.0493)	
Observations	290	290	341	341	341	290
R-squared	0.919	0.108	0.908	0.561	0.310	
No. of province	30	30	31	31	31	30

Notes: Data are annual from 2006 to 2015 on the province level. The dependent variables are investment (real gross capital formation), real commercial land price *Land price*, the share of manufacturing GDP in the total GDP of service and manufacturing $Share_{Man,GDP}$, and the share of manufacturing FAI (fixed asset investment) in the total FAI of service and manufacturing $Share_{Man,FAI}$. *Export value* is the export value deflated by the GDP deflator. Column (6) instruments manufacturing's GDP share with the export value. All variables are logged. Standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

to (4) together indicate that rising export values are associated with a larger share of manufacturing in production, which in turn, relates to a rise in investment and a fall in the land price. Column (6) instruments manufacturing's GDP share with export value and find the negative correlation between land price and manufacturing's GDP share is more significant.

In this story, higher capital income share in the manufacturing than service sector is an important assumption. Besides, the TFP processes of the manufacturing and service sectors can themselves generate a similar result and can interact with the effect of a change in export value. Thus, it is important to seriously calibrate/estimate the capital income shares in the two sectors and their TFP processes. Work on these is introduced in the next section before going to the model economy.

3 The Benchmark Model

In this section, I present an RBC model with two sectors, manufacturing and service, to explain the negative comovement between real (commercial) land price and investment documented in the previous section.

3.1 Agents, Technology, and Markets

The model economy is composed of one representative household and two representative firms, one in the service sector (labeled as sector 1) and the other one in the manufacturing sector (labeled as sector 2). The representative household lives for infinite periods and consumes manufacturing goods x , service goods n , and imported goods f . manufacturing and imported goods are fully tradable, and service goods are fully non-tradable. Labor l is supplied by the household, who also decides the investment I and land supply L . The preference of the representative household is given by the period utility function

$$u(x, f, n, l) = \frac{\left\{ \left[b(x^a f^{1-a})^{-\mu} + (1-b)n^{-\mu} \right]^{-\frac{1}{\mu}} (T-l)\omega \right\}^{1-\gamma}}{1-\gamma} \quad (5)$$

where $\frac{1}{\gamma}$ is the inter-temporal elasticity of substitution in aggregate consumption, which is represented in the constant-elasticity-of-substitution (CES) form of x , n , and f . The elasticity of substitution between tradable and non-tradable goods is $1/(1+\mu)$, and the expenditure share of manufacturing goods in tradable goods is given by a . Leisure also enters utility, and ω governs the labor supply elasticity. $T = 24$ is the maximum hours that can be supplied as labor l .

The representative firms in the two sectors employ labor $l_{i=1,2}$ and rent capital $K_{i=1,2}$ from the representative household and maximize one-period profit. Both labor and capital are fully mobile across sectors. The manufacturing sector firm's problem is given by

$$\max_{K_2, l_2} P_x z_2 K_2^{\alpha_2} l_2^{1-\alpha_2} - r_K K_2 - w l_2 \quad (6)$$

where z_2 is the exogenous productivity process of the manufacturing sector and P_x is the exogenous manufacturing/export goods price. r_K and w are the interest rate of capital and wage on the market. Capital income share is given by α_2 .¹³

Compared to the manufacturing sector firm, the service sector firm also rents land L_d from the household besides capital and labor. Given the exogenous productivity process z_1 and endogenous service goods price P_n , its static problem is

$$\max_{K_1, l_1, L_d} P_n z_1 (K_1^{\alpha_1} l_1^{1-\alpha_1})^\phi L_d^{1-\phi} - r_K K_1 - w l_1 - r_L L_d \quad (7)$$

¹³Imported goods is used as the numeraire.

where land income share is $1 - \phi$ and the income share of capital in total income of capital and labor is α_1 . r_L is the land rental rate.

Denote $S = \{z_1, z_2, P_x\}$ as the collection of exogenous states revealed at the beginning of each period, the Bellman equation of the representative household is

$$U(S, L, K, k) = \max_{x, n, f, l, L', k'} (1 - \beta)u(x, f, n, l) + \beta \mathbb{E}_{S'|S} U(S', L', K', k') \quad (8)$$

s.t.

$$f + P_x x + P_L(L' - L) + P_n n + k' - (1 - \delta)K = wl + r_K k + r_L L + T_L \quad (9)$$

$$K' = G(S, K) \quad (10)$$

where β is the discount factor and P_L is the nominal price of land. T_L is the lump-sum transfer by the government by selling the lands to the household. I assume that the land stock sold by the government is a constant \bar{L} . As a result, $P_L(L' - L) = T_L = 0$ in equilibrium. $G(.,.)$ is the law of motion for aggregate capital.

The exogenous states S are governed by the following processes

$$\log(z'_1) = \rho_1 \log(z_1) + \sigma_1 \epsilon_1 \quad (11)$$

$$\log(z'_2) = \rho_2 \log(z_2) + \sigma_2 \epsilon_2 \quad (12)$$

$$\log(P'_x) = \rho_x \log(P_x) + \sigma_x \epsilon_x \quad (13)$$

where $\epsilon_1, \epsilon_2, \epsilon_x$ are exogenous shocks and $0 < |\rho_i| < 1 \quad \forall i \in \{1, 2, x\}$. Each of $\epsilon_1, \epsilon_2, \epsilon_x$ follows a $N(0, 1)$ distribution and they can be correlated contemporaneously.

Service goods is non-tradable, so its market clearing condition is

$$n = z_1 (K_1^{\alpha_1} l_1^{1-\alpha_1})^\phi L_d^{1-\phi} \quad (14)$$

manufacturing goods, on the other hand, not only supplies the domestic consumption x , but also get traded for imported goods $\bar{x} = f$. Finally, the physical capital investment also comes fully from

manufacturing goods.¹⁴ So when its market clears,

$$P_x x + P_x \bar{x} + K' - (1 - \delta)K = P_x z_2 K_2^{\alpha_2} l_2^{1-\alpha_2} \quad (15)$$

where $f = P_x \bar{x}$.

Capital and labor market clearing yields

$$K_1 + K_2 = K \quad (16)$$

$$l_1 + l_2 = l \quad (17)$$

Government sells land to the representative household, who then rents the land to service sector firm. So we have two market clearing conditions for the land.

$$L_d = L \quad (18)$$

$$L = \bar{L} \quad (19)$$

3.2 Equilibrium and Characterization

With the economy environment and market clearing conditions introduced above, I can define the recursive competitive equilibrium (RCE) of this economy as

Definition 1. A recursive competitive equilibrium is a value function $U(S, P_x, L, K, k)$ and policy functions $x(S, L, K, k)$, $n(S, L, K, k)$, $f(S, L, K, k)$, $l(S, L, K, k)$, $L'(S, L, K, k)$, $k'(S, L, K, k)$ for the representative household, and $\{K_i(S, L, K, k)\}_{i=1,2}$, $\{l_i(S, L, K, k)\}_{i=1,2}$ and $L_d(S, L, K, k)$ for the firms, and prices (P_n, w, r_k, r_L, P_L) such that:

1. Given S and (P_n, w, r_k, r_L, P_L) , U solves the household Bellman equation (8) and x , f , n , l , K' , L' are the optimal policy functions.
2. Given S and (w, r_k, r_L) , K_1 , l_1 , L_d satisfies the services firm's FOC, and K_2 , l_2 satisfies the goods firm's FOC.
3. All goods and factor markets clear, i.e., equations (14) to (19) hold.

¹⁴Here I assume the current account surplus is always zero.

4. The law of motion for capital is consistent with household's capital choice policy function, i.e.

$$k'(S, L, K, K) = G(S, K) \quad (20)$$

Denote λ as the multiplier for the representative household's budget constraint (equation (9)) and

$$\mathbb{M} = (1 - \beta) \left\{ \left[b(x^a f^{1-a})^{-\mu} + (1 - b)n^{-\mu} \right]^{-\frac{1}{\mu}} (T - l)^\omega \right\}^{1-\gamma} \quad (21)$$

then the household's first order conditions are

$$x: \quad \mathbb{M} a b f^{(a-1)\mu} x^{-a\mu-1} = \lambda P_x \left[b(x^a f^{1-a})^{-\mu} + (1 - b)n^{-\mu} \right] \quad (22)$$

$$n: \quad \mathbb{M} (1 - b) n^{-\mu-1} = \lambda P_n \left[b(x^a f^{1-a})^{-\mu} + (1 - b)n^{-\mu} \right] \quad (23)$$

$$l: \quad \mathbb{M} \omega = \lambda w (T - l) \quad (24)$$

$$f: \quad \mathbb{M} (1 - a) b f^{(a-1)\mu-1} x^{-a\mu} = \lambda \left[b(x^a f^{1-a})^{-\mu} + (1 - b)n^{-\mu} \right] \quad (25)$$

$$K': \quad \lambda = \beta \mathbb{E}_{S'|S} \lambda' \left[r^{K'} + 1 - \delta \right] \quad (26)$$

$$L': \quad \lambda P_L = \beta \mathbb{E}_{S'|S} \lambda' \left[r^{L'} + P^{L'} \right] \quad (27)$$

