Is Beijing Too Large?

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Abstract

This paper estimates the agglomeration economies in Chinese cities and tests whether Chinese cities, in particualr, Beijing, are too large or not by applying the Henry George Theorem. Due to the difficulty in obtaining the data of land rent in China, we can not test the Henry George Theorem directly but compute the ratio between the total land value and the total Pigouvian subsidy for each cities and see if there is a significant difference between different levels of hierarchy of cities following Kanemoto et al.(1996). Because the ratio in Beijing is shown to be significantly larger than that of other cities, we could say that there is a possibility that Beijing has a tendency to be too large.

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Contents

1 Introduction

With the rapid development of China, the population of Beijing, the capital of China, is always the focus of society. In the past years, the Chinese government introduced a series of policy to control the population in Beijing, the purpose of this thesis is to figure out whether Beijing is too large or not.

The purpose of this thesis is twofold. The first is to estimate the agglomeration economies of Chinese cities and the second is to test whether Beijing is too large or not. There are few literatures on Chinese city size concerning agglomeration economies so far.

Luan et al.(2008) discussed that Chinese cities size from agglomeration economies, and used Chinese cities data in 2006 to examine the relationship between city size and output. The results showed expanding the city size cannot bring the corresponding economic growth. Therefore, they suggested that the government should give more support to the smaller cities when focusing on the larger city development.

Xi (2012) found that there is a positive correlation between the net urban agglomeration economies in Chinese city and city size. However, with the expansion of the city, the net scale economies is shown to be an inverted U shape. In other words, the net scale economies are relatively low for the city population over 5 million while the net scale economies are close to the optimal for the city population between 1 million and 5 million.

The most typical thesis should be Au and Henderson (2006), who test if the Chinese cities are too small by assuming the inverted U shape between city size and real income per worker. They show that only 10% of the 205 cities are overpopulated. This is in marked contrast to what is expected in a free migration economy---virtually all cities are too large.

However, there is no literature applying the Henry George Theorem to Chinese cities. This thesis applies the Henry George Theorem to test whether Chinese cities are too large or not. Depending on the sources of agglomeration economies and counteracting deglomeration economies, the theorem takes different forms. In all cases, however, the optimal city size is obtained when a certain measure of agglomeration benefits equals the total differential urban rent in the city, where the differential urban rent means the difference between land rent in an urban area and the rural rent at the edge of the city. Due to the difficulty in obtaining the data of land rent in China, we can not test the Henry George Theorem directly but compute the ratio between the total land value and the total Pigouvian subsidy for each cities and see if there is a significant difference between different levels of hierarchy of cities following Kanemoto et al.(1996). From this test, we cannot conclude that Beijing is too large or too small immediately. However, if the ratio of Beijing is significantly larger than that of other cities, then we could say that there is a possibility that Beijing has a tendency to be large.

The organization of this paper as follows. In Section 2, we estimate aggregate production functions and get the degree of agglomeration economies in each city. In Section 3, using the value of agglomeration economies above, we obtain the total Pigouvian subsidy and compare it with the total land value. Section 4 summarizes the results of this paper and proposes some improvements and suggestions.

2 Estimation of Agglomeration Economies

In this section we estimate aggregate production functions for cities in China. It is desirable to use the data of metropolitan statistical area (MSA) which is a geographical labor market with a relatively high population density at its core and close economic ties throughout the area. In China, however, since there is no official definition on the MSAs so far, single cities without suburbs is the sample to analyse, which will result in biases, in particular, for those larger cities. Because in larger cities, there are more suburbs which have a strong economic connection with. For example, according to the development plan of the metropolitan area of economy around the capital, 13 counties, cities and districts around Beijing have been included in the metropolitan area[1].Unfortuntately, we cannot take these suburbs around the city into account because the lack of the definition for the MSAs.

Metropolitan Area of Economy around Beijing

Figure 1

[1]As shown in the Figure 1, these areas are Zhuzhou city, Laishui county, Zhuolu county, Huailai county, Chicheng county, Fengning Manchu autonomous county, Luanping county, Sanhe city, Dachang Hui autonomous county, Xianghe county, Guangyang district, Anci district and Guan county.

