The Spatial Misallocation of Capital and Labor in China: A Welfare Analysis Based on Urban Accounting

Shangming Yang Yuming Fu Yi Lu

December 2017

Abstract

Various place-based, ownership-type-based, and sector-based industry policies result in disparate capital subsidies across Chinese cities. Using urban accounting methodology, we quantify the spatial misallocation of capital and labor and the consequent welfare loss due to the capital subsidies. We compute the rate of return on capital at the manufacturing establishment level and find significant dispersion in the rate across ownership types, industry sectors, and cities. Counterfactual exercises show that removing all capital subsidies (by equalizing the cost of capital across cities) widen the dispersion of capital and labor across cities and improves welfare by 19.97% for 2000 and 23.53% for 2007 in the short run, and by 23.97% for 2000 and 23.58% for 2007 in the long run. Place-based capital subsidy seems to have the largest effect on factor reallocation and welfare. The influence of capital subsidy to state-owned enterprises (SOEs) diminished between 2000 and 2007. The sector-based subsidy played only a minor role in 2000 and becomes rational in 2007.

Keywords: Spatial Misallocation, Welfare Analysis, Urban Accounting

JEL: R13, R12

Shangming Yang: Department of Real Estate, National University of Singapore, shangming.yang@u.nus.edu;
Yuming Fu: Department of Real Estate, National University of Singapore, yuming.fu@nus.edu.sg;
Yi Lu: School of Economics and Management, Tsinghua University, luyi@sem.tsinghua.edu.cn.

1 Introduction

Resource misallocation across firms can decrease a country's aggregate productivity significantly (Restuccia and Rogerson, 2008). While it is easy to understand the impact of misallocation on aggregate productivity from the theoretical perspective, the more important question is the quantification of this impact. The empirical literature on resource misallocation can be divided into two groups according to the methods to quantify the misallocation. The first group seeks to indirectly estimate the extent of misallocation without identifying the specific sources of misallocation. For example, Hsieh and Klenow (2009) calculated that the manufacturing TFP will be improved by 30-50 percent in China and 40-60 percent in India if the extent of within-sector distortions in these countries is reduced to that of the United States. Bartelsman et al. (2013) explored the role of selection in resource misallocation. The second group seeks to directly measure the consequences of specific sources of misallocation. These sources include regulation, property rights, trade and competition, and financial and informational frictions. We refer Restuccia and Rogerson (2017) for a literature review. This paper will follow the direct method and assess the spatial misallocation in China.

Spatial misallocation may result from various sources. For example, Albouy (2009) explored the spatial misallocation incurred by the federal tax in the USA. Fajgelbaum et al. (2016) studied that caused by the state tax in the USA. Unearthing these sources and evaluating their impacts separately on the aggregate TFP is of great importance if research is to provide guidance on the correction of misallocation. This can be inferred by estimating misallocation across different types of firms. In the literature, firms are classified by their ownership types or locations. For the former, Hsieh and Song (2015) reckoned that the reform of SOEs contributed to 20 percent of the aggregate-TFP growth from 1998 to 2007 in China. Li et al. (2016) measured the misallocation between SOEs and Non-SOEs within Chinese prefecture-level cities. The methodology employed in these two papers is basically from Hsieh and Klenow (2009). For the latter, an extensive literature investigated the effects of place-based policies, a specific cause of spatial misallocation. We refer Neumark and Simpson (2014) for a literature review. Brandt et al. (2013) considered distortions from both ownership-based and place-based policies. Specifically, they decomposed factor market distortions in China into that among provinces and that between SOEs and Non-SOEs within the province. Brandt et al. (2013) applied the method in Hsieh and Klenow (2009) to spatial analysis. The intuition is that more productive locations should employ more input, and produce more output. Several gaps, however, are needed to be filled.

Firstly, the underlying assumption in addressing the distortions among provinces, of the method used in Brandt et al. (2013) is that: without distortions among provinces, wage should be equalized across provinces, and so should capital cost. Without consideration of risk, the equalization of capital cost across provinces is reasonable. The equalization of wage is, however, doubtful if locational fundamentals are heterogeneous. Both nontraded sectors and amenities may cause spatial wage differential even without distortions. In other words, in applying the method in Hsieh and Klenow (2009) into the spatial-misallocation analysis, we should equalize utility instead of wage across locations. Brandt et al. (2013) assumed that locations are homogeneous in everything

except productivity. If there are no distortions, more input should be allocated to locations with higher productivity. In the present paper, locations are heterogeneous in amenities and urban frictions. Even without distortions in the input and output market, inputs are not necessarily allocated according to locations' relative productivity. This is because locations with higher productivity may have lower amenities or higher urban frictions. Although urban frictions and artificial amenities are frictions, they are different from those in the output and input market. Urban frictions cannot be shunned completely to get agglomeration economy (high productivity) and natural amenities cannot be reverted at least by local government in a short time. Ignoring these points may lead to inaccurate estimation of resource misallocation caused by distortions in the output and input market. Whether the estimation is upward or downward biased depends on the cross-sectional correlation between the city productivity and amenities, and on that between the city productivity and urban frictions. Take amenities as an example. Suppose higher-productivity cities are constrained, and they have higher amenities. Removal of distortions will incur less population reallocation than that estimated under the assumption of homogeneous amenities. In this case, the method without considering amenities will overestimate the distortions. On the contrary, if there is a negative correlation, it tends to underestimate the distortions. Secondly, there may be substantial misallocation across cities within a province in China. Typically, the provincial capital city will be subsidized.

This paper endeavors to extend the analysis of spatial misallocation in Brandt et al. (2013) into a case with finer spatial unit and spatial heterogeneity in amenities and urban frictions. Our focus is on the spatial misallocation of capital. We explore the possible distortions that contribute to the misallocation. Moreover, we investigate the impact of these distortions on the spatial distribution of capital and labor. We further quantify the GDP and welfare implication of the correction of misallocation. Unlike literature with the prevailing method adopted in Hsieh and Klenow (2009), or that with the innovative one in Bartelsman et al. (2013), we follow Bai et al. (2006) instead. Specifically, we take labor and output wedge as given, directly estimate capital cost from establishment-level data, and infer the spatial misallocation of capital. Theoretically, without consideration of risk, capital cost should be equalized across locations. The dispersion in capital cost across locations can thus be used to infer the spatial misallocation of capital. By decomposing the spatial misallocation of capital into that caused by ownership-type-based, sector-based, and place-based policies, we assess the welfare impact of each type of policies by adjusting the model in Desmet and Rossi-Hansberg (2013) to the case with heterogeneous capital cost incurred by the government intervention. A second contribution of the present paper is that: by considering the heterogeneity in capital cost, we may improve the accuracy of the calibration of locational fundamentals in the urban accounting model.

The merits of industry policies were intensely debated among Chinese economists (represented by Yifu Lin and Weiying Zhang) in 2016. The debate, however, lacked the support of empirical evidence. If we broadly define industry policy as the owner-type-based, sector-based, and place-based policies, the study in this paper may provide some illumination on the debate. Although reforms in SOEs and the constraint relaxation of coastal cities are broadly agreed among economists, it is still needed to measure the magnitude of the spatial distortions in the capital market caused by ownership-protection and place-based policies and to assess the welfare

implication of the removal of these distortions. Also, the sector-based policies are under considerable debate. The current paper provides one method for the quantification.

The paper proceeds as follows. Section 2 explicates the background of the distortions in China's capital market. Section 3 lays out the model. Section 4 describes the data. Using this data, we estimate the capital cost and decompose its variation into different types. To evaluate how the correction of each misallocation will reallocate capital and labor and how the welfare will change, we do counterfactual exercises in section 5. We render some conclusions in the last section.

2 Distortions of the Capital Allocation in China

We will focus on the banking system of China, other than the capital market. The gradual development of the capital market tends to enhance the capital mobility across regions, although to a limited extent in the period we investigated (2000 to 2007). This can be seen from the World Bank's financial sector assessment for China in 2011. In 2007, the bank assets account for 84.1% of the total financial system assets. At the end of 2009, commercial bank loans account for a larger share of total financial system assets (more than 70%) compared to equity, government debt, and corporate debt.

With a bank-dominated financial system, China started the reform in its banking sector from 1979. Before 1979, the People's Bank of China (PBC) was the only bank in the economy, which was replicated from the former Soviet Union. The reform can be summarized in the following three stages. (1) From 1979 to 1993, the Big Four state-owned banks-the Industrial and Commercial Bank of China (ICBC), the China Construction Bank (CCB), the Agricultural Bank of China (ABC), and the Bank of China (BOC)-were stripped from the PBC. In this period, tens of small and medium-sized banks and a large number of non-bank financial organizations were set up. Besides, there were thousands of urban and rural credit cooperatives operating. (2) From 1993 to 1997, three policy banks-the China Development Bank, the Agricultural Development Bank of China, and the Export-Import Bank of China- were established with the aim to take over the policy-lending function from the Big Four. Until now, the financial management, policy-driven business, and commercial business were run respectively by the PBC, the three policy banks, and the Big Four. At the same time, several joint-equity banks were originated. More than half of the urban credit cooperatives were closed, and the others were restructured into hundreds of city commercial banks, most of which were the financial vehicles of local government. (3) From 1997 to 2003, four asset management companies were created by the state to take over bad assets from the Big Four. From 2003 on, a stock-holding-system reform was introduced into the Big Four. Then, strategic investors were imposed, and the Big Four were listed. Before the end of 2007, the CCB, the ICBC, the BOC, and the Bank of Communications (BoCOM) were listed in both Hong Kong and Shanghai Stock Exchange. In the middle of 2010, the ABC was listed in the two stock markets as well.

The market-oriented reform of the Big Four strengthened their independence. Thus, their behavior will be more profit-driven, which will increase the capital mobility across regions. However,

during the gradual reform process, distortions in the credit direction were still prevailing. Dobson and Kashyap (2007) provided evidence for the government's intervention. Since the government at various levels kept involved in the bank ownership and decision-making, the Big Four could not purely make profit-maximization decisions. Besides, the three policy banks were launched with the aim to respond to the nation's policies. Also, the city commercial banks are to a large extent the financial vehicles of local government. The features of the financial institution in China during this period makes the capital market distortion possible. What is the incentive of the government to distort the capital market? In the following cases, the capital market may be distorted by the government's intervention, which may cause inefficiency.

Firstly, firms with different ownership type may face different capital cost. (1) SOEs can obtain cheap loans easily from banks. Since many local workers are employed in SOEs, the bankruptcy of SOEs will raise unemployment sharply. If the laid-off workers are not compensated properly, they may gather around the government office to express their resentment. Moreover, GRP will shrink with the closure of SOEs in the short time. To keep the society stable, and to protect the fame and future of local governors, they may continue to subsidize SOEs to retain employment via talking with officers of local branches of the Big Four or bailing the problematic SOEs informally. The difficulty encountered in the current closure of production overcapacity illustrates this point. The SOE reform in China has been pushed through for decades. To provide an overview of the results of the SOE reform, we plot the number and output of SOEs in manufacturing from 1998 to 2013 in Figure 1. Panel A shows that SOE number decreased substantially during this period, while the total firm number increased notably. Panel B reveals that both the total output and the output of SOEs expanded considerably. The SOE share declined markedly due to the more rapid expansion of the total output. To sum up, the SOE reform decreased the SOE number noticeably. But the remaining SOEs has been becoming larger and larger in terms of output. Their share in the total output, however, contracted substantially due to the more rapid increase of the other firms in the economy in terms of both number and output. (2) Another important owner-type-based policy, which aimed at attracting FDI, is that FDI enjoys lower business income tax than the domestic firms until 2007. <<Income Tax Law of the People's Republic of China for Enterprises with Foreign Investment and Foreign Enterprises>>, published in 1991, granted FDI a tax rate of 15%, which is much lower than the 25% tax rate for domestic firms. It was abolished in 2008 when a new law named <<Income Tax Law of the People's Republic of China for Enterprises>> was issued. From 2008 to 2012, the tax privilege for FDI was gradually eliminated.