Representative firms' first order conditions are

$$K_1: \quad r^K = P_n z_1 \phi \alpha_1 K_1^{-1} \left[K_1^{\alpha_1} l_1^{1-\alpha_1} \right]^\phi L^{1-\phi} \quad (28)$$

$$l: \quad w = P_n z_1 \phi (1 - \alpha_1) l_1^{-1} \left[K_1^{\alpha_1} l_1^{1-\alpha_1} \right]^\phi L^{1-\phi} \quad (29)$$

$$L: \quad r^L = P_n z_1 (1 - \phi) \left[K_1^{\alpha_1} l_1^{1-\alpha_1} \right]^\phi L^{-\phi} \quad (30)$$

$$K_2 : \quad r^K = P_x z_2 \alpha_2 K_2^{\alpha_2 - 1} l_2^{1 - \alpha_2} \quad (31)$$

$$l_2 : \quad w = P_x z_2 (1 - \alpha_2) K_2^{\alpha_2} l_2^{-\alpha_2} \quad (32)$$

Besides, I define the aggregate price level as

$$P_A = \left[b^{\frac{1}{1+\mu}} \left(\frac{P_x^a}{a^a (1-a)^{1-a}} \right)^{\frac{\mu}{1+\mu}} + (1-b)^{\frac{1}{1+\mu}} P_n^{\frac{\mu}{1+\mu}} \right]^{\frac{\mu+1}{\mu}} \quad (33)$$

4 Capital Income Shares and TFP Processes by Industry

Capital income shares and quarterly TFP processes of the manufacturing and service sectors, especially the covariance matrix of shocks to industrial TFP and export price are critical to the results. Thus, a reliable way to calibrate or estimate the capital income shares, as well as the TFPs by industry, is needed. In China, there is more available data for the industrial sector than manufacturing, and the production of manufacturing goods is closer to other industrial goods share than to service goods. As a result, I calibrate the TFPs and factor income shares of the industrial sector and use them for the manufacturing sector. The largest strand of literature on China's TFPs focus on the aggregate level (Bai and Zhang, 2015; Dong and Liang, 2013; Guo and Jia, 2005; Li and Zeng, 2009; Zhang and Shi, 2003). On the other hand, there are a few papers on industry-level TFPs. Li and Zhu (2005) and Chen (2011) calculate the TFPs of sub-industrial sectors. Cheng (2003), Yang (2008), and Chen (2011) study the service or service sub-industrial TFPs. However, only a few papers look into the relationship between industrial and service TFPs in China using comparable data. An early paper by Guo (1992) calculated simultaneously the TFPs of the primary (agriculture), secondary (industrial and construction), and tertiary (broad definition of service) industries. Ren and Sun (2009) used the input-output table published every three to five years to construct the industry-level TFPs on a lower frequency. However, none of these works provide quarterly TFP series, not to mention comparable quarterly industrial vs service TFP processes.

In order to calculate quarterly TFP series, quarterly capital stock and employment series of industrial and service sectors are needed. Due to limited availability of data in China, assumptions are made along the road. In the remaining parts of the section, I will first talk about the annual and quarterly FAI series by industry. Then, with the industry-specific FAI depreciation values in input-output tables of 2005 and 2007, I can calculate the industry-specific depreciation rates as well as the FAI stocks by industry. Next, with industry-specific labor income shares pinned down

by the average proportion of remuneration of employee in value-added in 2002, 2007, 2010, and 2012's input-output table, capital and commercial land income shares are estimated, and quarterly industrial and service sector TFP series are constructed. Finally, $AR(1)$ processes, as well as the covariance matrix of the residuals corresponding to the model, are estimated for the two TFP series.

4.1 Fixed Asset Investment by Industry

The National Bureau of Statistics of China (NBS) started publishing annual FAI by industry in 2003 (CEIC tickers *COMA* and *COCBMR-COCBNB*). I classify aggregate FAI into seven industries, agriculture, industrial (mining, manufacturing, and electricity, gas & water production and supply), construction, real estate, financial intermediation, transport, storage, and postal service, and service.¹⁵ And I focus on the industrial and service industries, which correspond to the two sectors in my model.

In terms of quarterly FAIs by industry, the NBS published ytd monthly urban (non-farm) FAI by industry since 1996. And most industry-level data I need started in 2004. Annual rural (and rural farm) FAIs by industry can also be found until 2015.¹⁶ Using ytd monthly series, quarterly urban (non-farm) FAIs can be calculated as follows

$$FAI_{urban, i, y, q} = FAI_{urban, i, ytd, y, 3*q} \quad \forall i, y, \text{ and } q \quad (34)$$

where $FAI_{urban, i, y, 3q}$ is the urban (non-farm) FAI of industry i in the $(3 * q)^{th}$ month of year y , and $FAI_{urban, i, y, q}$ is the urban (non-farm) FAI of industry i in the q^{th} quarter of year y . Then, I assume for each industry, urban (non-farm) and rural (farm) FAIs have the same quarterly fluctuations within a year. Thus, I interpolate the annual total FAIs $FAI_{i, y}$ using $FAI_{urban, i, y, q}$ to construct the quarterly FAI series by industry $FAI_{i, y, q}$.

$$FAI_{i, y, q} = FAI_{i, y, 4} * \frac{FAI_{urban, i, y, q}}{FAI_{urban, i, y, 4}} \quad \forall i, y, \text{ and } q \quad (35)$$

¹⁵The reason why I separate transport, storage and postal service from service is that the former uses special lands rather than commercial lands and is far more capital-intensive than normal service.

¹⁶Before 2011, the ytd monthly FAI series published by the NBS include only urban units. Since 2011, these ytd monthly FAI series include both urban units and rural non-farm households, which are essentially the non-farm FAIs. As a result, since 2011, rural farm rather than rural FAIs by industry should be added to the non-farm FAIs to obtain the total FAI series by industry.

4.2 Fixed Asset Stock by Industry

As an important variable for empiric works, the capital stock of China has been calculated by many, and most of them are on the aggregate or provincial capital stock (Chow, 1993; Shan, 2008; Zhang and Zhang, 2003). Xu, Zhou, and Shu (2007) estimated the fixed capital stock by industry (primary, secondary, and tertiary) and province from 1978 to 2002. However, annual fixed capital formation by province and industry they used are no longer published after 2002. Yang (2008), Xu, Duan, and Yang (2010), and Xue and Wang (2007) calculated the capital stock series of China's service industry, sub-industrial sectors, and 17 industries including services respectively. All of these papers research annual capital stocks because they focus on a longer horizon and early years when quarterly investment series by industry are not available.

Almost all of the papers in this literature adopt the perpetual inventory method (PIM), which is used by the OECD to measure capital. The basic idea is that capital stock in period t

$$K_t = I_t + (1 - \delta_t)K_{t-1} \quad (36)$$

where I_t and δ_t are the investment and capital depreciation rate in period t . My paper follows this routine along the calculation.

In the method of PIM, capital stock in the base year and capital depreciation rates can greatly affect the results. Many papers use 1952 as the base year. Chow (1993) estimated non-farm capital stock in 1952 to be 58.267 billion yuan, and total capital stock to be 175 billion yuan (at the price of 1952). Zhang and Zhang (2003) used industrial firms' data and Shanghai's FAI price index to calculate capital stock to be 80 billion yuan (at the price of 1952). The disagreement among researches on the base year capital stock is mainly due to their different definitions of capital and investment. Chow (1993) used the "accumulation" goods in the material product system (MPS) as the capital. Zhang and Zhang (2003) e.t.c used gross fixed capital formation (GFCF), and Huang and Ren (2002) e.t.c used fixed asset. According to the NBS, the major difference between GFCF and FAI related to my paper is that FAI includes the purchasing fees of land use right, old buildings, and old equipment and instruments while GFCF does not. The focus period of my paper is 2005-2015 when fixed capital formation data was no longer published, and only FAI data is available. Thus, whatever definition I use for and whatever method I use to adjust capital/investment data, the source could only be FAI data. As a result, I stick to FAI data first to be consistent with the FAI price index and the depreciation of fixed asset in the input-output tables I use. After constructing the quarterly series of fixed asset stock (FAS), I try to separate the (commercial) land use right purchase fees from the capital stock.

Besides the base year capital stock determination, the choice of capital depreciation rates also

worths serious consideration. The “accumulation” definition used by [Chow \(1993\)](#) already avoided the depreciation problem. [Wang and Fan \(2000\)](#) adopted an annual depreciation rate of 5% based on the GFCF definition. [Song, Liu, and Jiang \(2003\)](#) used the official nominal annual depreciation rate of 3.6% plus the economic growth rate as the annual capital depreciation rate. If the base year is 1952 and even if the base year capital stock is accurate, a small change in the depreciation rate can still lead to a huge difference in 2005’s FAS. The results can be even more controversial if different industries have different capital depreciation rates and we care about their individual capital stocks. To minimize the effects of base year FAS and depreciation rates, I use data around my base year 2005 and allows depreciation rates to be industry-specific and endogenous during the calculation following [Xu, Duan, and Yang \(2010\)](#) and [Xue and Wang \(2007\)](#). The idea is as follows.