2.1 Production Functions with Agglomeration Economies

We estimate an aggregate production function of a city in order to measure the degree of the agglomeration economies. Suppose that a production function of a city is written as $Y = F(N, K)$, where Y, N, K are the total production, employment and private capital, respectively. If there are no agglomeration economies, then a production function should be constant returns to scale with respect to N and K at the city level. Therefore, we can measure the degree of agglomeration economies by the increasing returns to scale of the estimated production function.

Assume that firms receive external benefits from agglomeration in a city, measured by the total employment N, then the production function of a firm can be written as $f(n, k, N)$, where n and k are respectively the employment and capital of one firm. For simplicity, suppose that there are m firms which are homogeneous, then the aggregate production function of a city is $Y = mf(n, k, N)$.

Although a variety of functional forms are possible for the urban production function, we first start with a simple Cobb-Douglas function.

$$Y = AK^{\alpha}N^{\beta} \tag{1}$$

Because the public finance expenditure G and accessibility B[2] should also be taken account into, the production function may be given by

$$Y = AK^{\alpha}N^{\beta}G^{\gamma}B^{\delta} \tag{2}$$

Because we assume that an individual firm's production function has constant returns to scale with respect to labor and capital, the magnitude of urban agglomeration economies can be measured by the degree of scale economy, $\alpha + \beta - 1$.

[2]The explaination of accessiblity B is given in the next section.

The estimation results at the back part show that we get a negative value of scale economy $\alpha+\beta-1$, then Pigouvian subsidy is negative, too. We therefore try another form[3].

$$Y = AK^{\alpha}N^{1-\alpha}N^{\gamma lnG+\delta lnB} \tag{3}$$

In this formulation the degree of agglomeration economies is $\gamma lnG + \delta lnB$.

2.2 Data and Classification of Cities

We use cross-section Chinese data in 2015. Y, N, G are respectively the gross regional product, employment and public finance expenditure of each city. It is too difficult to calculate the stock of capital K (fixed capital and goods in stock included) due to data problems. Hence, this paper uses the total fixed assets of industrial, which approximately replace the stock of capital used in production, following Luan(2008) and Au and Henderson(2006). Accessibility B is to measure the potential of market. For example, if a city has a huge population and population around the city is also large, then this city has a great accessiblity. Specific formula is following, accessibility of jth city, [4]

$$B_j = \sum_{i}^{291} \frac{\text{permanent resident of city } i}{e^{0.00001*\text{distance}_{ij}}} \tag{4}$$

where distance_{ij} is the distance between city i and city j. To compute the distance of two cities, we can use the latitudes and longitudes of two cities.[5]

As discussed above, due to the difficulty in obtaining the land rent data, we use the land price to test each city indirectly. The calculation for total land value is somewhat rough. Using the total transaction land price and transaction area, we can get the average land price of each city, then multiplying by the area of urban construction

[3] The formular is come from Y. Kanemoto, T. Ohkawara, and T. Suzuki, (1996), in their paper, they use the form by $Y = AK^{\alpha}N^{1-\alpha}N^{\gamma lnG}$, because of accessibility B taken into accout, the formular is shown as Equation (3)

[4] The coefficient 0.00001 makes the power lower such that the denominator of B_j is an appropriate value.

[5] We can input the latitude and longitude of two cities and obtain the distance on the website http://vldb.gsi.go.jp/sokuchi/surveycalc/surveycalc/bl2stf.html

land[6], we will get the total land value of each city. The specific way of transaction and the shortcomings of this calculation will be arranged at section 3.2. See the data sources at the Appendix.

In order to estimate the production functions and see the performance of different city groups, all 276 prefecture-level cities [7] are divided into two groups based on the permanent population. One group is the cities with a population of more than 5 million, another group is the rest of the cities. Due to the hukou system which restricts the migration in China, classification by permanent population probably cannot show the right hierarchy. For instance, Linyi city in Shandong province has a population of 10.22 million and that of Nanyang city in Henan province is 10.02 million whereas these two provinces are famous populous province in China. There are perhaps a large number of people who are not allowed to migrate into cities they want because of the hukou system. The magazine CBN weekly[8] may give another perspective to classify the cities in China. City hierarchy rank by CBN weekly in 2015 is based on the density and quantity of first-class brand came into, GDP, income per capita, 211 universities[9] and the number of Fortune Global 500, which measures each city comprehensively. This hierarchy rank is divided into five levels, which are from the greatest first tier cities to fifth tier cities. In order to meet the need of this paper, Chinese cities are classfied into the first tier and non-first tier.