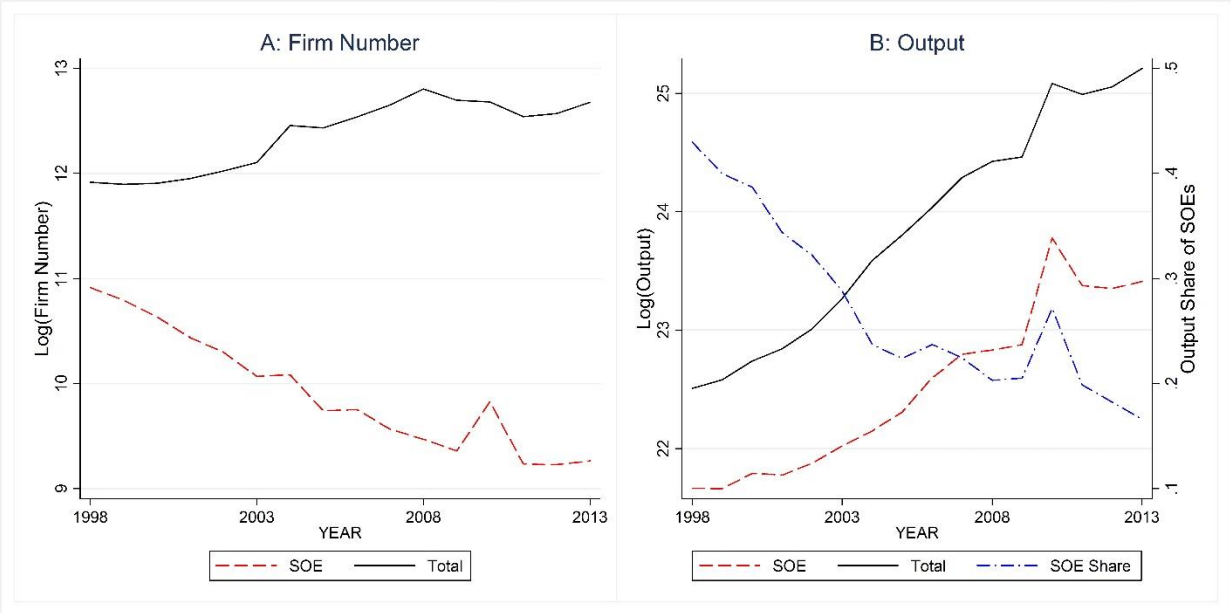

Figure 1 The Trend of SOE's number and output in China from 1998 to 2013

Secondly, governments may implement sector-based policies. The state usually issues policies or regulations to support, to constrain designated sectors, or to close product capacity in specific sectors, aiming at adjusting the economy's sector composition. Several examples are listed as follows: (1) <<The sectors, products, and technology that are encouraged by the government to develop currently>>, issued in 1997 by the now National Development and Reform Commission, is a typical guiding document. It has been revised in 2000. (2) <<A directory of obsolete producing capacity, process, and products that should be eliminated>>, issued by the now Ministry of Commerce of the People's Republic of China, documents the sectors that should be constrained and closed gradually. Totally three batches were published at the beginning, the end of 1999, and in 2002 respectively. (3) << A directory of overlapping projects that should be stopped in the industrial and commercial investment>>, issued in 1999 by the now National Development and Reform Commission, aims to prevent over-investment at that time. The three documents listed above were abolished in 2011. (4) <<Catalogue for the Directory of Industrial Structure Adjustment>>, were issued by the National Development and Reform Commission in 2005, and has been revised in 2011, 2013, and 2016. (5) Other policies that were implemented in specific sectors. Since China has been reformed from a central planning economy to a market-oriented one, the reform process saw a gradual withdraw of the state from the economy. The original ministries or commissions in the planning economy have been still monitoring the economy to make sure that it works well. Ever since the reform and opening-up, the nation has been gradually upgrading its industry from a labor-intensive one with low technology to a capital-intensive one with high technology. These ministries or commissions judged timely the sectors that should be encouraged to make sure that the upgrading could be progressed properly. In implementing the export-oriented development strategy, they supported sectors that are mainly export-oriented. When the recent years' environment pollution attracted people and the government's attention, they have been

implementing policies to close or upgrade highly-polluting producing method or industry and to encourage energy-friendly industry such as solar energy industry.

There are documents guiding FDI as well. <<Catalogue for the Guidance of Industries for Foreign Investment>> was issued in 1997 by the now National Development and Reform Commission. It has been revised in 2004, 2007, 2011, 2015, and 2017. By introducing FDI, China intended to relieve the capital scarcity and to learn from FDI the advanced technology and management. When the capital is no longer scarce as in recent years, the main aim is the latter. The encouraged sectors accord generally with the nation's industry upgrading strategy.

Thirdly, implementing place-based policies may incur distortions. China's regional policies generally follow the two-step strategy designed by Deng Xiaoping. In the first step, the country will employ the scarce resource to help the coast get rich. During this period, policies prefer the coast, and the middle and western regions should subordinate their local interest to this overall situation. In the second step, when the economy develops to a certain stage, more resource should be distributed to the development of the middle and western regions. At this stage, the coast should subordinate their interest to this stage's overall situation. Deng Xiaoping's design is consistent with the bell-shaped curve of the economic concentration in a country's development. Readers interested in this topic can read Yang and Fu (2017). In China's development, the turning point of the policy is at the beginning of the 21st century. After that, the central government paid more attention to the income inequality across regions. Several examples reveal the shift of the government's focus. (1) Two programs were issued and carried out: "the Grand Western Development Program" and "the revitalization program of the old industrial base in northeast". The central government directed more credit to undeveloped areas to facilitate the infrastructure construction there. (2) The newly-established development economic zones, which are believed to be the engine of China's development, were located mostly in the middle and western areas. Firms in a zone can get credit more easily and cheaply. Most of the zones have policies of land-rent reduction. Since most development zones have enlisted supported-sectors (most of which are export-orientated), the distortions have the tendency to entangle with that from sector-based policies. (3) The national land bureau planed the area of city construction land each year for every Chinese city. Cities cannot expand beyond the area granted. According to Han and Lu (2016), China's central government has granted more construction land-use quotas to the inland cities since 2003. To stimulate the economic development, cities in the middle and west leased out the land at a very low price to firms, and some land is even free.

Apart from the overall situations, there are other policies that may influence the capital market. One potential source comes from the political power of cities at different levels. Higher-level cities, such as the provincial city of a province, or the municipalities, often have the priority to use financial resources. Another potential source is related to the country's city development policy. In nearly 30 years after China's reform and opening-up, the government's policy was to control the size of big cities and to develop small and medium-sized cities. It was preferred by the government that rural people migrate to and work in the nearby cities other than several megacities. The government's view evolved gradually over time. In around the second half of the 2000s, it was gradually accepted that urban groups, which is often centered on megacities, should be the

driving force of urbanization. These two sources may distort the development of cities with different sizes via the distribution of public finance or the project-related bank credit.

The various policies which distort the capital market have been changing over time. The SOE reform reduced the distortion from owner-based policies substantially. The targeted sector and places have also been changing. To investigate the evolution of capital cost dispersion across cities, Figure 2 plotted the standard deviation of the capital cost across Prefectures (The calculation of capital cost will be explained in Section 4). It reveals an increasing trend for dispersion. We will choose the year 2000 and 2007 in our analysis for comparison. The reason to choose these two years will be explained in Section 4.

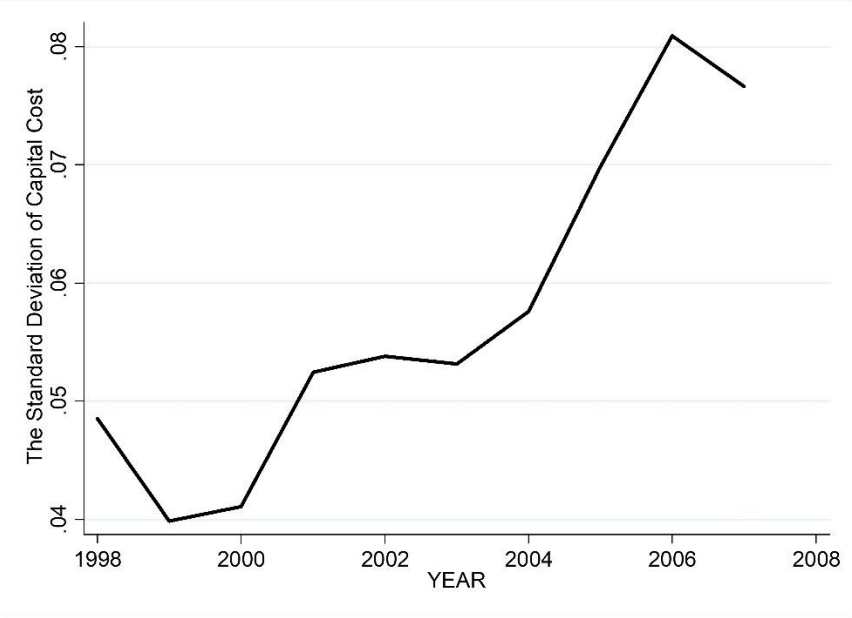

Figure 2 The Standard Deviation of Capital Cost Across Chinese Prefectures

The above policies are often executed by charging differentiated interest rates or imposing loan quotas. The complication of financial reform during this period and the varies types of industry policies entail the necessity to empirically assess the extent of capital misallocation. As illustrated in Dollar and Wei (2004), there are large variations in capital cost across cities, sectors, and ownership in the samples they surveyed. The survey data has the advantage of knowing exactly the ownership type of firms, but the magnitude of sample size (12,400 firms in 2005) confined the prediction about the capital misallocation across Chinese cities in different years. Thus, we will use establishment-level data in manufacturing to infer capital misallocation of China in 2000 and 2007. But before that, let us lay out the model first.

3 An Urban Accounting Model with Heterogeneous Cost of Capital

The model is based on Desmet and Rossi-Hansberg (2013) and a correction from Fu and Zhang (2016), with the only exception that capital cost will be heterogeneous across cities due to the capital subsidy. In the following, the model will be briefly restated.

A. Technology

City production function is given by:

$$Y_{ii} = A_{it}K_{it}^{\theta}H_{it}^{1-\theta}$$

in which Y_{it}, A_{it}, K_{it}, and H_{it} indicates respectively city production, productivity, capital, and total hours worked in city i. From the first order condition we have:

$$w_{it} = (1-\theta)\frac{y_{it}}{h_{it}} \quad and \quad r_{it} = \theta\frac{y_{it}}{k_{it}} \tag{1}$$

in which the lowercase letters indicate per capita variables. Note that due to the protection from the local government or the subsidy from the central government, cities have different capital cost. This is where we depart from the model in Desmet and Rossi-Hansberg (2013). Productivity A_{it} can be calculated as:

$$A_{it} = \frac{Y_{it}}{K_{it}^{\theta}H_{it}^{1-\theta}} = \frac{y_{it}}{k_{it}^{\theta}h_{it}^{1-\theta}} \tag{2}$$

B. Preferences

Agent's problem in city i is:

$$\max_{\{c_{it},h_{it},k_{it}\}} \sum_{t=0}^{\infty} \beta^t [logc_{it} + \psi \log(1-h_{it}) + \gamma_{it}]$$

in which c_{it}, h_{it}, and γ_{it} is city-specific consumption, working hours, and amenity respectively. ψ indicates the relative preference for leisure. β is the discount rate.