The input-output tables of 2005 and 2007 published by the NBS include the depreciation of fixed asset $D_{i, 2005}$ and $D_{i, 2007}$ for each industry i . Denote $\delta_{i, t, A}$ as the annual fixed asset depreciation rate of industry i in year t and $P_{FAI, t, A}$ the FAI price index of year t .¹⁷ Then the FAS of industry i at the end of 2004 and 2006 are

$$FAS_{i, 2004} = \frac{D_{i, 2005}}{P_{FAI, 2005, A} * \delta_{i, 2005, A}} \quad (37)$$

$$FAS_{i, 2006} = \frac{D_{2007}}{P_{FAI, 2007, A} * \delta_{i, 2007, A}} \quad (38)$$

Further denote $\psi_{i, t, A} = 1 - \delta_{i, t, A}$, according to the PIM,

$$\frac{D_{i, 2007}}{P_{FAI, 2007, A} * \delta_{i, 2007, A}} = FAS_{i, 2006} = \frac{FAI_{i, 2006}}{P_{FAI, 2006, A}} + \psi_{i, 2006, A} \left[\frac{FAI_{i, 2005}}{P_{FAI, 2005, A}} + \psi_{i, 2005, A} \frac{D_{2005, i}}{P_{FAI, 2005, A} * \delta_{2005, i, A}} \right] \quad (39)$$

Assume $\delta_{i, t, A} = \tilde{\delta}_{i, A}$ is a constant from 2005 to 2007 for each industry i and so does $\tilde{\psi}_{i, A} = 1 - \tilde{\delta}_{i, A}$. With the annual FAI series mentioned above, we can solve for the industry-specific annual fixed asset depreciation rates $\tilde{\delta}_{i, A}$,¹⁸ which are around 0.0661 for the industrial sector and 0.051 for service. Then the FAS of industry i at the end of my base year 2004 can be calculated.¹⁹

Next, with the quarterly FAI series by industry $FAI_{i, y, q}$ constructed above and quarterly FAI

¹⁷I normalize the FAI price index of 2004 to be 1.

¹⁸There are multiple roots of each of the functions and we take the real root which is between 0 and 1.

¹⁹I use the same method as above to calculate the depreciation rates of 2008-2010 and 2011-2012 with input-ouput tables of 2007, 2010, and 2012, assuming constant depreciation rates in these two periods. I use the 2008-2010 depreciation rates for this period and the 2011-2012 depreciation rates for 2011 and on.

price index series $P_{FAI, y, q}$ published by the NBS,²⁰ quarterly FAS by industry from 2005 to 2015 can be recursively calculated as²¹

$$FAS_{i, y, q} = \frac{FAI_{i, y, q}}{P_{FAI, y, q}} + (1 - \tilde{\delta}_{i, Q})FAS_{i, y, q-1} \quad (40)$$

where I assume FAS depreciates evenly in each quarter of a year, i.e. $\tilde{\delta}_{i, Q} = \frac{\tilde{\delta}_{i, A}}{4} \quad \forall i$.

4.3 Employment by Industry

The NBS publishes annual employment of primary, secondary, and tertiary industries (CEIC tickers *CGAJAV-CGAJAX*)²² since 1952 ($L_{pri, y, 4}$, $L_{sec, y, 4}$, and $L_{ter, y, 4}$), as well as quarterly urban non-private employment by industry (CEIC tickers *CGBB-CGBL* and *CGAIFE*) since 1994 ($L_{urban_non_private, i, y, 4}$). The Ministry of Human Resources and Social Security of the PRC reports annual employment of private enterprise and self-employed individual by industry (CEIC tickers *CGCJBP-CGCJBV*) since 1993 ($L_{private, i, y, 4}$). For the secondary industry, the sum of annual private enterprise and self-employed individual and urban non-private employment accounts for 46%-68% of the total employment, and this proportion is even higher for the tertiary industry, which is around 54%-92%.²³

For each of the primary, secondary, and tertiary industries, I first interpolate the annual (end of year) employment with the sum of of annual private enterprise and self-employed individual and urban non-private employment of the seven industries to obtain the fourth quarter employment by industry from 2005-2015.

$\forall y$ and $i \in \{\text{secondary industries}\}$

$$L_{i, y, 4} = L_{sec, y, 4} * \frac{L_{urban_non_private, i, y, 4} + L_{private, i, y, 4}}{\sum_{i \in \{\text{secondary industries}\}} (L_{urban_non_private, i, y, 4} + L_{private, i, y, 4})} \quad (41)$$

$\forall y$ and $i \in \{\text{tertiary industries}\}$

$$L_{i, y, 4} = L_{ter, y, 4} * \frac{L_{urban_non_private, i, y, 4} + L_{private, i, y, 4}}{\sum_{i \in \{\text{tertiary industries}\}} (L_{urban_non_private, i, y, 4} + L_{private, i, y, 4})} \quad (42)$$

Then for each industry and each quarter within a year, I assume the economy-wide quarterly

²⁰I normalize the FAI weighted quarterly FAI price index of 2004 to be 1.

²¹ $FAS_{i, 2005, 1} = \frac{FAI_{i, 2005, 1}}{P_{FAI, y, 1}} + (1 - \tilde{\delta}_{i, Q})FAS_{i, 2004}$ and $FAS_{i, y, 1} = \frac{FAI_{i, y, 1}}{P_{FAI, y, 1}} + (1 - \tilde{\delta}_{i, Q})FAS_{i, y-1, 4}$ for the first quarter of each year.

²²End of year number, the same for annual employment of private enterprise and self-employed individual.

²³Both proportions increase with year.

employment as a proportion of the fourth quarter employment is the same as that of urban non-private employment. With this assumption, I construct the quarterly employment series by industry.

$$L_{i, y, q} = L_{i, y, 4} * \frac{L_{urban_non_private, i, y, q}}{L_{urban_non_private, i, y, 4}} \quad \forall i, y, \text{ and } q \quad (43)$$

4.4 Factor Income Shares and TFP Processes

Capital income shares and the two TFP processes can greatly influence the relationship between aggregate investment and the land price which is used by the service industry only. However, as we mentioned above, the available data for capital, the FAI, is different from GFCF in land purchasing fees. As a result, I need to infer the capital income share in the service sector indirectly.²⁴

The input-output tables of 2005, 2007, 2010, and 2012 include remuneration of employee for each industry, the average of which as a proportion of value-added are used to pin down the industry-specific labor income shares, $(1 - \alpha_1)\phi = 0.505$ and $1 - \alpha_2 = 0.342$. For the industrial sector, as I assume constant return to scale production function, the capital income share is just α_2 . Then the quarterly log TFP for the industrial sector can be calculated as

$$\log(TFP_{ind, y, q}) = \log(RGDP_{ind, y, q}) - 0.658 * \log(FAS_{ind, y, q}) - 0.342 * \log(L_{ind, y, q}) \quad (44)$$

Here I use the Producer Price Index (PPI) to deflate the nominal GDP of the industrial sector.²⁵

For the service industry, I only have FAS series which include both the purchasing fees of commercial lands and capital. Besides, a subset of quarterly nation-wide of commercial land values can be constructed from the land transaction data. As massive commercial land transactions started in 2002 after the government of China required all commercial lands to be publicly traded through bid invitation, auction, and listing. Transactions before 2002 are negligible compared to those after 2002. I assume that commercial land purchase fees started in 2002 and the quarterly purchasing values of commercial lands by service industry units as a proportion of total quarterly purchasing values of commercial lands is a constant. I further assume that the quarterly purchasing values of commercial lands in my land transaction sample is also a constant proportion of nation-wide quarterly purchasing values of commercial lands. I use an endogenous scalar m to adjust the quarterly purchasing values of commercial lands by service industry units, i.e., capital stock of the

²⁴Industrial land prices are much lower than those of commercial lands and not the focus of my paper. Thus, I treat industrial lands as part of the capital (FAS) of the industrial sector, i.e., capital stock of the industrial sector $KS_{ind, y, q} = FAS_{ind, y, q}$

²⁵The NBS publishes monthly PPI (previous month=100) since 2003. I construct monthly industrial sector price index as $P_{ind, y, m, M} = \frac{PPI_{y, m} * P_{ind, y, m-1, M}}{100}$ or $P_{ind, y, 1, M} = \frac{PPI_{y, 1} * P_{ind, y-1, 12, M}}{100}$. Quarterly industrial sector price index is then $P_{ind, y, q, Q} = P_{ind, y, (3*q), M}$.

service industry

$$KS_{ser, y, q} = FAS_{ind, y, q} - m * \sum_{t_y=2002, t_q=1}^{y, q} \frac{NomComLanVal_{t_y, t_q}}{P_{FAI, t_y, t_q}} \quad \forall i, y, \text{ and } q \quad (45)$$

where $NomComLanVal_{t_y, t_q}$ of quarter t_q , year t_y in my land transaction sample. Its value is adjusted by P_{FAI, t_y, t_q} because when the transaction happens, it is counted as FAI.