2.3 Estimation Results

We first estimate the simple Cobb-Douglas production function, so that equation (1) is rewritten as

[6]Urban construction land consists of land for residence, administration and public services, commercial and bussiness facilities, manufacturing, logtistics and warehouse, municipal utilities, roads, squares and green space.

[7]There are 291 prefecture-level cities in total but 15 cities are omitted due to the data missing.

[8]CBNweekly is a weekly-published business news magazine, which was founded by Shanghai Media Group and produced by China Business Network Media (CBN). CBNweekly advocates new concepts, adopts the relaxing and readable style and creates the unique philosophy of business news to provide readers with fresh and valuable business news service. As far as contents are concerned, the magazine not merely examines the professional corporate phenomena, but involves the practical industry information and the corporate concerns.

[9]Project 211 is a project of National Key Universities and Colleges initiated in 1995 by the Ministry of Education of the People's Republic of China, with the intent of raising the research standards of high-level universities and cultivating strategies for socio-economic development.

$$ln\frac{Y}{N} = A_0 + a_1 ln\frac{K}{N} + a_2 lnN \tag{5}$$

It will be imprecise if we use city data without suburbs. Therefore, a little modification is necessary. The gross production, capital, employment and public finance expenditure of a city with suburbs around are Y_T, K_T, N_T and G_T, which are assumeed to be proportional to the gross production Y, capital K, employment density D[10] and public finance expenditure G of the single city without suburbs. i.e., $Y_T = c_1 * Y$, $K_T = c_2 * K$, $N_T = c_3 * D$, $G_T = c_4 * G$. The production function of a city with suburbs is then given by

$$Y_T = AK_T^{\alpha} N_T^{\beta} \tag{6}$$

Substituting the proportional assumptions into equation (6), we can get

$$ln\frac{Y}{D} = A_0 + a_1 ln\frac{K}{D} + a_2 lnD \tag{7}$$

where $a_1 = \alpha$ and $a_2 = \alpha + \beta - 1$.

[10]Here employment density D should equal empolyment in single center city divided by the area of urban construction land.

Table 1 reports the estimation results for Equation (7) for different size groups.

Table 1
Estimates of a Cobb-Douglas Production Function without Public Finance Expenditure and Accessibility Under Permanent Population Classification

Parameter Number of Oberservations	All cities 276	Over 5 mil 83	Under 5 mil 193
A_0	2.63 (4.66)	4.19 (4.12)	5.59 (7.79)
a_1	0.81 (25.25)	0.84 (17.03)	0.61 (14.84)
a_2	0.04 (0.61)	-0.30 (-2.57)	0.15 (2.01)
$\overline{R}^2$	0.74	0.87	0.66

Note: Numbers in parentheses are t values.

The regression results are summarized in Table 1. We can see the scale economy a_2 of cities with a population of more than 5 million is neagtive and significant. One possible reason is that we use single cities as samples, which do not involve suburbs around cities, in particular larger cities. Second reason is that service sector has a great proportion in larger cities, which also exist scale economy. For example, the video film industry in Beijing developed rapidly, which attracted more than 70% film distribution companies, media companies and post-production companies all over the country, and excellent resources, like outstanding literary creators, directors and actors, all gathered here. However, due to the difficulty in obtaining the capital data on service sector, we have to use industrial fixed assets to replace capital data. Third reason is that it is stricter on hukou system restriction in larger cities than that in other cities, so the restriction may limit the scale economy in larger cities . Then we change the classification by CBN weekly. As seen in Table 2, however, the 1st tier cities still have a negetive scale economy and other coefficients do not change much either.

Table 2

Estimates of a Cobb-Douglas Production Function without Public Finance Expenditure and Accessibility Under CBN weekly Classification

Parameter Number of Oberservations	All cities 276	1st tier 19	2nd-5th tier 257
A_0	2.63 (4.66)	4.19 (1.40)	1.87 (2.09)
a_1	0.81 (25.25)	0.82 (9.11)	0.71 (20.69)
a_2	0.04 (0.61)	-0.12 (-0.64)	-0.04 (-0.71)
$\overline{R}^2$	0.74	0.88	0.70

Note: Numbers in parentheses are t values.