An agent is subject to the following constraints:

$$\begin{aligned} c_{it} + x_{it} &= w_{it}h_{it}(1-\tau_{it}) - w_{it}h_{it}(R_{it}+T_{it}) + r_{it}k_{it} + s_{it}k_{it} \\ &= w_{it}h_{it}[1-(\tau_{it}+R_{it}+T_{it})] + r_{it}k_{it} + s_{it}k_{it} \\ &= w_{it}h_{it}(1-\tau'_{it}) + r_{it}k_{it} + s_{it}k_{it} \end{aligned}$$

and

$$k_{it+1} = (1-\delta)k_{it} + x_{it}$$

where τ_{it} is the rate of wage tax levied by the government. Each agent lives on one unit of land and has to commute from the living place to the working place (city center). R_{it} and T_{it} are land rent and commuting cost respectively. r_{it} and s_{it} indicate the capital return rate and the capital subsidy. An agent's income contains the after-tax wage income, the capital return, and the capital subsidy. The spending includes consumption, investment and the expenditure on land rent and commuting. We use τ'_{it} to indicate labor supply wedge, part of which comes from wage tax, and part from commuting and land rent. x_{it} is investment and δ indicates the depreciation rate.

We assume that government levy a capital tax on the capital in some cities and use the capital tax to subsidize the capital investment in other cities. The assumption of footloose capital implies that

the sum of capital return and subsidy should be equalized across cities: $r_{it} + s_{it} = \bar{r_t}$. The budget constraint for the government in providing subsidy means: $\sum_i s_{it} K_{it} = 0$. Substitute subsidy into it: $\sum_i (\bar{r_t} - r_{it}) K_{it} = 0$. We can obtain: $\bar{r_t} = \frac{\sum_i r_{it} K_{it}}{\sum_i K_{it}}$, which is the weighted average capital cost of the country. We further assume that at the country level, the capital is in steady state and at its Golden Rule level, or $\bar{r_t} = \delta$. We have: $r_{it} + s_{it} = \delta$. From this equation we see that if the government subsidize the capital in one city, the capital return rate will be lower.

The agent's budget constraint can be simplified as:

$$c_i = w_{it} h_{it} (1 - \tau'_{it})$$

The first order condition of this problem is:

$$w_{it}(1 - \tau'_{it}) = \psi \frac{c_{it}}{1 - h_{it}} \tag{3}$$

Substitute c_{it}=$w_{it} h_{it} (1 - \tau'_{it})$ into it, and we get:

$$h_{it} = \frac{1}{1 + \psi} \tag{4}$$

Combining equation (3) with equation (1) we can get:

$$1 - \tau'_{it} = \frac{\psi c_{it} h_{it}}{(1 - \theta) y_{it} (1 - h_{it})}$$

Substitute (4) into it:

$$1 - \tau'_{it} = \frac{c_{it}}{(1 - \theta) y_{it}} \tag{5}$$

C. Commuting Costs, Land Rents, and City Equilibrium

This part is the same as in Desmet and Rossi-Hansberg (2013). The sum of commuting cost and rental cost in a monocentric city model is a function of city size:

$$R_{it}(d) + T_{it}(d) = \kappa \left(\frac{N_{it}}{\pi} \right)^{\frac{1}{2}} \tag{6}$$

in which κ denotes commuting cost in terms of time per mile.

The total miles traveled by citizens in the city is given by:

$$TC_{it} = \frac{2}{3} \pi^{-\frac{1}{2}} N_{it}^{\frac{3}{2}}$$

D. Government Budget Constraint

The public spending of city government in transportation infrastructure is set to be a function of commuting cost and wage:

$$GS_{it} = g_{it} h_{it} w_{it} \kappa TC_{it} = g_{it} h_{it} w_{it} \kappa \frac{2}{3} \pi^{-\frac{1}{2}} N_{it}^{\frac{3}{2}}$$

in which g_i is government inefficiency in providing public goods. It indicates the number of workers needed to build and maintain per unit time's commuting. A smaller g_i means a more efficient government in providing commuting infrastructure.

In this paper, we assume that government owns the land of the city, which is reasonable in China considering the "land finance" of local government. Assume commuting fee is a product of

commuting time and wage rate of workers[1]. The commuting cost and land rent paid by workers are collected by the city government. The government revenue is thus:

$$GR_{it} = N_{it}\left(w_{it}h_{it}\tau_{it} + w_{it}h_{it}(R_{it} + T_{it})\right) = w_{it}h_{it}N_{it}(\tau_{it} + R_{it} + T_{it}) = w_{it}h_{it}N_{it}\tau'_{it}$$

The government then spends these collections and income tax levied on workers in the construction and maintenance of city infrastructure. The budget constraint of city government is then:

$$w_{it}h_{it}N_{it}\tau'_{it} = g_{it}h_{it}w_{it}\kappa\frac{2}{3}\pi^{-\frac{1}{2}}N_{it}^{\frac{3}{2}}$$

thus:

$$\tau'_{it} = \frac{2}{3}g_{it}\kappa\pi^{-\frac{1}{2}}N_{it}^{\frac{1}{2}}$$

or:

$$\tau'_{it} = g'_{it}\kappa' N_{it}^{\frac{1}{2}} \tag{7}$$

where $g'_{it} = \frac{2}{3}g_{it}$, and $\kappa' = \kappa\pi^{-\frac{1}{2}}$.

E. Equilibrium

Substitute capital cost of equation (1) into (2):

$$y_{it} = A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}h_{it} = A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}\frac{1}{1+\psi} \tag{8}$$

Consumer budget constraint is:

$$c_{it} = w_{it}h_{it}(1-\tau'_{it}) = (1-\theta)y_{it}(1-\tau'_{it}) = (1-\theta)A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}h_{it}(1-\tau'_{it})$$

$$= (1-\theta)A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}\frac{1}{1+\psi}(1-\tau'_{it}) \tag{9}$$

where the first equation uses wage rate of equation (1), the second uses equation (8), and the last one uses the expression of (4).

Using (9), we can get consumer's utility. Free-mobility assumption implies that utility in every city is equal to a reservation utility $\bar{u}$, which can be determined in the closed-economy model. Thus,

$$\bar{u} = log\left((1-\theta)A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}\frac{1}{1+\psi}(1-\tau'_{it})\right) + \psi\log(1-h_{it}) + \gamma_{it}$$

Substitute equation (7) into it:

$$\bar{u} = log\left((1-\theta)A_{it}^{\frac{1}{1-\theta}}\left(\frac{\theta}{r_{it}}\right)^{\frac{\theta}{1-\theta}}\frac{1}{1+\psi}\left(1-g'_{it}\kappa' N_{it}^{\frac{1}{2}}\right)\right) + \psi\log\left(1-\frac{1}{1+\psi}\right) + \gamma_{it} \tag{10}$$

[1] In a model with both commuting time and commuting fee, the land rent differential mirrors the difference in both commuting time and commuting fee paid by workers. The monetary cost of commuting time is worker's opportunity cost, or wage rate. Thus, the commuting fee is just doubled in this case.

From this equation, we can see that city population N_{it} is a function of city efficiency A_{it}, capital cost r_{it}, government inefficiency g'_{it}, and city amenity γ_{it}. To see the effects of the quadratic city-specific characteristics (A_{it} r_{it} g'_{it} γ_{it}) on city population N_{it}, take the derivative of each of the quadratic on both sides of equation (9), we can get:

$$\frac{\partial N_{it}}{\partial r_{it}} < 0, \qquad \frac{\partial N_{it}}{\partial A_{it}} > 0, \qquad \frac{\partial N_{it}}{\partial g'_{it}} < 0, \qquad \frac{\partial N_{it}}{\partial \gamma_{it}} > 0$$

When there is a larger subsidy on the capital in a city, the capital cost in this city will be lower. Since the substitution rate of capital and labor is unit due to the assumption of Cobb-Douglas production function, this will incur a higher capital-labor ratio and higher output per worker, which will drive up wage rate and thus utility. Thus, more workers will move to this city. This is the underlying economics of China's city size distribution. Au and Henderson (2006) found that a large portion of cities in China are undersized. They believe that it is caused by the migration restrictions imposed nationally. We think that the capital subsidy is another important reason. The effects of the rest three characteristics are the same as in Desmet and Rossi-Hansberg (2013), which is not the concern of the present paper.

The economy-wide utility is determined by the labor-market-clearing condition:

$$\sum_{i=1}^{I} N_{it} = N_t \tag{11}$$

The capital stock in each city is:

$$K_{it} = \frac{N_{it}}{1+\psi}\left(\frac{\theta A_{it}}{r_{it}}\right)^{\frac{1}{1-\theta}}$$

Since $\frac{\partial N_{it}}{\partial r_{it}} < 0$, we have:

$$\frac{\partial K_{it}}{\partial r_{it}} < 0$$

The capital-labor ratio is:

$$\frac{K_{it}}{N_{it}} = \frac{1}{1+\psi}\left(\frac{\theta A_{it}}{r_{it}}\right)^{\frac{1}{1-\theta}}$$

The total capital stock is thus:

$$K_t = \sum_i K_{it} = \sum_i \frac{N_{it}}{1+\psi}\left(\frac{\theta A_{it}}{r_{it}}\right)^{\frac{1}{1-\theta}} \tag{12}$$

The urban system is closed.

4 Data and Estimation

4.1 The estimation of Capital Cost

China's Annual Industrial Survey conducted by the National Bureau Statistics is employed to calculate the capital cost. As mentioned before, Dollar and Wei (2007) adopted a survey data to estimate firm-level capital cost. Their concern is that ownership evolves fast in the reform period,

which will make the firm's actual ownership type different from the registered one. During China's reform, it is more likely that SOEs evolves to POEs, thus our classification, as can be seen from the following analysis, may misclassify some POEs into SOEs. If we believe the result in Dollar and Wei (2007) that SOEs have lower capital cost than POEs, the estimated capital cost gap between SOEs and POEs will be downward biased. In other words, our estimation provides a lower bound for the variation from ownership-type. Note that we include only manufacturing firms (with 2-digit sector code from 13 to 42). Thus, we capture only the capital cost of manufacturing firms (SOEs and above-scale POEs), which is used to proxy the capital cost of the economy. In China, a substantial subsidy is granted to the infrastructure investment in western areas. Although we do not directly capture this subsidy, it may have spillover effects on tradable-goods sectors.

The estimation follows that in Bai *et al.* (2006). The capital payment share of a sector is calculated as: $\alpha_{st}^K = 1 - \alpha_{st}^L$, in which s indicates sector, and t time. K and L indicates capital and labor respectively. The share of capital payment at sector s in year t is:

$$\alpha_{st}^K = 1 - \alpha_{st}^L = 1 - \frac{\sum_{j \in s,t}(wage_{jst} + welfare_{jst})}{\sum_{j \in s,t} VA_{jst}}$$

in which j indicates firm. The payment to workers contains wage and welfare fee. VA is firm's value added. A firm's capital includes borrowed capital and firm owner's capital. Thus, the payment to capital equals to the income from both the borrowed and firm owner's capital:

$$r_{jst} = \frac{VA_{jst} * \alpha_{st}^K - \pi_{jst}}{k_{jst}}$$

where π denotes profit. k is firm's capital stock and r is the cost of borrowed capital.

In China's Annual Industrial Survey, value-added, wage payable, welfare payable, profit, and total asset are reported. It also reports firm's location, ownership type, and the sector it belongs. With the above equation, we can calculate firm's capital cost. With total asset as weight, we can obtain the weighted-average capital cost in cohorts divided by city, ownership type, and sector. It should be noted that we drop firms before taking average with a cost less or equal to 0, or that higher than 1. Firms with the capital cost at the lower or higher 1% end in a sector are dropped as well.

We will analyze capital misallocation across different types and locations in the year 2000 and 2007. The year 2000 is chosen to indicate the economy of China before joining in WTO. For years before 2000, we have no measurement of the resident population. The year 2007 indicates the economy before the financial crisis. During this crisis, Chinese central government stimulated the economy by a four-trillion plan, which may ease the capital constraint. Also, the year 2007 is the last year we have the data for value added. The following analysis will focus on these two years, with exceptions pointed out.

There are lots of factors in firm's capital cost. The focus of this paper is on the subsidy. In case of footloose capital, capital cost should be equalized across firms without subsidy. If there is a subsidy on capital, a firm can obtain capital at a lower cost, and it will adjust capital employment until its marginal revenue product of capital equals the marginal cost of capital. Thus, capital cost indicates the marginal revenue productivity of capital.