In order to calculate the TFP of the service industry, I also need to know the total areas of commercial land in the country, about which there is no official data at all.²⁶ As a result, I have to use the construction land areas by annual survey to I for the commercial land areas.²⁷ I assume the construction land areas increase evenly within a year and thus constructed the quarterly construction land area $Land_{con, y, q}$. Given the scalar m , I run the following regression²⁸

$$\log(RGDP_{ser, y, q}) = \alpha + \beta_K \log(KS_{ser, y, q}) + \beta_L \log(L_{ser, y, q}) + \beta_{Land} \log(Land_{con, y, q}) + \epsilon_{y, q} \quad (46)$$

I adjust the scalar m carefully until $\beta_L = 0.5053$, i.e., the labor income share is anchored by the remuneration of employee as a percentage of value-added in the service industry. Capital income share of the service industry is then $\alpha_1 \phi = 0.2666$ according to the regression result. Commercial land income share is then $1 - \phi = 1 - 0.5053 - 0.2666 = 0.2281$.²⁹ The quarterly log TFP for the service industry is

$$\log(TFP_{ser, y, q}) = \log(RGDP_{ser, y, q}) - \hat{\beta}_K \log(KS_{ser, y, q}) - \hat{\beta}_L \log(L_{ser, y, q}) - \hat{\beta}_{Land} \log(Land_{con, y, q}) \quad (47)$$

Lastly, I seasonally adjusted and hfiltered $\log(TFP_{ser, y, q})$ and $\log(TFP_{ind, y, q})$ and fit the cyclical part of each process $\log(TFP_{ser, y, q})_{cyclical}$ and $\log(TFP_{ind, y, q})_{cyclical}$ independently using $AR(1)$.³⁰ I did the same with $\log(Rep_{y, q, Q})$,³¹ which I used as a proxy for export price because no price data are available. The residuals of $AR(1)$ processes of $\log(TFP_{ind, y, q})_{cyclical}$

²⁶Commerical lands purchased after 2002 are only a small part of the total stock of commerical lands, most of which were allocated to firms by the government for free before 2002.

²⁷Commercial land is one type of constuction land.

²⁸Service industry GDP is deflated using GDP deflator.

²⁹The final choice of m is 0.603424, corresponding to an average commerical land value proportion in FAS of 36.85%.

³⁰The SAS Proc "X12" cannot deal with negative values, so I seasonally adjusted $TFP_{ser, y, q}$ and $TFP_{ind, y, q}$ first, and then take logs.

³¹The construction of $\log(Rep_{y, q, Q})$ is the same as how I construct $\log(Rev_{y, q, Q})$ before. I used it for calibration because no other export price data are available. However, in the evidence part, I insisted on $\log(Rev_{y, q, Q})$ because it is the only Fisher index I can apply multiplicity to.

and $\log(RExP_{y, q, Q})_{cyclical}$ has a coefficient matrix

$$\begin{bmatrix} 1.0000 & 0.0563 \\ 0.0563 & 1.0000 \end{bmatrix} \quad (48)$$

5 Calibration and Results of the Benchmark Model

After I described the model and defined the equilibrium, calibration is introduced in this section. Quantitative results of the benchmark model see a negative correlation between real commercial land price and investment following a positive export price shock. The most important though difficult part of calibration has been done in the last section. So in this section, I will just talk about the calibration and then present the results of the model. In particular, I provide explanations for unmatched moments, some of which are based on China's institutional background.

5.1 Calibration

Preferences. The discount factor β is set to 0.99 to match the quarterly real lending rate of 1%. [Ostry and Reinhart \(1992\)](#) estimated five Asian developing countries' intertemporal elasticity of substitution, which was robustly around 0.8. γ is chosen to match $1/\gamma = 0.8$. [Mendoza \(1995\)](#) estimated the elasticity of substitution between tradable and non-tradable goods, which was $1/(\mu + 1) = 0.74$ for industrialized countries. [Ostry and Reinhart \(1992\)](#), on the other hand, found that more industrialized developing countries have a lower elasticity of substitution. China, unlike the other developing countries, is highly industrialized. So I choose $\mu = 0.35$ of industrialized countries for China. The upbound of labor supply T is set to 24 (hours per day). The parameter governing the utility of leisure, ω is chosen such that in the steady state, 85 percent of time T is spent on working, i.e., $l_{ss}/T = 0.85$. The share of income spent on service goods, b is selected such that the steady-state ratio of manufacturing goods over service goods consumption matches the average ratio found in 2005-2012 input-output tables. The share of manufacturing goods consumption in manufacturing sector output, a is set to match the average ratio in 2005-2012 input-output tables.

Technologies. Capital depreciation rate δ is chosen as 0.25 such that the annual depreciation rate is 10 percent as in most literature. Parameters for TFP and export price processes $\{\rho_{i=1, 2, x}, \sigma_{i=1, 2, x}\}$ are estimated as introduced in [section 4](#). So are the factor income shares $\alpha_{i=1, 2}$ and ϕ . Steady state export price $P_{x, ss}$ is set to 1 as in [Mendoza \(1995\)](#). The calibrated values of all parameters can be found in [Table 4](#).

Table 4: Calibrated Parameter Values

Parameters	Values	Comments
β	0.99	Matches the quarterly real lending rate between 2005 and 2015.
γ	1.25	Ostry and Reinhart (1992) estimation for Asian developing countries.
μ	0.35	Mendoza(1995) for industrialized countries.
T	24	24 hours per day.
ω	0.111	Steady state $\frac{l}{T} = 0.85$ as in Mendoza(1995).
a	0.94	Steady state $\frac{\text{Manufacturing goods consumption}}{\text{Manufacturing sector output}}$ matches that in the data.
b	0.519	Steady state $\frac{\text{Manufacturing Goods Consumption}}{\text{Service Goods Consumption}}$ matches that in the data.
δ	0.025	Corresponds to annual depreciation rate of 10%.
ρ_x	0.798	AR(1) coefficient of log real export price index.
σ_x	0.0097	AR(1) standard error of log real export price index.
ρ_1	0.868	TFP processes estimated by me.
ρ_2	0.662	TFP processes estimated by me.
σ_1	0.0167	TFP processes estimated by me.
σ_2	0.0152	TFP processes estimated by me.
$\sigma_{2, x}$	0.0563	TFP processes estimated by me.
Steady state P_x	1	Following Mendoza(1995).
α_1	0.345	Matches services $\frac{\text{Remuneration of employee}}{\text{Value added}}$ given ϕ .
α_2	0.658	Matches goods $\frac{\text{Remuneration of employee}}{\text{Value added}}$.
ϕ	0.772	Factor income shares estimated by me.

5.2 Quantitative Results

Table 5 and Table 6 compare some of the Chinese sample's moments with those simulated by the benchmark model. The signs of simulated correlations of interest are all consistent with those in the sample. The correlation between log real investment and land price is -0.073 in the benchmark model, compared to -0.42 in the sample. Real land price is negatively correlated with the export price in the model as in the data, although the correlation is less negative in the model (-0.43 v.s. -0.63). The export price co-moves with real investment both in the model and in the data, though the correlation is higher in the model. One of the reasons is that I assume all manufacturing goods to be exportable.

In terms of the standard deviations, model-simulated series have higher standard deviations than those in the data except for the real land price. This can still be explained by my assumption of a fully tradable manufacturing sector. Despite their absolute sizes, the relative sizes of real service output, real manufacturing output, and real investment are similar in the model as in the data ($\{0.0144, 0.0268, 0.0403\}$ in the model vs. $\{0.0078, 0.0194, 0.0218\}$ in the data). The only

Table 5: Model's Standard Deviations and Correlations with Real Sectoral Outputs (Benchmark Model)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0144	-0.071	0.998
Real manufacturing Output	0.0268	0.963	0.198
Real Investment	0.0403	-	-0.0725
Real Land Price	0.0199	-0.0725	-
Export Price	0.0117	0.454	-0.434

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0$.

Table 6: Sample's Standard Deviations and Correlations with Real Sectoral Outputs: China 2005:1-2015:4

Variables	Standard Deviations	Correlation with Real Investment	Correlation with Real Land Price
Real Service Output	0.0078	0.185	-0.109
Real manufacturing Output	0.0194	0.476	-0.232
Real Investment	0.0218	-	-0.416
Real Land Price	0.153	-0.416	-
Export Price	0.0134	0.260	-0.628

Notes: All variables are logged and hp-filtered. Samples during crisis, i.e., 2009:1-2010:4 are dropped.

exception, the real land price, has a much higher standard deviation in the data. This can be partially blamed on a transaction-based land price series, which experiences a large variation in quarterly characteristics of land transacted.