Next, we take the public finance expenditure and accessiblity into consideration, similar to the modification above, $Y_T = AK_T^{\alpha}N_T^{\beta}G_T^{\gamma}B^{\delta}$ can be rewirtten by

$$ln\frac{Y}{D} = A_0 + a_1 ln\frac{K}{D} + a_2 lnD + a_3 ln\frac{G}{D} + a_4 ln\frac{B}{D} \quad (8)$$

where $a_1 = \alpha$, $a_2 = \alpha + \beta + \gamma + \delta - 1$, $a_3 = \gamma$ and $a_4 = \delta$.

Table 3 reports the estimation results of equation (8). We can see the public finance expenditure estimator a_3 are all positive and significant in all groups, which is totally different from the case in Japan. In Japan, the coefficient is negative (Kanemoto and Saito 1998) and authors give a reason that Japanese government may aim for the redistribution effect between areas, the low income areas get the main priority to have the public finance expenditure. However, China is a developing country, focusing on the development of larger cities where probably have a higher income. The fact that a_4 has a positive value and a significant t value supports the New Economic Geography in that the closer to consumers, the more productive the city. Estimator a_4 has no obvious difference between 1st tier and 2nd-5th tier. One reason may be that China has hukou system which restricts people to migrate, so there should be more people in the first tier cities if in the free migration economy, which means the difference of accessibility may be larger in the free migration countries. The urban externality a_2 is positive for all groups, but insignificant for 1st tier cities, which has a low t value 0.32 compared with a high t value 3.51 in 2nd-5th tier cities. We have discussed the three reasons in the above. In fact, some papers get the similar results as well: Chen and Jiang (2000) shows that cities with a population between 1-5 million[11] have the largest net scale economy in their empirical research. Jin (2006) shows that cities with a popualtion more than 10 million has no urban scale economy while some medium and small cities have urban scale economy following Carlino,G.A. (1982). It is amazing that the urban externality of 2nd-5th tier group is six times as large as that of 1st tier group, which is similar with the case in Japan. The degree of scale economy in cities with a population over 1 milloin is only 7%, while that in cities with population 0.2-0.4 million is 25% in Japan (Kanemoto et al.1996).

Table 3

Estimates of a Cobb-Douglas Production Function with Public Finance Expenditure and Accessibility Under CBN weekly Classification

Parameter	All cities	1st tier	2nd-5th tier
Number of Oberservations	276	19	257
A_0	-0.81	5.69	10.00
	(-1.66)	(2.79)	(12.57)
a_1	0.38	0.38	0.37
	(12.69)	(3.43)	(11.93)
a_2	0.21	0.04	0.24
	(5.06)	(0.32)	(3.51)
a_3	0.70	0.33	0.05
	(17.58)	(3.77)	(14.60)
a_4	0.19	0.24	0.19
	(6.28)	(2.03)	(6.24)
$\overline{R}^2$	0.89	0.94	0.86

Note: Numbers in parentheses are t values.

Note that in this production function, the degree of scale economy $\alpha + \beta - 1 = a_2 - a_3 - a_4$ is negative for 1st tier cities, which implies a negative Pigouvian subsidy. Therefore, following Kanemoto et al. (1996), we try another production function

[11]Most 2nd-5th tier cities have a population between 1-5 million. So population between 1-5 million cities are basically equivalent to the 2nd-5th cities.

$Y = AK^{\alpha}N^{1-\alpha}N^{\gamma lnG+\delta lnB}$. The modification for $Y_T = AK_T^{\alpha}N_T^{1-\alpha}N_T^{\gamma lnG_T+\delta lnB}$ is following,

$$ln\frac{Y}{D} = A_0 + a_1 ln\frac{K}{D} + a_2 lnGlnD + a_3 lnBlnD \tag{9}$$

where $a_1 = \alpha$, $a_2 = \gamma$ and $a_3 = \delta$. The degree of agglomeration ecnomies is $\gamma lnG + \delta lnB$.

Table 4 shows the results of equation (9), in this form of production function, the coefficient of the accessibility, a_3, is just 0.0004 and insignificant, which is not very ideal espescially for the 1st tier cities. Because of nonlinearity, the scale economy depends on the public finance expenditure and accessiblity of each group, we compute the average value of public finance expenditure and accessibility for each group first and then substitute the values into the agglomeration economies, $\gamma lnG + \delta lnB$. The degrees of agglomeration economies are considerably smaller in Table 4 than in Table 3. The degree of agglomeration economies of 1st tier cities is still smaller than that of 2nd-5th tier cities. In all cities group doubling the city size increases production by 8%. In the 2nd-5th tier cities group, the production increases are about 6% while the production increases are only 3% in the 1st tier cities.