To show the variation in capital cost across ownership, we calculate the asset-weighted average of capital cost for each ownership type. Firms are divided into three groups: state-owned enterprise (SOE), foreign-invested enterprise (FIE), and private-owned enterprise (POE). Table 1 presents the classification of the firm type in the data. Firms with type code 110, 141, and 151 are classified as SOE, and that with type code beginning with 2 or 3 as FIE. The leftover is grouped into POE. The classification is based on the capital source or capital-obtaining terms. In the FIE group, capital is obtained either by preferential terms or not from mainland China[2].

Table 1 The Registration Types for Firms in Chinese NBS Firm-level Data

Code	Type	Code	Type
	Domestic firms		**HMT-investment venture**
110	State-owned firms	210	Joint venture
120	Collective-owned firms	220	cooperative enterprises
130	Joint-equity cooperative enterprises	230	HMT Sole-proprietorship enterprise
141	State-owned joint venture	240	HMT corporation
142	Collective-owned joint venture	290	Other HMT firms
143	State and Collective joint venture		**Foreign-investment venture**
149	Other joint venture	310	Sino-foreign joint venture
151	State-funded limited-liability company	320	Sino-foreign cooperative enterprises
159	Other limited-liability company	330	Foreign sole-proprietorship enterprise
160	Corporation	340	Foreign corporation
171	Sole-proprietorship privately-operated enterprise	390	Other foreign firms
172	Partnership privately-operated enterprise		
173	Privately-operated limited-liability company		
174	Privately-operated Corporation		
190	Other domestic firms		

Panel A of Figure 3 displays the weighted average capital cost for each group in 2000 and 2007. It should be noted that it is the nominal cost that is reported here. Thus, the level comparison across different years is meaningless without the consideration of the price change of both capital and final goods. As can be seen from the figure, SOEs have a much lower capital cost than the other two groups in both years. In other words, they are heavily subsidized by the government. From 2000 to 2007, the cost differential between SOEs and POEs expands from roughly 3 percent to more than 5 percent. The easy accessibility to cheap capital may be the main reason for SOEs' capital-intensive technology. The cost of FIEs lies between that of SOEs and POEs, which reveals the government's preferential terms to attract FDI or the difference in the capital source.

[2] The "foreign" here simply means the outside of mainland China.

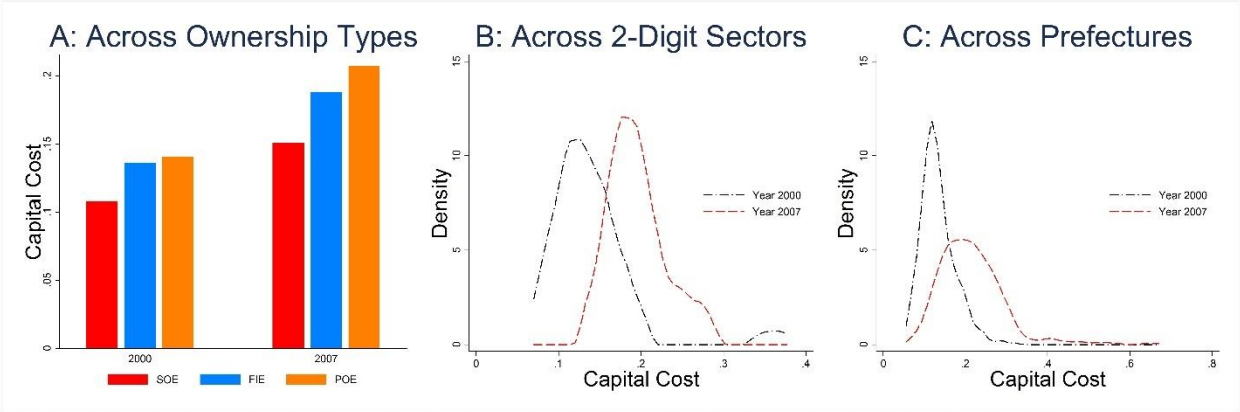

Figure 3 The Variation of Capital Cost Across Ownership Types, Sectors, and Prefectures

Another dimension, in which we could investigate the capital cost variation, is the 2-digit sector. We plotted in Panel B the kernel density of capital cost across 2-digit sectors in 2000 and 2007. It unfolds that capital cost varies greatly across sectors. The capital cost spreads from less than 10 percent to more than 20 percent in 2000, and from about 12 percent to 32 percent in 2007. The great variation may imply the government's subsidy on certain sectors.

The last dimension we will explore is location, or Prefecture-level city specifically. With firm's capital cost, city's cost can be calculated as the weighted average cost of firms in the city. Thus, we must first delimit the city boundary. To do urban accounting, we should average the capital cost of firms within city district. However, the number of firms in small cities may be insufficient to accurately calculate the capital cost. We calculated the weighted average capital cost of firms within two different city delimitations: one is city district, and the other is city administrative region. Figure 4 plots the correlation between these two measurements, which reveals a positive correlation between them. Thus, in the urban accounting process, we will employ the latter one. The density of capital cost across cities in 2000 and 2007 is reported in Panel C of Figure 3. Both years see a substantial variation in capital cost. In 2000 it spreads from 3 percent to 30, and in 2000 from 3 to 40. The density of 2007 has a much fatter tail on both sides, which indicates a much larger variation in capital cost across Chinese prefecture-level cities.

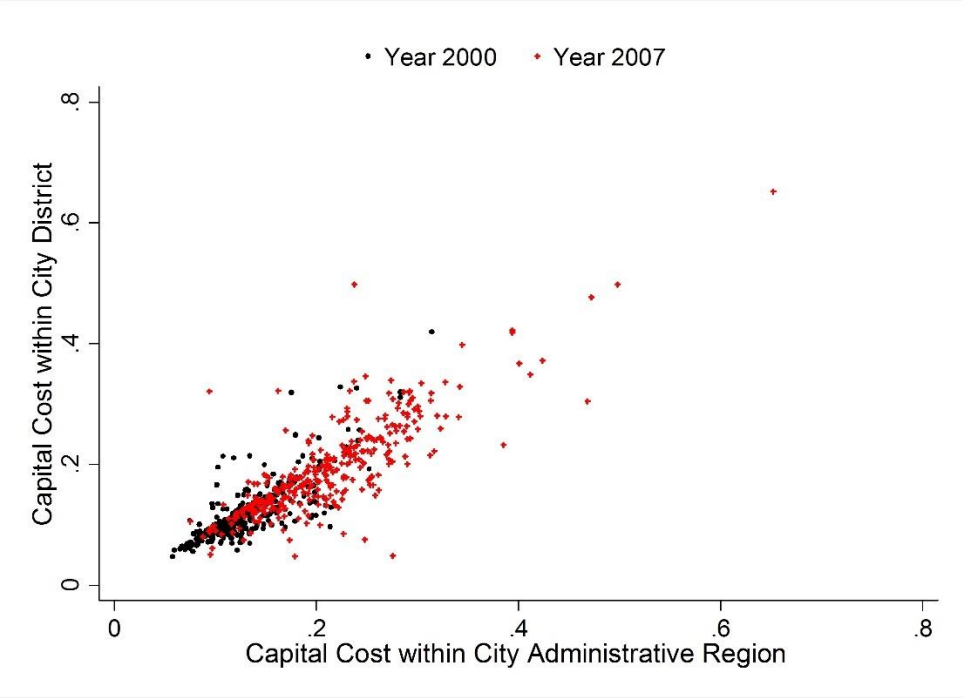

Figure 4 The Correlation Between the Capital Cost of City District and that of City Administrative Region

The three dimensions analyzed above tangle with each other. The lower capital cost of SOEs may be because SOEs concentrate in certain sectors or located in certain cities that are subsidized. The lower capital cost of certain sectors may originate from the fact that these sectors compose more SOEs or locate in cities that are supported by policies. Similarly, the lower capital cost of certain cities may stem from the phenomenon that these cities have more than the proportional portion of SOEs or firms in supported sectors. To unravel this tangle, we regress firm's capital cost on ownership dummy, 2-digit-sector dummy, city fixed effect, and year fixed effect from 1998 to 2007:

$$r_{jksmt} = \mu_1 * Ownership_k + \mu_2 * Sector_s + \mu_3 * Region_m + \mu_4 * year_t + \mu_0 + \varepsilon_j$$

Considering the number of coefficients, we will not display the results here. We instead summarize the results in the following: (1) The coefficients of ownership dummy have the expected sign. FIEs' capital cost is 3.1 percent higher than SOEs', and POEs' 8.2 percent higher. (2) All sector dummies have a significant effect. Panel A of Figure 5 draws these fixed effects. Sectors granted large subsidy are electronic, equipment, machinery, medicine. Chemical-related sectors get the second largest subsidy. Sectors related to metal, oil, clothes, leather, bamboo, and tobacco have the highest capital cost. In Figure 6 we plot the correlation between the change of export from 2000 to 2007, in terms of both export value and export ratio (export share in sales revenue), and the average sector fixed effects in these eight years. The figure reveals that sectors with higher subsidy saw a faster growth rate in both export value and export ratio. Be cautious that it reveals only a correlation. (3) Most city-fixed effects are significant. Since there are hundreds of cities, it is space-consuming to graph them. We instead use province fixed effect and graph them in Panel B of Figure 5. As can be seen from the figure, the western provinces, the municipalities, and the rusted northeast

provinces are subsidized. In most of the middle and the eastern provinces, capital cost is very high. Of these provinces, Zhejiang is expected to have high capital cost, but the regression validates that it is subsidized. In general, the results are consistent with those in Dollar and Wei (2007): there is a considerable variation in capital cost across ownership types, sectors, and cities.

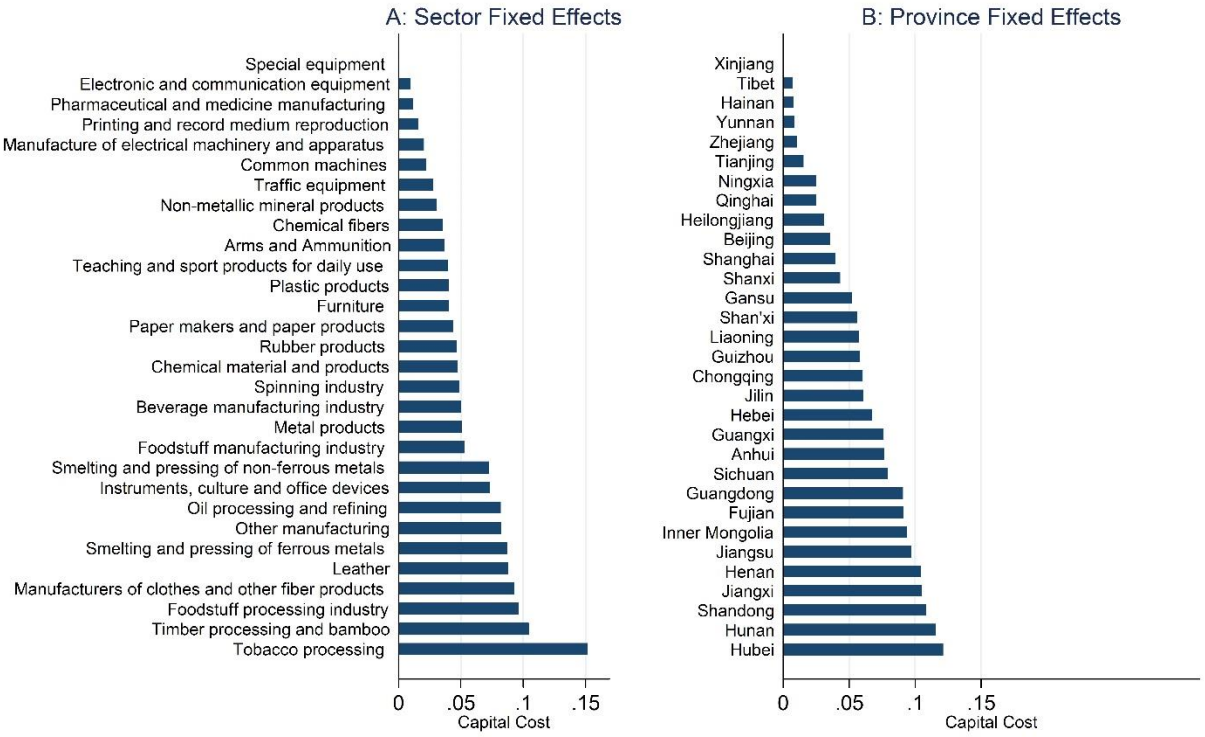

Figure 5 The Sector and Province Fixed Effects

Do note, however, that in the regression we simply assume an idiosyncratic error term. As Wu (2017) argued, the variation of average revenue product of capital may come from the variation of firm's markup and productivity shock. It may also arise from financial frictions. The assumption in Bai *et al.* (2006) leads to the equalization of average and marginal revenue product of capital. As for financial frictions, Wu (2017) found that they contribute to a much smaller portion (around 30 percent) to the capital misallocation than policy distortions. In our analysis, we simply assume that frictions are random and are not correlated with our investigated variables.