Figure 2 plots impulse responses of different variables to a one standard deviation shock on the export price. A positive export price shock increases real aggregate investment and lowers real land prices. Opposite responses of sectoral outputs reveal the source of the negative correlation between investment and land price following the shock. Higher export price raises the demand for manufacturing goods and attracts resources from the service sector to the manufacturing sector, which is indicated by the falling service employment ratio. Thus, manufacturing output rises while service output drops. The demand for capital, which is more intensive in the manufacturing sector, goes up, and so does the aggregate investment. By contrast, the demand for commercial land, which is used only by the service sector contracts. Real land price declines as a result.

Following an export price shock, nominal return to the land and the nominal land price indeed

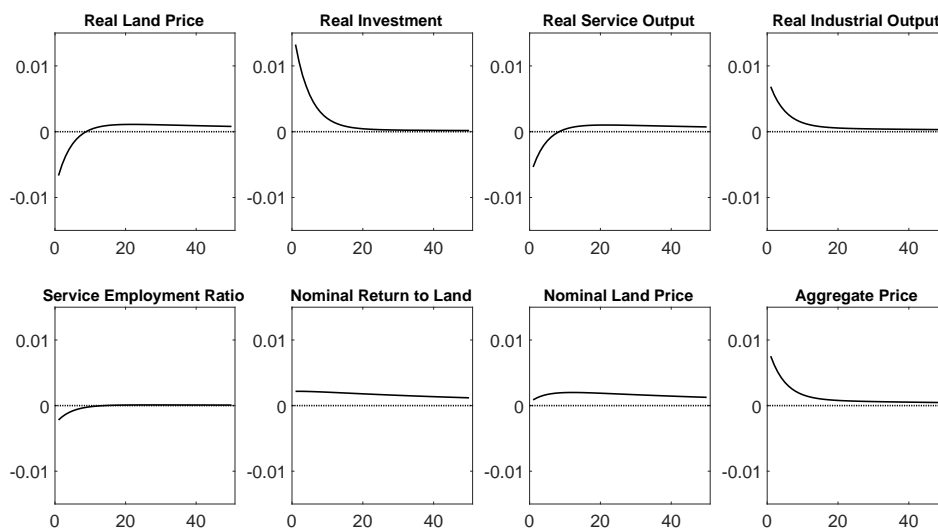


Figure 2: IRFs to an Export Price Shock in the Benchmark Model: I

Notes: The shock is a one standard-deviation shock. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$.

moves up a little bit thanks to a higher export price, which pushes up all the prices in the economy, including nominal wage and interest rate (Figure 3). However, aggregate price moves up by even more. As a result, real land price falls. Consumption of service goods decreases as expected because more resources are relocated to the manufacturing sector. What's a little bit surprising is that imported goods consumption does not increase much, even though fewer manufacturing goods are consumed. A higher relative price of export goods can partially explain it. A rising investment due to a larger manufacturing sector is the other reason.

Figure 4 rules out the possibility of a service sector TFP shock leading to negatively correlated land price and investment. A negative service sector TFP shock decreases not only the service sector output but also the demand for manufacturing goods. This negative effect on manufacturing goods is due to both an income effect and the complementarity between service and manufacturing goods.³² Consequently, investment in the manufacturing sector as well as the aggregate investment both fall in addition to the drop in the real land price.

Thus, it can be concluded that the export price (or at most the manufacturing TFP, which has a similar role of export price in the model) generates the negative correlation between real land price and real investment, while the TFP of the service sector cannot.

³²Remember the elasticity of substitution between service and non-service goods is $1/(1 + \mu) = 1/1.35 < 1$

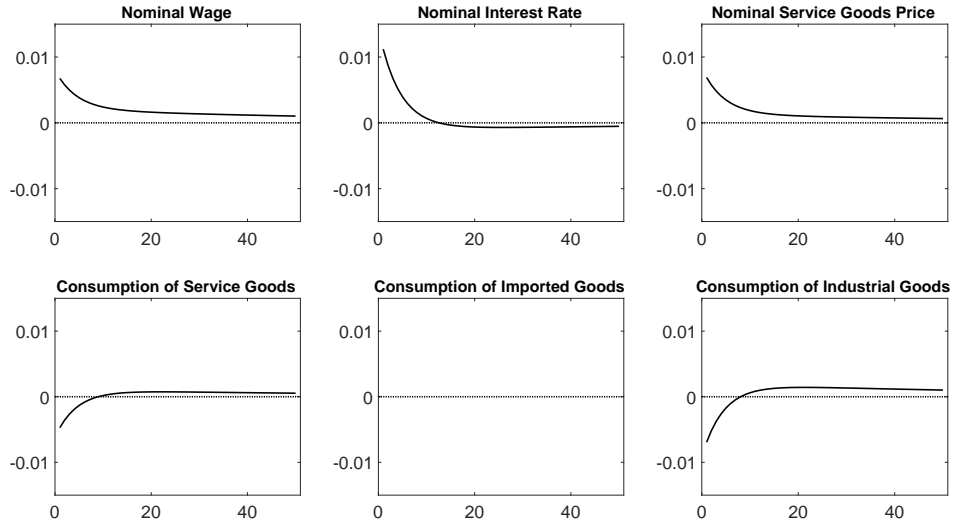


Figure 3: IRFs to an Export Price Shock in the Benchmark Model: II

Notes: The shock is a one standard-deviation shock. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.2666$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$.

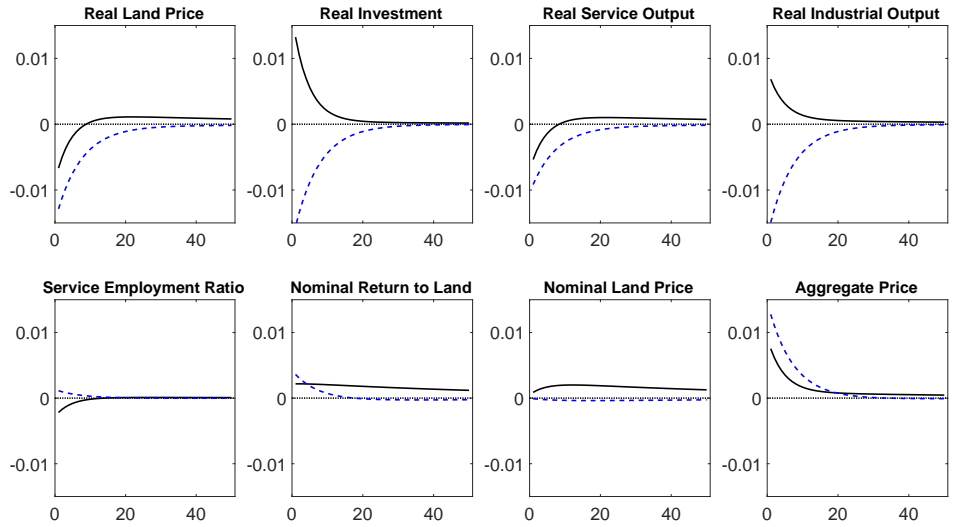


Figure 4: The Role of Service TFP Shock in the Benchmark Model

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price (negative service TFP) shock. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.2666$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$.

5.3 Discussions on Unmatched Moments

As noticed, there are several moments unmatched. The correlations between real service/manufacturing outputs and the real land price are both positive in the model (0.998 and 0.198) while both negative in the data (-0.109 and -0.232). Besides, the real service output and the investment co-move in the data with a correlation of 0.185 rather than a negative one as in the model (-0.071). The correlation between real manufacturing output and real investment is also much lower in the data (0.476) than in the model (0.963).

To figure out why these moments are not matched, I first admit the possibility of inaccurate calibration of the parameters and deviate from the benchmark parameter values to see whether they can improve the results. [Table 7](#) ([Table 8](#)) changes the correlation between sectoral TFP shocks from 0 to -0.3 (0.3). Negatively (positively) correlated sectoral TFPs move the returns to factors more intensively used by each sector in the opposite (same) directions. Thus, it is expected that with a correlation of -0.3 , real investment/export price and land price are more negatively correlated, and the correlations are closer to those in the data. However, the correlation between real service output and investment becomes even more negative in the model rather than positive in the data. On the other hand, if I instead assume positively correlated sectoral TFPs, real service output and investment can move in the same direction, but the correlations of interest, i.e., those between real investment/export price and land price become less negative (-0.403) or even positive (0.0494).

Table 7: Model’s Standard Deviations and Correlations with Real Sectoral Outputs (Benchmark Model, Negatively Correlated Sectoral TFPs)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0153	-0.207	0.998
Real manufacturing Output	0.0233	0.943	0.133
Real Investment	0.0360	-	-0.203
Real Land Price	0.0214	-0.203	-
Export Price	0.0117	0.414	-0.472

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.2666$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = -0.3 * \sigma_1 * \sigma_2$.