Table 4
Estimates of a Modified Cobb-Douglas Production Function with Public Finance Expenditure and Accessibility Under CBN weekly Classification

Parameter	All cities	1st tier	2nd-5th tier
Number of Oberservations	276	19	257
A_0	1.91	1.78	-0.59
	(4.34)	(1.61)	(-1.26)
a_1	0.83	0.84	0.73
	(28.76)	(10.92)	(25.22)
a_2	0.007	0.004	0.006
	(1.08)	(0.43)	(2.12)
a_3	0.008	0.0004	0.005
	(0.82)	(0.02)	(1.75)
$\overline{R}^2$	0.75	0.87	0.72
Agglomeration Economies	0.08	0.03	0.06

Note: Numbers in parentheses are t values.

3 A Test for Optimal Size of Beijing

Using the estimates of agglomeration economies obtained above, we can test if Beijing is too large or not.

3.1 The Henry George Theorem for Optimal City Size

The Henry George Theorem, named for 19th century U.S. political economist and activist Henry George, states that the optimal city size is obtained when Pigouvian subsidy equals the total differential urban rent in the city, where the differential urban rent means land rent in an urban area minus the rural rent at the edge of the city. Furthermore, it is easy to show that the second order condition for the optimum implies that the total differential rent is larger than the Pigouvian subsidy if the city size exceeds the optimum. In this paper, we assume that all residents are homogeneous for simplicity and we have three potential sources for agglomeration forces: externalities between firms in a city, public finance expenditure and accessibility of a city. Deglomaration force is the urban costs. When the city expands, the average commuting cost increases and the housing or land prices rises throughout the city. Note that the condition for optimal city size depends on the degree of publicness of public good. We consider two extreme cases, i.e., pure local public good and pure private good cases.

In the case of pure local public good, we assume that a large number of developers in a city, each developing an extremely small area, and each supplying the local public good in their area. The developers rent land from the rural landlords and sublet it to city residents at the market rent. Therefore, the developer's profit is following

$$\pi = [R(x) - R_a]h(x) - c(X) \tag{10}$$

where $R(x)$ is the unit land rent at radius x from the center,

R_a is the unit rural land rent,

$h(x)$ is the housing area at radius x,

X is the amount of public good supplied of the city, and

$c(X)$ is the cost of supplying X public good.

Furthermore, we assume that the profit is distributed equally among all city residents. In other words, this agglomeration activity generates external benefits π that returns to the residents, which means this profit is the Pigouvian subsidy. Hence, the Pigouvian subsidy is the difference between the differetial urban rent and the cost $c(X)$.

In the case of pure private good, however, it is not the responsibility for land developer to supply the private good. Therefore, there is no cost reduction in the profit of land developer. The Pigouvian subsidy or the profit of the land developer is given by

$$PS = \pi = [R(x) - R_a]h(x) \tag{11}$$

In fact, most of the public finance expenditure involve lots of congestion and cannot be regarded as a pure public good. For the impure local public goods, we use only part of the costs of the goods, i.e., $0 < c_{impure} < c(X)$. For the feasibility of calculating, we just consider the two extreme cases above.

Next, we will first derive the Pigouvian subsidy of the Cobb-Douglas case. In this case, the firm's production function can be written as $f(k, n, N, G, B) = Ak^{\alpha}n^{1-\alpha}N^{\alpha+\beta-1}G^{\gamma}B^{\delta}$, where k and n are respectively capital and labor inputs of one firm. An extra employee in this city will marginally increase production by $m\frac{\partial f}{\partial N}$, so that the total Pigouvian subsidy in a city is given by

$$PS = Nm\frac{\partial f}{\partial N} = (\alpha + \beta - 1)Y \tag{12}$$

where Y is the total production, $Y = AK^{\alpha}N^{\beta}G^{\gamma}B^{\delta}$.

Unfortunately, $\alpha + \beta - 1$ is negative according to the estimation results in Section 2. Hence, we cannot use this type of production function because of the negative Pigouvian subsidy.