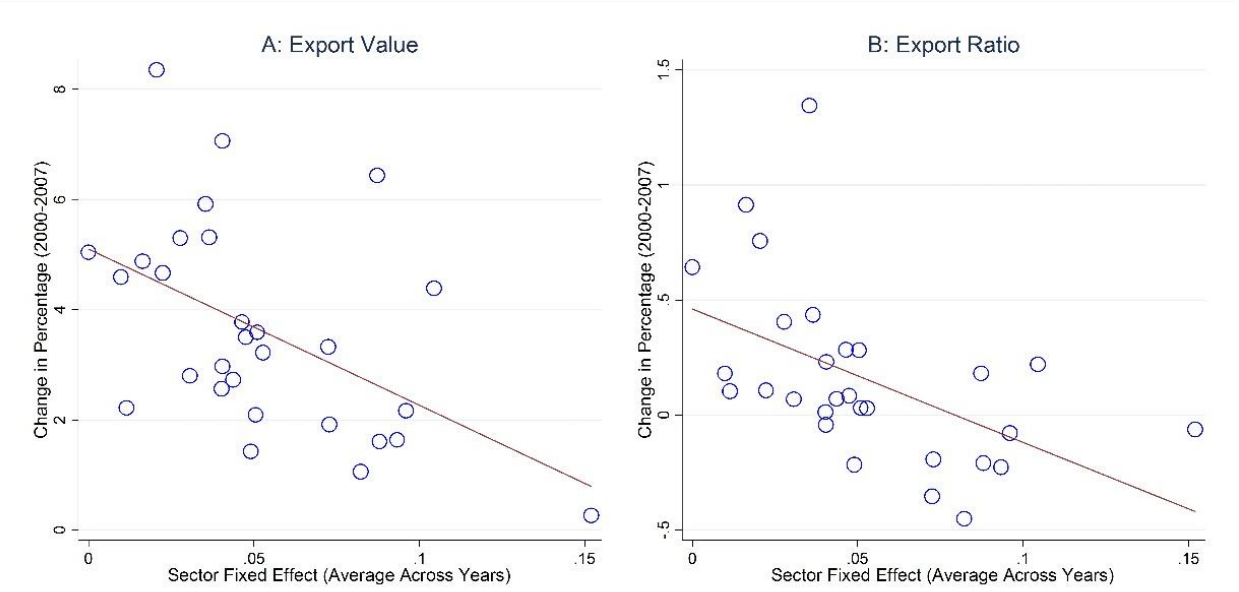

Figure 6 The Negative Correlation Between Sector Fixed Effect and Export Change From 2000 to 2007

4.2 Identification of Urban Fundamentals

Most variables used in urban accounting, such as gross regional production (GRP) and population, are obtained from China City Statistical Yearbook. Due to China's Hukou system, the registered population is different from the resident population in a city. The resident population in 2000 is obtained from that year's population census. For that in 2007, we calculated it as the ratio of GRP and GRP per capita, since after 2006 it was required to report GRP per resident population in China City Statistics Yearbook. The number of Employed Staff and Workers in the yearbook is used to indicate employment. All variables are the ones within city district.

With small g'_{it} and κ', $\log(1-g'_{it}\kappa' N_{it}^{\frac{1}{2}}) \approx -g'_{it}\kappa' N_{it}^{\frac{1}{2}}$. Using this approximation, we can get the expression of city population from (10):

$$N_{it} = \left(\frac{\log(1-\theta) + \psi log\psi - (1+\psi)\log(1+\psi) - \bar{u} + \gamma_{it} + \frac{\log(A_{it})}{1-\theta} + \frac{\theta}{1-\theta}\log(\frac{\theta}{r_{it}})}{g'_{it}\kappa'} \right)^2 \quad (13)$$

The calibration is as follows:

(1) Set $\theta = 0.5221$ as in Bai *et al.* (2006) and $\psi = 2.3$ which is calculated with the method in Fu and Zhang (2016). Equation (7) is used to calculate city productivity A_{it} .
(2) Equation (5) is used to estimate τ'_{it} .
(3) Take logarithm of equation (6) and rearrange it, we get: $\log\tau'_{it} - \frac{1}{2}\log N_{it} = \log\kappa' + \log g'_{it} = \varsigma + \varepsilon_{it}$.

Regress $(\log\tau'_{it} - \frac{1}{2}\log N_{it})$ on constant we get $\hat{\varsigma}$. κ' is calculated as: $\kappa' = e^{\hat{\varsigma}}$.

(4) Equation (7) is used to calculate g'_{it} .

(5) Set $\bar{u} = 10$, equation (13) is used to calculate city amenity γ_{it} .

In step (2), we follow the procedure in Fu and Zhang (2016) to estimate c_{it}. The rent and commuting cost per capita in a city is assumed to be $b\sqrt{N_i}$. The total rent and commuting cost in the city is thus $b\sqrt{N_i}N_i$. Sum across the province to which the city belongs, divide it by the total consumption of the province, and we can get the spending share of rent and commuting in the total consumption at province level: $\frac{b\sum_{i\in P}\sqrt{N_i}N_i}{\sum_{i\in P} ConsPerCap_i * N_i}$, in which $ConsPerCap_i$ is the consumption per capita in city i. The spending share of rent and commuting in the total consumption is observable at province level. Thus, we can estimate b for each province. Once we know b, city's rent and commuting cost per capita can be estimated as $b\sqrt{N_i}$. The pure consumption per capita in a city, which is c_{it} in equation (5), is then the total consumption per capita net of the estimated rent and commuting cost per capita.

To present the spatial differences in locational fundamentals, we delineated the calculated locational features in the map of mainland China in Figure 7 and 8 for the year 2000 and 2007 respectively. The need to merge different sets of data confines the Prefectures in our analysis. However, even across these limited number of cities, there is a large variation in locational fundamentals.

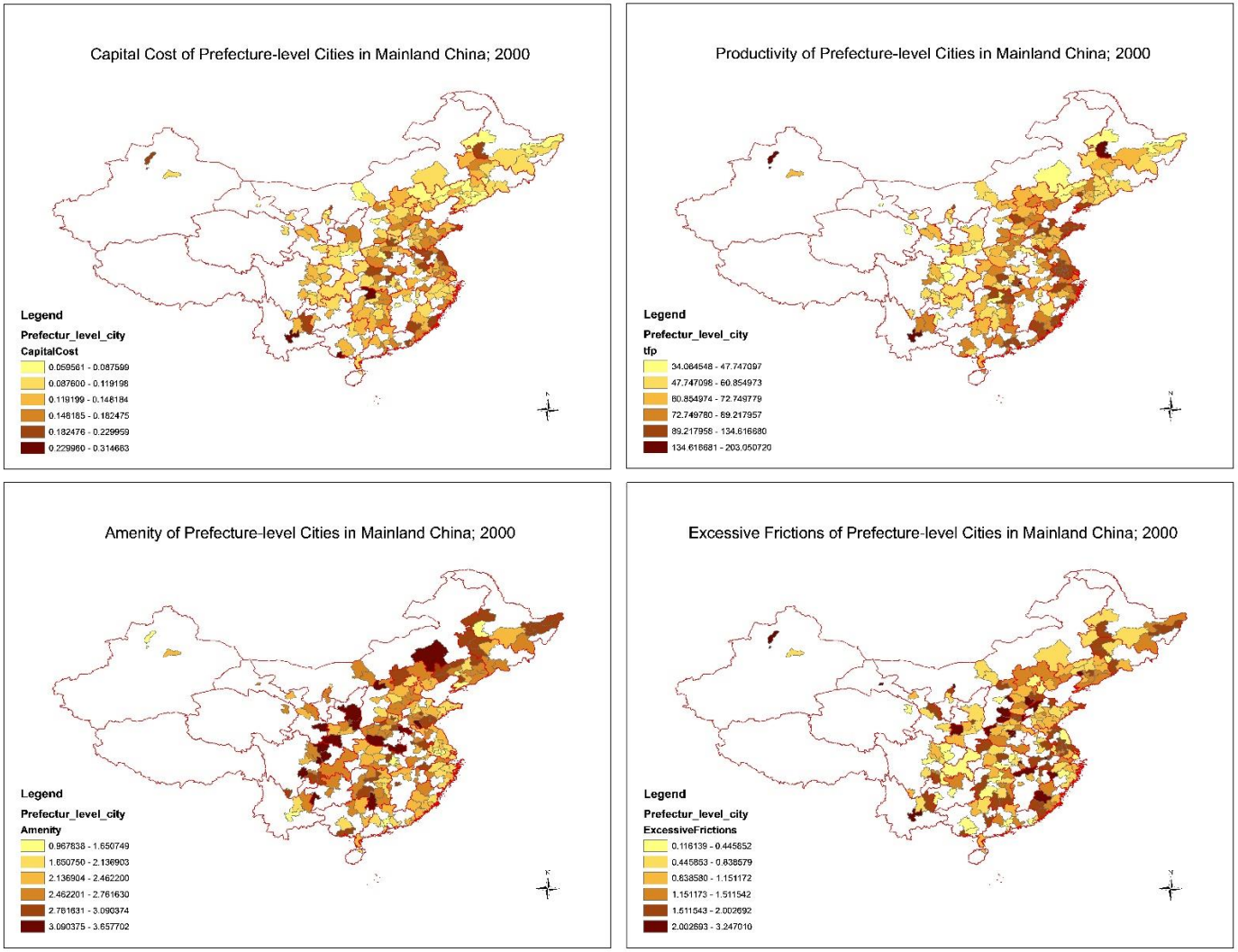

Figure 7 The Spatial Differences in Locational Fundamentals Across Chinese Cities in 2000