Next, I experiment with a higher capital income share in the service sector. When doing so, I leave the labor income shares in both sectors unchanged because the calibration of them deserves larger confidence. As a result, a larger capital income share (0.4) corresponds to a smaller land income share in the service sector (0.0948). Expectations are that real service output becomes more

Table 8: Model’s Standard Deviations and Correlations with Real Sectoral Outputs (Benchmark Model, Positively Correlated Sectoral TFPs)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0134	0.0536	0.998
Real manufacturing Output	0.0298	0.976	0.265
Real Investment	0.0442	-	0.0494
Real Land Price	0.0183	0.0494	-
Export Price	0.0117	0.507	-0.403

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.2666$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0.3 * \sigma_1 * \sigma_2$.

correlated with aggregate investment because the service sector demands higher investment now. Besides, shifting from the manufacturing sector to the service sector is not supposed to result in an as large decrease in aggregate investment as before due to a smaller gap between capital intensities in the two sectors. However, simulated results shown in [Table 9](#) are quite surprising. The results are similar to those with negatively correlated TFP shocks, i.e., smaller real investment/export price and land price correlations but a more negative real service output and investment correlation. These results have the same problems with those from negatively correlated TFP shocks. We can have either a closer service output and investment correlation to the data or closer real investment/export price and land price correlations, but not both. And the unexpected results here can only be understood if we look at the service sector output share in the steady state. The share shrinks from 0.466 to 0.382 with a larger capital income share. A smaller service sector means that this sector, as well as returns to factors intensively used by it, are under greater impact by the export/manufacturing goods price. As a result, though real investment does not increase as much as before following an export price shock, land price decreases more ([Figure 5](#)). Of course, 0.382 is unreasonably small compared to that in the data.

Changing key parameter values does not help much with the unmatched moments. Thus, there must be some missing structures leading to negatively correlated land price and sectoral outputs. Considering the fact that my model tells a totally demand-side story of the land, the supply-side effect, which is specific to China and Chinese institutions, can help with the results.

Land in China is owned by the state (government), central or local, who only sells or allocates the use rights of land to developers. In 2002, the Ministry of National Land and Resources required all land for private development³³ to be sold through public auctions after August 31, 2004.³⁴

³³e.g. business, tourism, entertainment, and commodity house

³⁴Public auctions include bid invitation, auction, and listing.

Table 9: Model’s Standard Deviations and Correlations with Real Sectoral Outputs (Benchmark Model, Higher Capital Income Share in Service)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.01329	-0.2	0.9955
Real manufacturing Output	0.02318	0.9567	0.0866
Real Investment	0.03606	-	-0.2045
Real Land Price	0.01913	-0.2045	-
Export Price	0.01169	0.4353	-0.5239

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.4$, land income share is $1 - \phi = 0.0948$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0$.

As a result, the government can greatly impact the supply of land and has the incentive to adjust land supply when needed just as it does to the investment. When GDP growth slows down, the government can intentionally support real estate price because it counts for a large share of GDP and is used as collateral by many firms.³⁵ One important and effective way is to reduce the supply of land to boost land and real estate price. Besides this, the government can use even more direct policy tools such as executive orders or interviews with real estate developers to temporarily prevent real estate price from falling.³⁶ This effect can alone explain why the outputs of both sectors are negatively correlated with real land prices. Vice versa, when housing prices grow too fast along with the economy, the central government implements various policies including higher downpayment ratios or purchasing restriction policies to curb the soaring prices.³⁷ And the correlation being larger (less negative) for the service sector is consistent with my benchmark model. Besides, this channel also makes real investment/export price and land price correlations more negative and closer to those in the data.

On the other hand, the unmatched real outputs and investment correlations can be blamed on another effective and frequently used countercyclical tool by the Chinese government, the government-led investment. One famous example is the four trillion yuan³⁸ stimulus package in response to the 2008 financial crisis. When the economy slows down, government-led investment protects the aggregate investment from dumping, which disconnects real investment and real

³⁵For example, in October 2008, the central government used a bunch of policy instruments to support real estate price.

³⁶This information came from private interviews with local real estate developers.

³⁷More details about the Chinese government’s intervention on real estate and land prices are introduced in Fang, Gu, Xiong, and Zhou (2016) and Glaeser, Huang, Ma, and Shleifer (2017).

³⁸around 586 billion US dollars

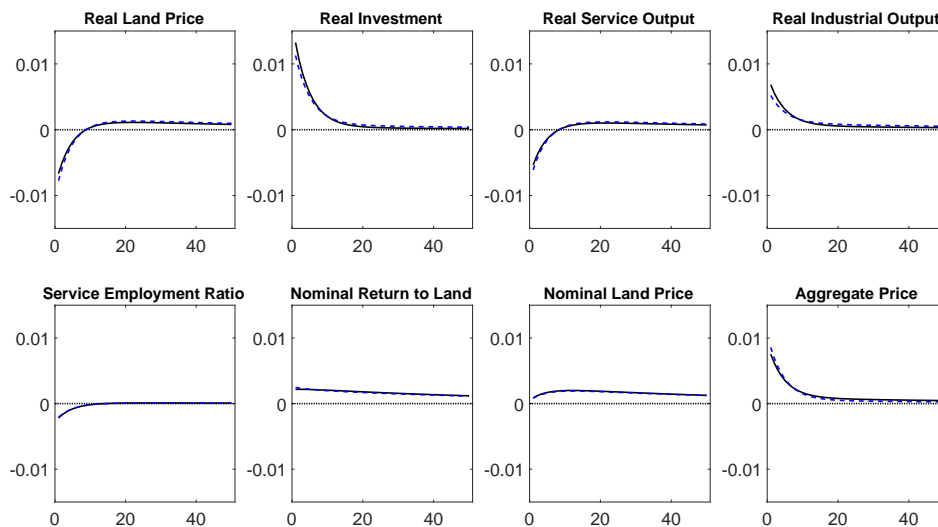


Figure 5: IRFs to an Export Price Shock in the Benchmark Model with Larger Service Capital Income Share

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price (negative service TFP) shock. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.4$, land income share is $1 - \phi = 0.0948$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$

manufacturing output to some extent (0.476 than in the data v.s. 0.963 in the model). The positive correlation between service output and investment can be partially explained by the land supply policy and the composition of stimulus packages. When there is a negative shock on the export sector, resources are supposed to move to the service sector by market forces in my model. However, the stimulus packages by the Chinese government are mostly used on public infrastructure development and manufacturing projects. Together with the mismatched land/real estate prices supported by the government, the service sector is harmed, and output cannot increase that much. As a result, real service output cannot be negatively correlated with the real aggregate investment as predicted by the model.

6 Extension to Models with Capital Adjustment Costs

In the benchmark model, the negative correlation between real investment and land price results from factors such as capital moving between the two sectors. A natural question arises whether the result is robust to barriers to the movement. In this section, I deviate from the benchmark model to two different economies where there are capital adjustment costs. The first one includes sectoral

adjustment costs, i.e., capital stock adjustment in each sector, whether increases or decreases, incurs a cost. In contrast, the second one features capital adjustment cost, which happens only when capital relocates between the two sectors. Models will be introduced, followed by calibration to adjustment cost parameters.³⁹ Finally, quantitative results are shown and discussed.

In the benchmark model, only aggregate capital K is pre-determined and sectoral demand for capital within period pin down K_1 and K_2 . On the contrary, in both extensions, K_1 and K_2 are pre-determined by the representative household. I also introduce investment in each sector I_1 and I_2 because with adjustment costs, capital price may be different in the two sectors and not equal to 1.

$$I_1 = K_1' - (1 - \delta)K_1 \quad (49)$$

$$I_2 = K_2' - (1 - \delta)K_2 \quad (50)$$

I define sectoral capital adjustment costs as $\left\{ \psi_i * (I_i - \delta K_i)^2 / 2 \right\}_{i=1,2}$. Then the budget constraint of the household becomes

$$\begin{aligned} f + P_x x + P_L(L' - L) + P_n n + I_1 + I_2 + \frac{\psi_1}{2}(I_1 - \delta K_1)^2 \\ + \frac{\psi_2}{2}(I_2 - \delta K_2)^2 = wl + r_1 K_1 + r_2 K_2 + r_L L + T \end{aligned} \quad (51)$$

and the market clearing condition for manufacturing goods market is

$$\begin{aligned} P_x x + P_x \bar{x} + I_1 + I_2 + \frac{\psi_1}{2}(I_1 - \delta K_1)^2 \\ + \frac{\psi_2}{2}(I_2 - \delta K_2)^2 = P_x z_2 K_2^{\alpha_2} l_2^{1-\alpha_2} \end{aligned} \quad (52)$$

Replace equations (9) and (15) with equations (51) and (52), a new equilibrium for this economy can be defined just as [Definition 4.1](#). Due to page limit, I skip the definition here. The parameters governing the size of capital adjustment cost, $\psi_{i=1,2}$, are vital but hard to calibrate. The calibration of them will be discussed later in this section.