Next let us see the other production function. The firm's production function is given by $f(k, n, N, G, B) = Ak^{\alpha}n^{\beta}N^{\gamma lnG+\delta lnB}$, and the total Pigouvian subsidy in the city is given by

$$PS = (\gamma lnG + \delta lnB)Y \tag{13}$$

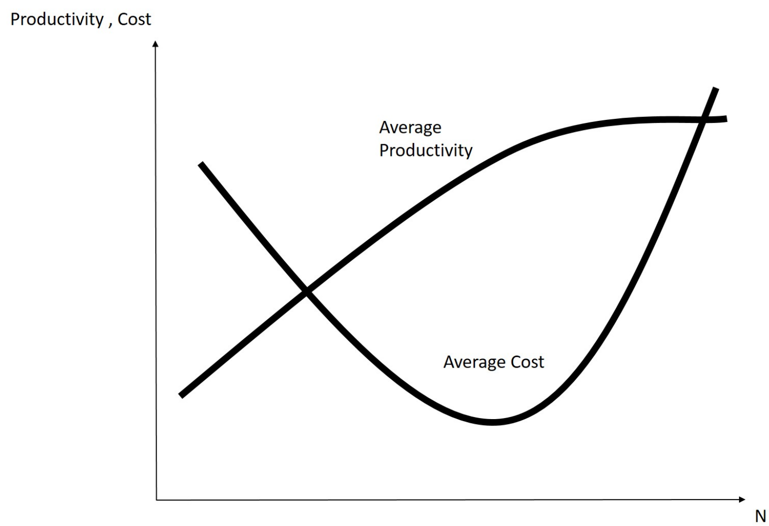
We can compare this Pigouvian subsidy with the total urban rent or the total urban rent minus the public finance expenditure in order to see if Beijing has a tendency to be large.

3.2 Hierarchy of Cities and Total Land Value

Because of the difficulty in obtaining the data of land rents, we do not test the Henry George Theorem directly. What we do instead is to compute the ratio between the total land value and the total Pigouvian subsidy for each city and see if there is a significant difference between different levels of hierarchy (Kanemoto et al.1996). [12] The following argument shows that there is a good reason to believe that cities tend to be too big and that the divergence from the optimum tends to be larger for cities at a higher level of hierarchy. First, let us see why cities have the tendency to be

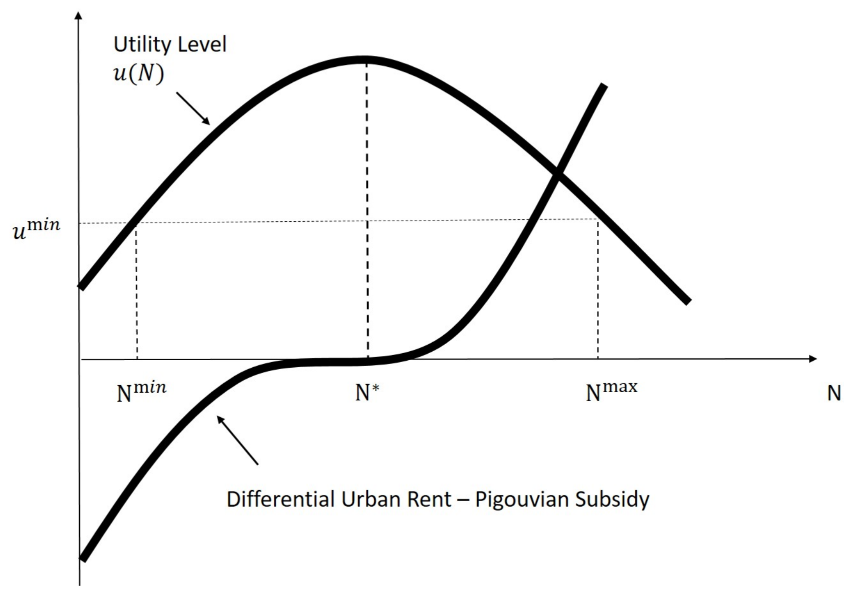
[12] In fact, they assume that the ratio of aggregate land values to aggregate land rents is constant across levels of hierarchy. We check this assumption by the aggreagate housing price and aggregate housing rent data because there is data of land rent for residential use only in China. However, we found that the housing ratio differs between 1st tier and 2nd-5th tier cities. The ratio of the 1st tier cities is significantly larger than the 2nd-5th tier cities because there is sufficient infrastructure in the 1st tier cities, which may lead to over-investments in real estate, espeically in Beijing and Shanghai.