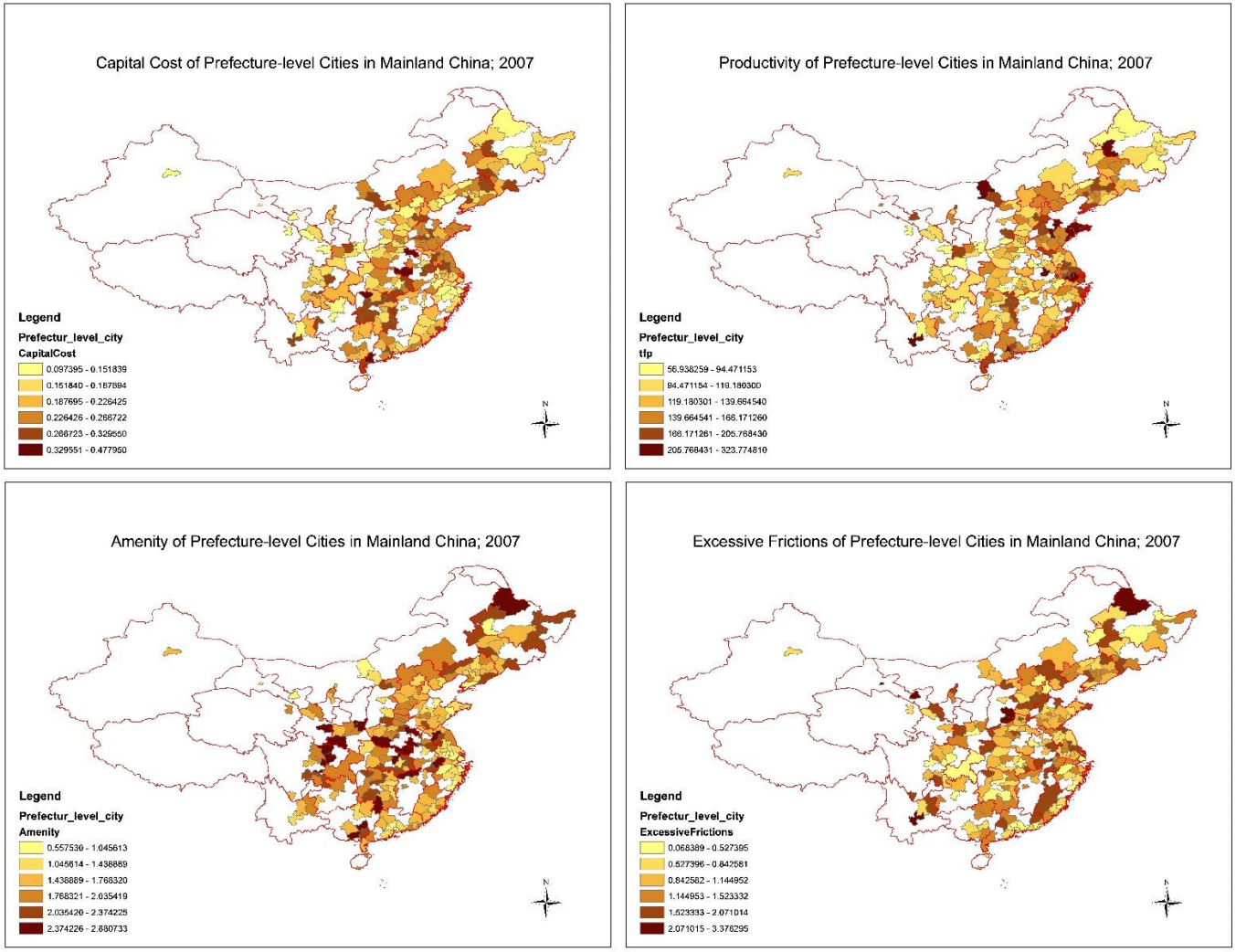

Figure 8 The Spatial Differences in Locational Fundamentals Across Chinese Cities in 2007

In the China City Statistical Yearbook, wage rate and the capital stock are reported but is not used in our calibration. Figure 9 draws the correlation between the logarithm of capital and wage that are calculated from the model and that reported in the yearbook. As can be seen from the figures, the calculated variables are positively correlated with the reported ones, which verifies the reliability of the model to some extent.

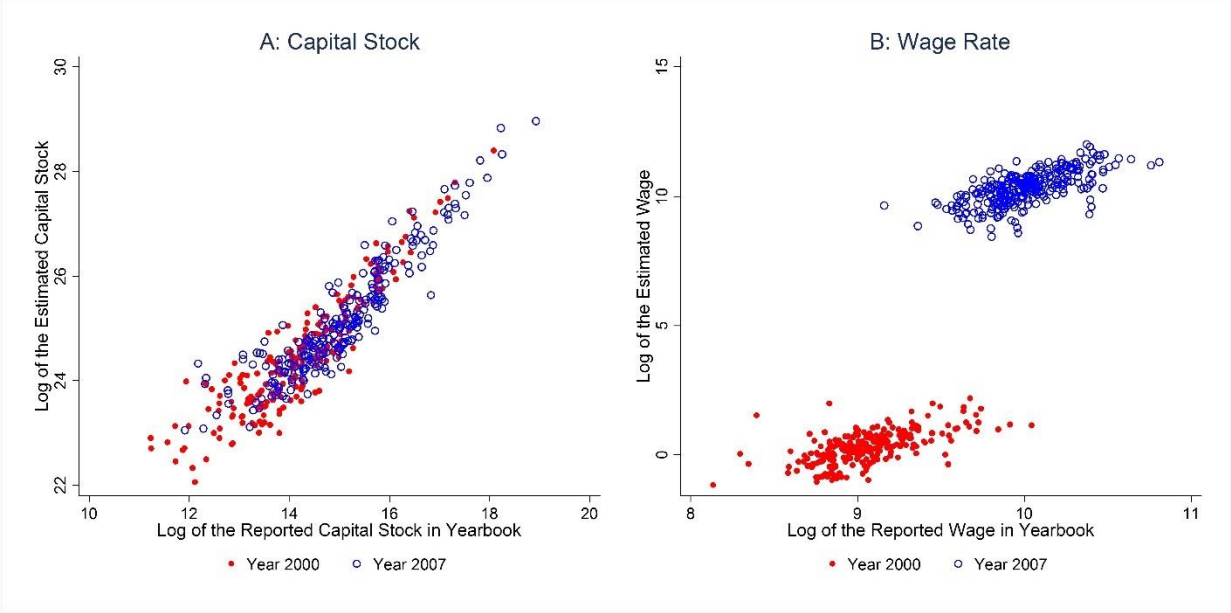

Figure 9 The Correlation Between the Logarithm of the Variables Estimated and that Reported in Yearbook

5 Counterfactual Exercises

Now we have all the necessary variables and parameters, and we can do counterfactual exercises to investigate how capital and labor will be reallocated, and how the reallocation will change the GDP and welfare of the country, if capital cost variation stemming from each of the three types of policies, namely ownership-type-based, sector-based, and place-based policies, is shut down in turn.

5.1 Decomposition of the Capital Cost Variation

The variation of capital cost across cities has been elucidated in the last section. we ask how much of the observed variation in capital cost across cities is caused by the three types of policies. In other words, we will decompose the observed variation across cities into three parts: variation from place-based policies, that from sector-based policies, and that from ownership-type-based policies.

We run the following cross-sectional weighted OLS regression with firm's asset as the weight for the investigated year:

$$r_{jksm} = \phi_1 * Ownership_k + \phi_2 * Sector_s + \phi_3 * City_m + \phi_0 + \varepsilon_j$$

in which j, k, s, and m indicate firm j with ownership type k in sector s and Prefecture m. In total there are three variation sources. Eliminating them one by one results in three counterfactual capital costs: r_OS, r_OP, and r_SP. The postfix in the expression indicates variation origin. Similarly, by eliminating them two by two we can obtain another three: r_O, r_S, and r_P. If we eliminate all the three variation sources, the weighted average capital cost of the country, which is denoted by r_AVE, can be obtained. We use r_Actual to indicate the actual capital cost. The elimination process can be illustrated as follows. Take r_OS as an example. Using the above regression, we predict r_OS by equalizing firm's city fixed effect to that of an arbitrary city. This brings us the problem of unfixed capital cost level. In the next subsection, we will show that the estimated distribution will be horizontally shifted until the counterfactual total capital stock (for the short-run effects) or the weighted average capital return rate of the country (for the long-run effects) is the same as that before the counterfactual test. The intuition for the former is that if more capital is directed to some cities, capital available in other cities will be slashed. For the latter, a stable dynamic equilibrium will ensure a constant capital return rate. Figure 10 plots the respective kernel density of capital cost across cities in the case that total capital stock is kept constant. The four figures seem to suggest that variation from the place-based policy is very large, while those from the ownership-type-based and the sector-based are relatively small. Those calculated in the case of constant weighted average capital return rate are quite similar.

One thing needs to be clarified here. Although we use firm data to compute capital cost dispersion across cities and to identify the channels that contribute to such dispersion, our focus is on regional misallocation only and we overlook misallocation across firms. Our computation is built on this focus. This is a limitation of our model. It is nevertheless useful to assess the regional misallocation implications of the place-based, sector-based, and ownership-type-based capital allocation policies.

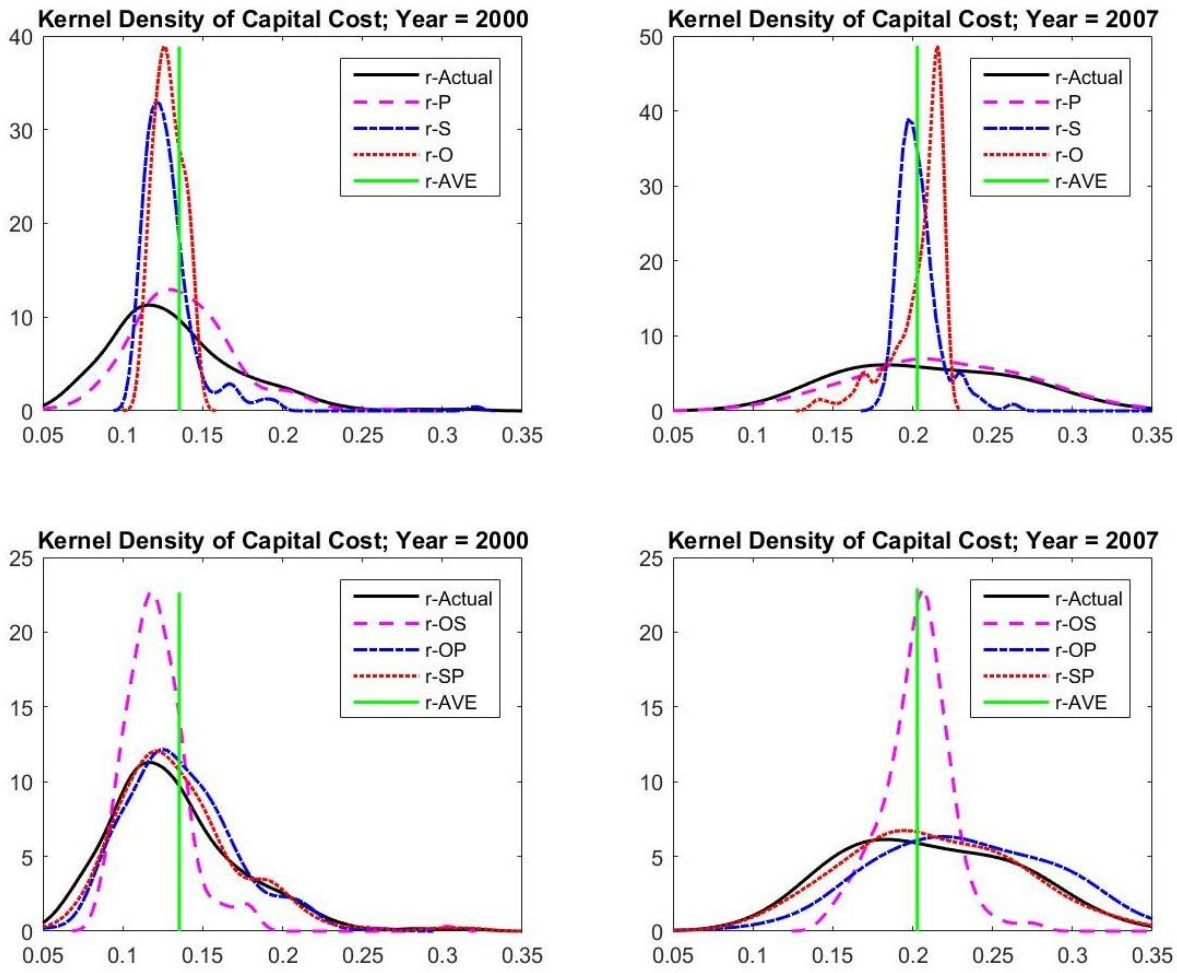

Figure 10 The Kernel Density of the Actual and the Counterfactual Capital Cost

If we remove the subsidy in a city, what will happen to the city? In the next subsection, we will answer this question by employing the model in Section 3. The intuition is that the removal of subsidy will increase the capital cost in the city. Thus, the city will employ less capital than before, or there will be a capital outflow for the city. The drop of capital-labor ratio will cause a reduction of the output per capita under the assumption of Cobb-Douglas production function. This will lower the wage and thus the utility of the city. Workers in the city will start to move to other cities until the utility of the city is equal to that in other cities again. In sum, previously subsidized cities will see an outflow of capital and labor, while those which are previously constrained will see an expansion of capital and labor. Mathematically it has been demonstrated in Section 3 that: $\frac{\partial K_{it}}{\partial r_{it}} < 0$, and $\frac{\partial N_{it}}{\partial r_{it}} < 0$.