In terms of the cross-sectoral capital adjustment cost, I define it to be symmetric for the two sectors. The cost is a function of the log ratio of sectoral capital stocks. Denote r_1 and r_2 as the

³⁹Other parameters are calibrated either according to the literature or steady-state values, which are the same in new models with those in the benchmark one.

interest rates of capitals in the two sectors, and the budget constraint of the household is

$$f + P_x x + P_L(L' - L) + P_n n + I_1 + I_2 + \frac{\psi}{2}(\log(K'_1) - \log(K'_2) - \log(K_1) + \log(K_2))^2 = wl + r_1 K_1 + r_2 K_2 + r_L L + T_L \quad (53)$$

and this corresponds to a manufacturing goods market clearing condition

$$P_x z_2 K_2^{\alpha_2} l_2^{1-\alpha_2} = P_x x + P_x \bar{x} + I_1 + I_2 + \frac{\psi}{2}(\log(K'_1) - \log(K'_2) - \log(K_1) + \log(K_2))^2 \quad (54)$$

Similarly, equations (53) and (54) in place of equations (9) and (15) give rise to a new economy with a cross-sectoral capital adjustment cost and an equilibrium can be defined. It is not easy to calibrate ψ for this economy due to lack of convincing capital stock data and sectoral GDPs affected by institutional forces. Thus, I choose $\psi = 5000$ such that investment is lumpy enough, which can be seen from the impulse responses.

The benchmark parameter values for $\psi_{i=1,2}$ are chosen as 0.0037. I calibrate them to match the standard deviation of log real investment in the model with that in the data. This is one of the conditions based on which [Mendoza \(1991\)](#) sets the values. The other condition is that the $\psi_{i=1,2}$ values produce an average cost of adjustment of about 0.1 percent of GDP. In my model, however, this ratio is only 0.01 percent. One explanation is that my model has another layer of friction besides the classical friction in his model, which is the cross-sectoral friction. And firms tend to adjust capital less frequently. [Table 10](#) shows the simulated moments with benchmark parameter values. None of the moments except for those related to export price resemble those in the data. Further analysis of the impulse response functions helps understand why these moments are unmatched.

[Figure 6](#) displays the impulse responses to a one standard deviation shock on the export price (dashed blue line). Surprisingly, in contrast to that in the benchmark model, a positive export price shock increases the real land price and decreases real investment. In order to understand this, the effect of a rising export price is divided into an income effect and a production (investment) substitution effect. The income effect induces the household to consume more, especially more service goods. The parameter $1/(1 + \mu) = 1/1.35 < 1$ I choose indicates service and manufacturing goods are complementary. The production substitution effect, on the other hand, attracts resources from the manufacturing to the service sector as in the benchmark model. With capital adjustment costs, the incentive to reallocate the investment is suppressed. As a result, the income effect dominates the production substitution effect, and real land price rises while real investment falls. Combined with the comovement of real land price and investment following the service TFP shock

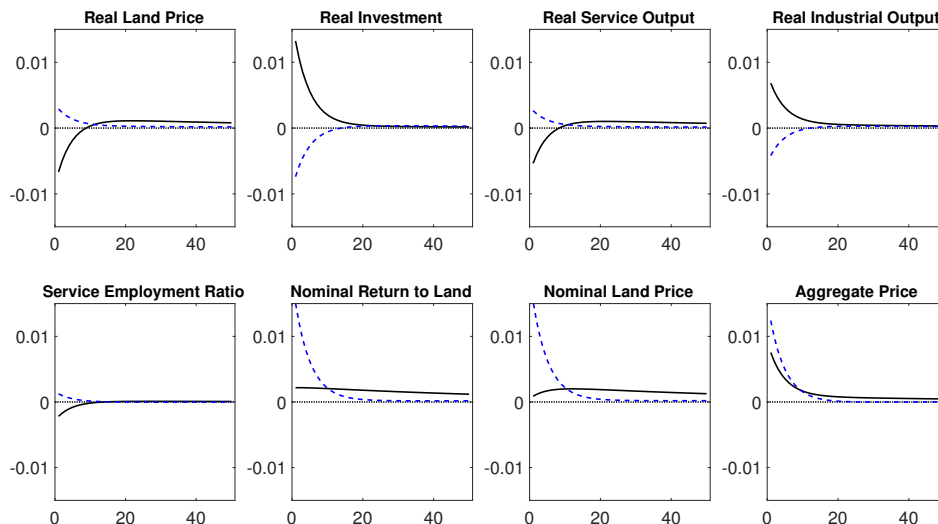


Figure 6: IRFs to an Export Price Shock in the Model with Sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.0037$

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price shock in the benchmark (sectoral capital adjustment cost) model. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. Capital adjustment cost parameters are $\psi_{i=1,2} = 0.0037$.

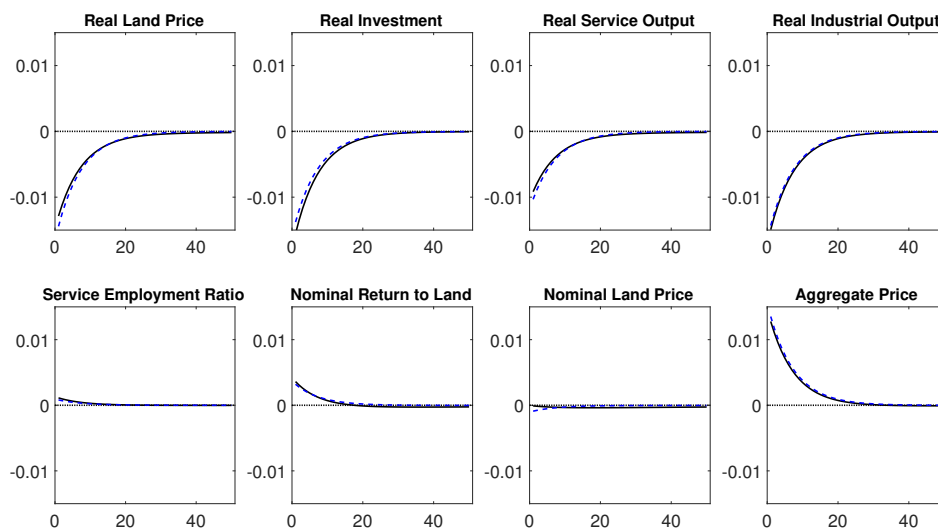


Figure 7: The Role of Service TFP Shock in the Model with Sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.0037$

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation negative service TFP shock in the benchmark (sectoral capital adjustment cost) model. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. Capital adjustment cost parameters are $\psi_{i=1,2} = 0.0037$.

as in [Figure 7](#), the correlation between land price and investment is definite to be positive (0.392). In addition, when income effect dominates, outputs in both sectors are negatively correlated with real investment (-0.676 and -0.546). And the negative correlation between real land prices and outputs can be explained again by the government's intervention.

Table 10: Model's Standard Deviations and Correlations with Real Sectoral Outputs (Model with Sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.0037$)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0171	-0.676	0.413
Real Manufacturing Output	0.0194	-0.546	0.554
Real Investment	0.0218	-	0.392
Real Land Price	0.0215	0.392	-
Export Price	0.0117	0.197	-0.443

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0.3 * \sigma_1 * \sigma_2$. Capital adjustment cost parameters are set to $\psi_1 = \psi_2 = 0.0037$.

The model is an abstract of the world, and the small share of capital adjustment cost in the GDP further indicates a lot is missing about the investment. Thus, it is risky to choose $\psi_{i=1,2}$ only to match the standard deviation of log real investment in the data. So I vary the size of sectoral adjustment costs to see whether some of the unmatched moments can be revised. [Table 11](#) and [Table 12](#) show the moments of the sectoral adjustment cost model with $\psi_{i=1,2}$ equal to 0.025 and 0.0001 respectively. [Table 11](#) looks similar with [Table 9](#). Further investigation into [Figure 12](#) reveals that with low adjustment costs 0.0001, the real land price still drops, and real investment still rises following a positive export price shock. However, this effect is smaller than that in the benchmark model and dominated by the effect of service TFP shocks. Consequently moments are unmatched in [Table 12](#) just as in [Table 9](#).

It is noticeable that [Table 13](#) also looks similar to [Table 9](#) and [Table 11](#). This is not hard to understand because the cross-sectoral adjust cost only prevents capital from moving across sectors but not adjusting within sectors. Such a small cost is comparable to $\psi_{i=1,2} = 0.0001$ in the sectoral adjustment cost model.

On the other hand, when sectoral adjustment costs are high enough (0.025)⁴⁰, real investment and land price become negatively correlated again as in [Table 11](#). Just as when $\psi_{i=1,2} = 0.0037$, income effect dominates, and real land price rises while investment falls after a positive export

⁴⁰chosen to be equal to that estimated by [Craine \(1975\)](#) and close to that used in [Mendoza \(1991\)](#).