Is the subsidy granted in high-productivity, low-urban-friction, and high-amenity cities, or the reverse is true? To answer this question, we regress capital cost on other locational fundamentals: productivity, excessive frictions, and amenities. The result is displayed in Table 2. In table 2, column 1, 3, 5, 7 display the results for the year 2000, with r, r_O, r_S, r_P as dependent variable

respectively, and column 2, 4, 6, 8 present those for 2007. If the policy makers were somehow influenced by location fundamentals in giving capital subsidy, how were they influenced? It appears that the policy makers charge a higher cost of capital where efficiency is higher, amenity is higher, and excess friction is lower. Thus, the subsidy, whether intended or unintended, hurt the productive, livable and low-excessive-friction cities. The only exception is that sector-based policies in 2007 tends to be implemented in low-excessive-friction cities.

Table 2 The Regression of Capital Cost on Other Locational Fundamentals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	2000	2007	2000	2007	2000	2007	2000	2007
VARIABLES	r_Actual	r_Actual	r_O	r_O	r_S	r_S	r_P	r_P
lgA	0.231***	0.332***	0.0125***	0.0237***	0.0659***	0.0224**	0.152***	0.286***
	(0.00737)	(0.00966)	(0.00379)	(0.00701)	(0.00884)	(0.00880)	(0.00935)	(0.0130)
g'	-0.0167***	-0.0258***	-0.00185*	-0.00611***	-0.00312	0.00682***	-0.0117***	-0.0265***
	(0.00189)	(0.00268)	(0.000975)	(0.00194)	(0.00227)	(0.00244)	(0.00240)	(0.00361)
γ	0.115***	0.181***	0.000838	0.0149***	0.0362***	0.0120**	0.0775***	0.154***
	(0.00474)	(0.00580)	(0.00244)	(0.00421)	(0.00569)	(0.00528)	(0.00602)	(0.00782)
Constant	-1.137***	-1.733***	0.0804***	0.0555	-0.236***	0.0522	-0.706***	-1.443***
	(0.0414)	(0.0560)	(0.0213)	(0.0407)	(0.0496)	(0.0510)	(0.0525)	(0.0755)
Observations	192	211	192	211	192	211	192	211
R-squared	0.853	0.854	0.145	0.085	0.256	0.089	0.606	0.704

Notes: r_Actual is the actual capital cost. r_O is the counterfactual capital cost in which the variation from sector-based and place-based policies are eliminated and only that from the owner-type-based policies are left. Similarly, r_S and r_P indicate the variation in capital cost caused by sector-based and place-based policies respectively.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

To explore the aggregated TFP (or GDP) and welfare implication, we need to know whether there is any cross-sectional correlation between productivity and excessive frictions and that between productivity and amenities. If high-productivity cities happen to have low excessive friction, and high amenities, then removal of subsidy will promote the aggregate TFP, and enhance the welfare considering the fact in Table 2 that higher-productivity cities are constrained. We plot the correlation in Figure 11. Panel A reveals that cities with higher productivity tend to have lower amenity in both 2000 and 2007. Do note that in the calibration we attribute all factors other than capital cost, excessive frictions, and productivity in affecting population distribution to amenity. Thus, the estimated amenity may contain many things. For example, if a city has strict migrant restrictions, the model will interpret that the city has lower amenities. Another example is that if a city demands more high-skill workers, which makes low-skill workers difficulty to find a job in the city, the model will explain that the city has lower amenities. This may explain partly the negative correlation in Panel A. Panel B unfolds that higher-productivity cities tend to have higher excessive frictions. The noise, however, is quite large, especially in 2007.

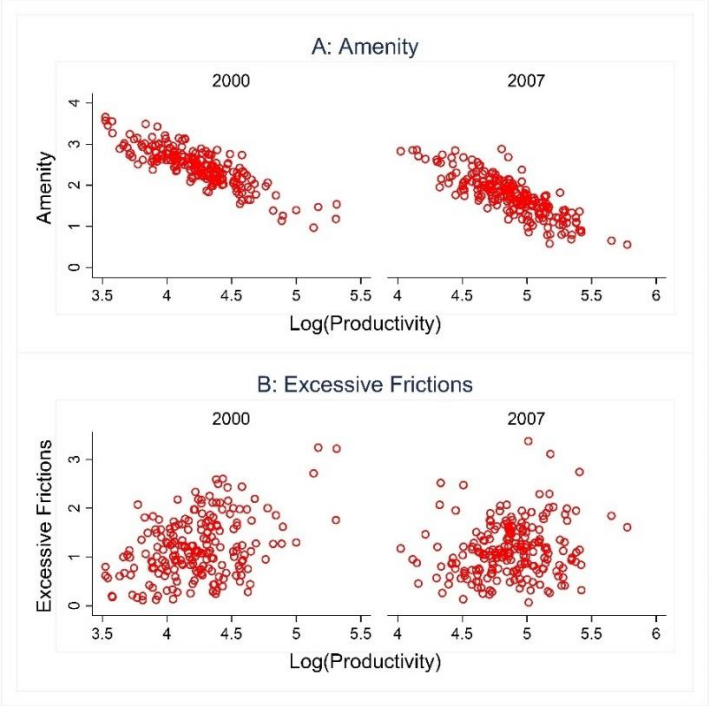

Figure 11 The Correlation Between Urban Productivity and Other Fundamentals

The above analysis illustrates that the removal of subsidy will incur reallocation of capital and labor into cities with higher productivity, lower excessive frictions, and higher amenities. Let us analyze the three channels in Table 3 one by one. (1) If capital and labor move into high-productivity cities, both the aggregated TFP and welfare will rise. (2) Reallocation of labor into low-excessive-friction cities will increase consumption and thus welfare. However, since low-excessive-friction cities tend to be low-productivity ones, this will indirectly decrease the aggregated TFP and thus welfare. (3) Reallocating labor to high-amenity cities will enhance the welfare. Because high-amenity cities tend to have low

productivity, this will decrease the aggregated TFP and thus welfare indirectly. The analysis is summarized in the above panel of Table 3. The bottom panel displays the exception of sector-based policy in 2007. Previous literature only considers channel (1). Table 3 discloses that the effects of spatial misallocation on both aggregated TFP and welfare are determined jointly by the three channels. Moreover, the correction of misallocation does not necessarily escalate the aggregated TFP and welfare. Whether the aggregated TFP and welfare will rise or fall, is determined by the relative force of the three channels. We will empirically estimate them in the counterfactual exercises.

Table 3 The Analysis of the Impact of Labor Reallocation on Aggregate TFP and Welfare

Channel	(1)	(2)		(3)	
TFP(GDP)	+	+	-		-
Welfare	+	+	-	+	-
Exception: Sector-based policies in 2007					
Channel	**(1)**	**(2)**		**(3)**	
TFP(GDP)	+	-	+		-
Welfare	+	-	+	+	-

5.2 Counterfactual Exercises

Removing subsidy will reallocation capital and labor across locations. There are two sources of potential gains. The first one comes from the efficiency improvement since locations have different productivity. The second one is from the capital-income saving (net of the depreciation rate). We have to determine how to use the saving. In the following, we consider two polar cases. In one case, the capital-income saving is spent on consumption. In the other case, it is spent on the capital accumulation until the capital return rate decreases to the depreciation rate. We call the former the short-run effect and the latter the long-run effect.

5.2.1 The Short-Run Effects

In the counterfactual exercises, the capital cost in each city is set to a counterfactual one. With the other variables and parameters fixed, a new utility is found to satisfy equation (10) and (12). In other words, we find a new utility such that the sum of the generated city population matches the actual aggregate population. In the procedure, we say that a city exits if the term in the parentheses of equation (12) is zero or negative for the city. Until now the procedure is the same as that in Desmet and Rossi-Hansberg (2013). As mentioned in the last subsection, the decomposition of the capital cost dispersion allows us to estimate the differences in capital cost across locations. But the level of capital cost is not pinned down yet. Arbitrarily choosing the level of capital cost may alter the total capital stock substantially. Thus, we should adjust the level of capital cost. The procedure is as follows:

given a distribution of counterfactual $\tilde{r}$, a distribution of city population $\widetilde{N}$ is found by following the above procedure. Given $\tilde{r}$ and $\widetilde{N}$, total capital stock $\widetilde{K}$ can be calculated according to equation (11). If it is larger than the actual one (The capital stock calculated from the model, not that reported in the Yearbook), a new $\tilde{r}' = \tilde{r} + \Delta$ is used to redo the above procedure. If it is smaller, then $\tilde{r}' = \tilde{r} - \Delta$ is used. Repeat the procedure until the total capital stock is the same as the actual one.

Since our experiment starts from an exogenous change of capital cost, let us first analyze the change of the capital stock distribution. Figure 12 exhibits the distribution of the logarithm of actual and counterfactual capital stock. Two features stand out: (1) If we shut down all the variation, capital stock will be more dispersed. That means various types of subsidy restrain capital investment in cities with large capital stock but incur overinvestment in cities with low capital stock. (2) It seems that place-based policy has the largest effect on capital misallocation in 2007. Capital reallocation will incur labor reallocation. Figure 13 exhibits the labor redistribution. As can be seen from the figure: (1) Removal of all variation dispersed the population distribution. (2) The place-based policy seems to have the largest effect in 2007. (3) The effect of owner-type-based and sector-based policy seems to be much weaker in 2007 than that in 2000.

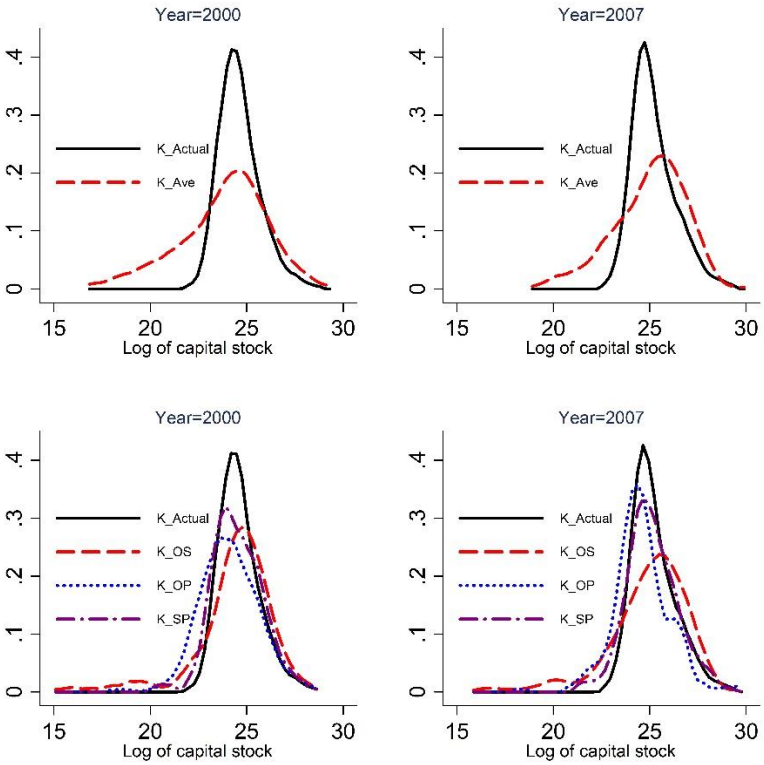

Figure 12 The Kernel Density of Actual and Counterfactual Capital Stock Across Cities

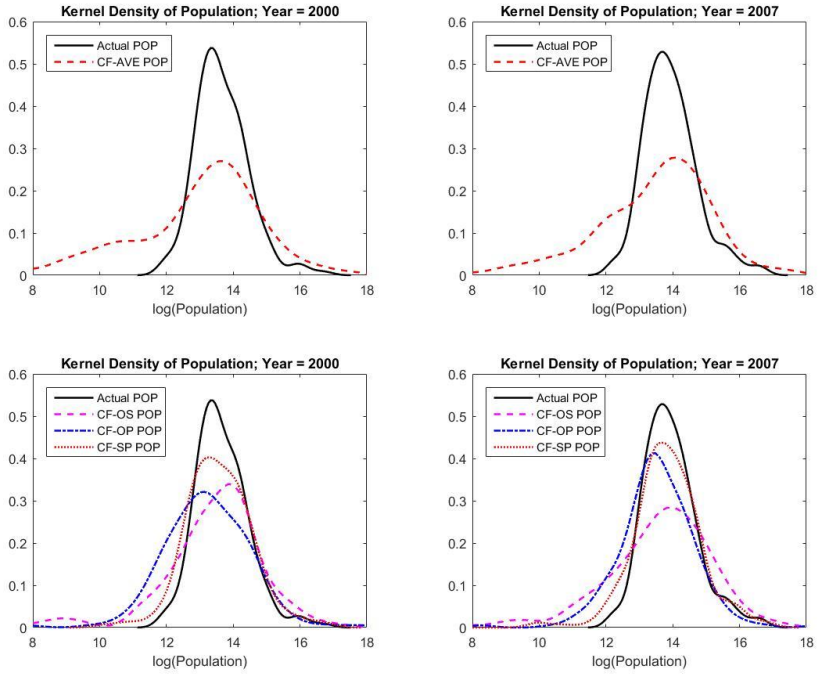

Figure 13 The Kernel Density of Actual and Counterfactual Population Across Cities

The reallocation of capital and labor will affect aggregate GDP since locations are heterogeneous in productivity. The welfare will be affected by both the increase in the labor income or capital income. Before presenting the result, let us illustrate how we calculate the welfare improvement incurred by the capital-income saving. Reallocating capital will increase the capital income. In the short run, we assume that people will spend the capital income on consumption. To be simple, we have to find a way to distribute the capital-income saving among people such that their utility will increase by the same portion. Following this way, we will not distort the spatial equilibrium of capital and labor and it will simplify the analysis significantly. Moreover, to keep the result comparable to that in the long run, we assume that capital income suffers from urban frictions either. Let us indicate the per capita allocation of the capital-income saving in city i as ks_i. The percentage change of utility will be [3]: $\log\left(1+(1+\psi)\frac{ks_i}{w_i}\right)$. No distortion to the equilibrium means $\frac{ks_i}{w_i}$ is a constant. Assume $b=\frac{ks_i}{w_i}$. We have $bw_iN_i = ks_iN_i$. Sum across cities: $b\sum w_iN_i = \sum ks_iN_i$. Thus, we can calculate: $b=\frac{\sum ks_iN_i}{\sum w_iN_i}$. The utility improvement should be $\log(1+(1+\psi)b)$.

The impacts of the three types on the aggregate GDP and welfare are displayed in Table 4. We summarize Table 4 as follows. (1) Removing all variation will increase GDP and

[3] $\log(w_ih_i+ks_i)\,(1-\tau_i') = \log w_ih_i(1-\tau_i')(1+\frac{ks_i}{w_ih_i}) = \log w_ih_i(1-\tau_i') + \log(1+\frac{ks_i}{w_ih_i})$. The percentage change of utility is: $\log(1+\frac{ks_i}{w_ih_i}) = \log(1+(1+\psi)\frac{ks_i}{w_i})$.

welfare by 22.92% and 19.97% respectively in 2000, while 2.24% and 23.53% in 2007. (2) The capital-income saving part contributes to most of the welfare improvement in 2000, while in 2007 it is the reallocation part that dominates. (3) Place-based policies dominate the other two in terms of their effects on TFP and welfare. (4) The distortions from owner-type-based policies declined from 2000 to 2007 in their impacts on GDP, which is consistent with the SOE reform. As shown in the table, the effects of owner-type-based policies in 2007 are quite small. (5) The sector-based policies became rational in 2007: removal of sector-based policies will contract GDP by 12.18%, a large number considering that China's real GDP growth is around 10% in 2007.

Table 4 The Results of the Counterfactual Exercises-the Effects on Aggregate GDP and Welfare in the Short Run

Year	Variables		Removal of Place-based	Removal of Sector-based	Removal of Owner-type-based	Removal of All
2000	GDP		14.89%	0.30%	5.68%	22.92%
	Welfare	Total	19.62%	2.07%	5.44%	19.97%
		Reallocation	6.37%	1.73%	-0.26%	1.43%
		Capital-income savings	13.24%	0.33%	5.70%	18.54%
2007	GDP		3.18%	-12.18%	-1.78%	2.24%
	Welfare	Total	19.41%	-22.84%	0.63%	23.53%
		Reallocation	16.10%	-6.42%	2.63%	21.16%
		Capital-income savings	3.31%	-16.42%	-2.00%	2.36%

The short-run effects can be summarized as follows. The removal of capital market distortions incurs reallocation of capital and labor across cities. Such reallocation makes the distribution of capital and labor across cities more dispersed, and it will raise the GDP and welfare of the whole country. Of the three types of variation, the place-based policy seems to have a much larger effect on reallocation, GDP, and welfare than the other two. Sector-based policies seem to be rational in 2007.

5.2.2 The Long-Run Effects

In the long run, we assume that the capital-income saving will be spent on investment. Thus, the capital stock will expand until the capital return rate is the same as the depreciation rate of capital again. The total capital stock will not be constant. In the counterfactual exercises, we determine the level of the capital cost by keeping instead the weighted average of the capital return a constant. The redistribution of capital and labor across Prefectures, which will not be displayed here, are quite similar to that in the short run. The effects on GDP and welfare are summarized in Table 5. The removal of all distortions will increase GDP and welfare by 54% and 23.97% respectively in 2000, while

4.74% and 23.58% in 2007. The dominance of place-based policies, the declined effects of owner-type-based policies, and the positive effect of sector-based policies in 2007 still hold.

Table 5 The Results of the Counterfactual Exercises -the Effects on Aggregate GDP and Welfare in the Long Run

Year	Variables	Removal of Place-based	Removal of Sector-based	Removal of Owner-type-based	Removal of All
2000	GDP	30.27%	0.51%	9.62%	54.00%
	Welfare	19.96%	1.97%	3.46%	23.97%
2007	GDP	6.77%	-17.46%	-3.15%	4.74%
	Welfare	19.26%	-12.73%	1.32%	23.58%

Compared with the short-run effects, the improvement in the aggregated GDP and welfare is larger in the long run. For the former, the GDP enhancement comes not only from reallocation efficiency but also the expansion of capital stock. For the latter, the path determined by the Golden Rule is the optimal one.

6 Conclusion

Various industry policies implemented in China distort the capital market. The present study assessed the extent of capital market distortion by investigating the capital cost variation across firms with different ownership, in different sectors and locations. We found substantial capital cost variations. We aggregated firm's capital cost at the level of the prefecture-level city and explored the spatial misallocation incurred by these distortions. The removal of capital market distortions will cause a more dispersed distribution of both capital and labor across cities. In the short run, GDP and welfare will increase by 22.92% and 19.97% respectively in 2000, and 2.24% and 23.53% in 2007. In the long run, the improvement is 54% and 23.97% in 2000, and 4.74% and 23.58% in 2007.

By decomposing the spatial variation of the capital cost into that from owner-type-based, sector-based, and place-based policies, we found place-based policies have a much larger effect on the spatial reallocation of capital and labor, GDP, and welfare. Sector-based policies improve GDP by 12.18% (17.46% in the long run) in 2007, which may justify the rationale of sector-based policies at least in the capital market. The owner-type-based policies declined noticeably from 2000 to 2007.

The result suggests that industry policies in the capital market created a spatial misallocation of resource, abated the aggregate GDP and welfare of the country. Note that we have considered neither distortions in output and labor market nor the misallocation within the city. Distortions may be even larger if they are considered. The positive effect of sector-based policy on GDP in 2007 comes partly from the fact that these subsidies happen to be in low-excessive-friction cities. In general, industry policy will cause

misallocation and efficiency loss. The result in the present paper illuminates the debate in 2016 in China on the industry policy. The methodology we employed provides a simple way to evaluate the welfare impact of spatial misallocation in the case of heterogeneous locational characteristics (excessive frictions and amenities). This study, with heterogeneous capital cost considered, also makes the urban accounting of Chinese cities more accurately.

This paper expounds the GDP and welfare implication only in a static sense. As Asker et al. (2014) pointed out, inefficient resource allocation in static may be efficient dynamically. A dynamic spatial equilibrium with capital accumulation may be a more challenging research direction.

References

Albouy D. (2009). The Unequal Geographic Burden of Federal Taxation. *Journal of Political Economy, 117*(4).

Asker, J., Collard-Wexler, A., & Loecker, J. D. (2014). Dynamic Inputs and Resource Misallocation. *Journal of Political Economy, 122*(5).

Au, C., & Henderson J. V. (2006). Are Chinese Cities Too Small? *The Review of Economic Studies, 73*(3), 549-576.

Bai, C.-E., Hsieh, C.-T., & Qian, Y. (2006). The Return to Capital in China. *Brookings Papers on Economic Activity*.

Bartelsman, E., Haltiwanger, J., & Scarpetta, S. (2013). Cross-Country Differences in Productivity: The Role of Allocation and Selection. *The American Economic Review, 103*, 305-334.

Brandt, L., Tombe, T., & Zhu, X. (2013). Factor Market Distortions across Time, Space, and Sectors in China. *Review of Economic Dynamics, 16*(1), 39-58.

Desmet, K., & Rossi-Hansberg, E. (2013). Urban Accounting and Welfare. *The American Economic Review, 103*(6), 2296-2327.

Dobson, W., & Kashyap, A. K. (2006). The Contradiction in China's Gradualist Banking Reforms. *Brookings Papers on Economic Activity*.

Dollar, D., & Wei, S. J. (2007). Das (Wasted) Kapital: Firm Ownership and Investment Efficiency in China. *NBER Working Paper*.

Fajgelbaum, P. D., Morales, E., & Serrato, J. C. S. (2016). State Taxes and Spatial Misallocation. *Working Paper*.

Fu, Y., & Zhang, L. (2016). Spatial Pattern of Urbanization and Welfare in China. *Dissertation in NUS, Chapter 3*.

Han, L., & Lu, M. (2016). Housing Prices and Investment: An Assessment of China’s Inland-favoring Land Supply Policies. *Journal of the Asian Pacific Economy, 22*(1), 106-121.

Hsieh, C.-T., & Klenow, P. J. (2009). Misallocation and Manufacturing TFP in China and India. *Quarterly Journal of Economics, CXXIV*(4), 1403-1448.

Hsieh, C.-T., & Song, Z. M. (2015). Grasp the Large, Let Go of the Small: The Transformation of the State Sector in China. *Brookings Papers on Economic Activity*.

Li, X., Ma, L., & Tang, Y. (2016). Spatial Misallocation across Chinese Firms. *Working Paper*.

Neumark, D., & Simpson, H. (2015). Place-Based Policies. *Handbook of Regional and Urban Economics, 5B,* 1197-1287.

Restuccia, D., & Rogerson, R. (2017). The Causes and Costs of Misallocation. *Journal of Economic Perspectives, 31*(3), 151-174.

Wu, G. (2017). Capital Misallocation in China: Financial Frictions or Policy Distortions? *Working Paper.*

Yang, S., & Fu, Y. (2017). Essays on China's Industrialization and Economic Geography. *Dissertation in NUS*. Chapter 1.