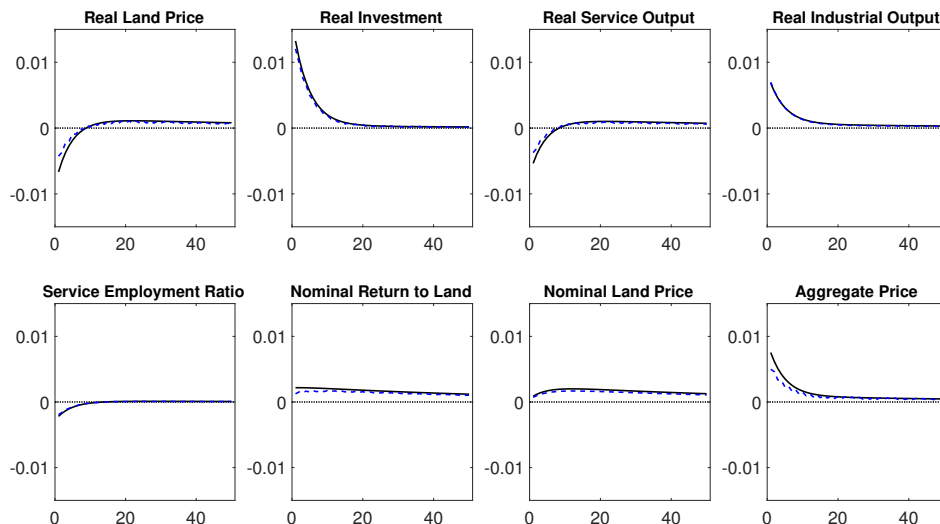


Figure 8: IRFs to an Export Price Shock in the Model with Cross-sectoral Capital Adjustment Costs

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price shock in the benchmark (cross-sectoral capital adjustment cost) model. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. Capital adjustment cost parameter is $\psi = 5000$.

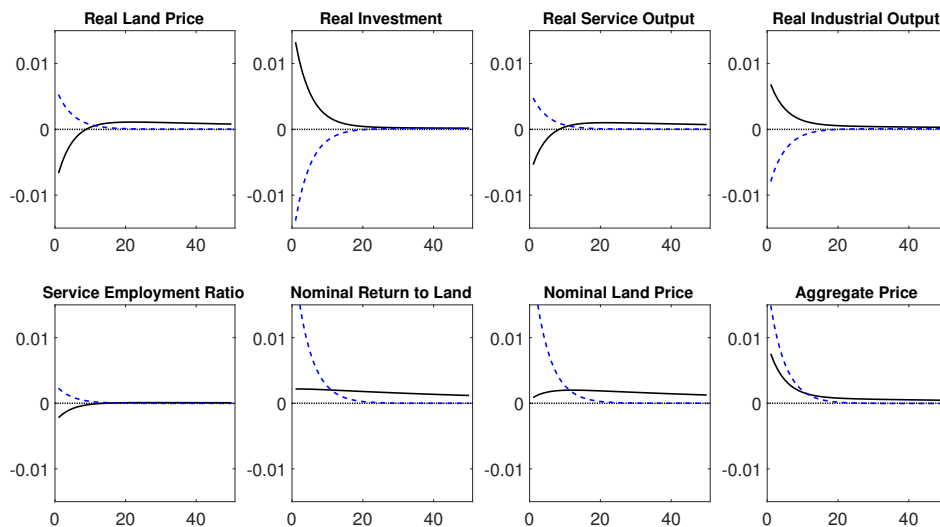


Figure 9: IRFs to an Export Price Shock in the Model with Cross-sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.025$

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price shock in the benchmark (sectoral capital adjustment cost) model. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. Capital adjustment cost parameters are $\psi_{i=1,2} = 0.025$.

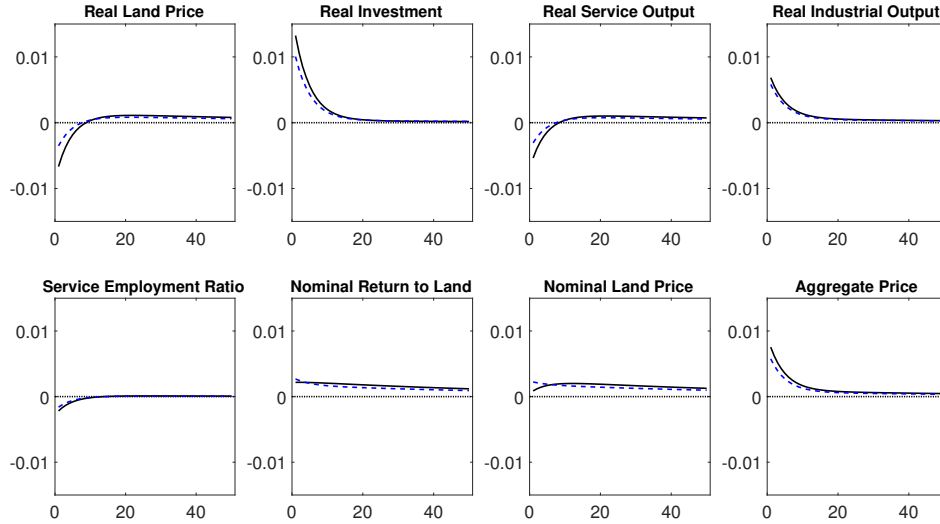


Figure 10: IRFs to an Export Price Shock in the Model with Cross-sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.0001$

Notes: Solid black (dashed blue) for the IRFs to a one standard-deviation export price shock in the benchmark (sectoral capital adjustment cost) model. Variables in percentage change from trend except for service employment ratio, which is in absolute value. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. Capital adjustment cost parameters are $\psi_{i=1,2} = 0.0001$.

shock (Figure 9). This effect is large enough with $\psi = 0.025$, even the effect of service TFP shocks is dominated, and a negative correlation between real land price and investment emerges in Table 10. Although a large adjustment cost parameter generates the negative correlation of interest I need, too negative correlations between outputs and investment (-0.888 and -0.817) due to the large income effect are not acceptable.

It is also interesting that $\psi_{i=1,2} = 0.0037$ and $\psi_{i=1,2} = 0.025$ lead to similar standard deviations of log real investment. In other word, this adjustment cost is not well identified. When the adjustment cost parameter is small, firms adjust investment more frequently and less dramatically. On the contrary, a large adjustment cost parameter discourages firms from frequent investment adjustment. However, abrupt changes in investment when needed increase the standard deviation of real investment.

To sum up, it is hard to calibrate or even identify the adjustment cost parameters in a model with capital adjustment costs. And the cost reverses the correlation of interest because the key channel is dominated by either the income effect or the effect of service TFP shocks. In order to re-establish the desired results, more structures ignored in my model are required to amplify the negative correlation generated by the production substitution effect.

Table 11: Model's Standard Deviations and Correlations with Real Sectoral Outputs (Model with Sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.025$)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0206	-0.888	0.603
Real Manufacturing Output	0.0235	-0.817	0.703
Real Investment	0.0325	-	-0.169
Real Land Price	0.0249	-0.169	-
Export Price	0.0117	0.301	-0.563

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0.3 * \sigma_1 * \sigma_2$. Capital adjustment cost parameters are set to $\psi_1 = \psi_2 = 0.025$.

Table 12: Model's Standard Deviations and Correlations with Real Sectoral Outputs (Model with Sectoral Capital Adjustment Costs, $\psi_{i=1,2} = 0.0001$)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0132	0.370	0.998
Real Manufacturing Output	0.0251	0.967	0.587
Real Investment	0.0336	-	0.364
Real Land Price	0.0185	0.364	-
Export Price	0.0117	0.412	-0.244

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0.3 * \sigma_1 * \sigma_2$. Capital adjustment cost parameters are set to $\psi_1 = \psi_2 = 0.0001$.

Table 13: Model's Standard Deviations and Correlations with Real Sectoral Outputs (Model with Cross-sectoral Capital Adjustment Costs)

Variables	Simulated Standard Deviations	Simulated Correlation with Real Investment	Simulated Correlation with Real Land Price
Real Service Output	0.0136	0.192	0.998
Real Manufacturing Output	0.0270	0.969	0.439
Real Investment	0.0377	-	0.2044
Real Land Price	0.0188	0.204	-
Export Price	0.0117	0.442	-0.306

Notes: All variables are logged and hp-filtered. The capital income share of the service sector is $\alpha_1 * \phi = 0.267$, land income share is $1 - \phi = 0.228$, and labor income share is $(1 - \alpha_1) * \phi = 0.505$. The covariance between shocks to log export price and log manufacturing TFP is $\sigma_{e_{px}, e_2} = 0.0563 * \sigma_2 * \sigma_{px}$. The covariance between shocks to log sectoral TFPs is $\sigma_{e_1, e_2} = 0.3 * \sigma_1 * \sigma_2$. Capital adjustment cost parameter is set to $\psi = 5000$.

7 Conclusion

In this paper, I document the negative correlation between real land price and investment in China and use a two-sector real business cycle model to explain it. A positive shock on the export (industrial) price leads to a higher demand for industrial goods than service goods and reallocation of resources to the industrial sector. As a result, the aggregate investment increases because the industrial sector is more capital intensive while the commercial land which is used only by the service sector sees its price decline.

In contrast to previous papers on either positive or negative correlation between real estate price and investment, my explanation for the negative correlation is no longer causal. Also, whether it is the collateral, the speculation, or the crowding out channel, certain friction or misallocation exist and the allocation of resources is inefficient, leaving room for policy intervention. In my paper, however, reallocation of resources is efficient, and there is no need for policies.

Last but not least, I hope my paper can turn researchers' eyes from an already smaller and still shrinking industrial sector to a larger and rapidly growing service sector when they look into China. The interactions between these two sectors and their relationship with other macro variables of interest, i.e., investment, land price, and employment, worth more future works on them.

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