large. If there is agglomeration economies in cities, then according to proposition of increasing returns to scale, the productivity increases with city size. However, when the city size is too large, the marginal increase in productivity will diminish. Therefore, productivity (average benefit) of a city is like the curve shown in Figure 2. Next, we explain the cost of a city, when a firm starts producing, a certain amount of fixed cost is necessary. The fixed cost is huge for each resident in the city if the city is small, but the average cost of a city decreases with city size. Nevertheless, when a city is larger than a certain threshold, external diseconomy, for example, the commuting cost for long distance, air pollution, which are the most serious problems in Beijing, raises the average cost as shown in Figure 2.



The Relationship Between Average Productivity, Average Cost and City Size
Figure 2

Net benefit per resident is the difference between the average productivity and average cost, which can be regarded as the utility of a resident living in the city. Figure 3 shows the relationship between city size and utility level. It is obvious that spatial equilibria must satisfy that all cities have the same utility. Even though all cities have the same utility, the population is may not always be the same between them. The same utility can be achieved by two different sizes of population (left and right to the peak N^*) in Figure 3. However, the equilibrium on the left of the peak N^* is unstable. Any shock which causes migration to other cities will make this city's population smaller and decrease the utility. Further, more and more people begin to move to other cities. Therefore, the stable equilibrium is definitely on the right of the peak and all cities have the same population. Unlike the case of city size smaller than N^*, on the contrary, the utility will decrease when people move in and the utility increases when people move out for cities larger than N^*. Due to the utility's decrease of the city which people move in, the residents have an incentive to move out to other cities, eventually, the equilibrium is restored. Thus, all equilibria which are between N^* and N^{max} are stable. From the argument above, we know that all cities formed by the agglomeration economies have a tendency to be large and because of the stability, the optimal city size cannot be achieved just by market itself, the government intervention is necessary.



The Total Differential Urban Rent and The Pigouvian Subsidy
Figure 3

Beijing's government has already acted to restrict population growth and planned to move non-capital functions away from the city. This year, Beijing will continue to relocate wholesale markets, factories, universities and hospitals to suburban areas and Hebei province. In April 2017, a new area in Hebei named Xiong'An is established, the construction of the area is described as part of the "millennium strategy" and this area is a state-level new area. Its main function is to serve as a development hub for Beijing-Tianjin-Hebei economic zone as shown in Figure 4. Additionally, "non-core" functions of the Chinese capital, including offices of some state-owned enterprises, government agencies, and research and development facilities, are expected to migrate here.

Beijing-Tianjin-Hebei Economic Zone and Xiong'An New Area

Figure 4

However, the above argument does not take the hierarchical structure of cities into account. In fact, there is a complex hierarchy system of cities. For instance, a mount of headquarters of firms and financial institution are located in Beijing and Shanghai, where the headquarter function services will be provided to other cities. On the other hand, such as Chengdu and Nanjing, are local center cities. Cities in each hierarchy have different functions which determine its own size. Hence, depending on the order of hierarchy, the size is different from each other. Because of multiplicity of equilibria, the difference between the actual and optimum city size depends on the history. The range of possible divergence, however, depends on the size of the start-up city. Kanemoto et al. (1996) said that with a hierarchical structure, a new city in a certain hierarchy usually comes from a city at a lower level. This means that it is relatively easy to increase the number of cities at a lower level of the hierarchy. In contrast, it is extremely difficult to add a new city at the highest level of the hierarchy. For instance, the population of Wuhai is less than 0.56 million, once the city size get the stable equilibrium which larger than its optimal size, people may easily establish a new city immediately to prevent the utility decrease because of the small population and less infrastructure. On the contrary, Beijing is about 22 million, even though the stable equilibrium exceeds its optimal size, it is hard to bulid a new city like Beijing, which leads to the divergence from the optimum become larger. Therefore, we can conjecture that divergence from the optimal city size is larger for larger cities. The main task of this section is to check if this conjecture is true. Computing the ratio between the total land value (minus the total public finance expenditure) to the total Pigouvian subsidy for cities at different levels of hierarchy, we check if the ratio is larger for Beijing than for other cities.

As for the total land value, in China, Land Bureaus at the local and provincial levels are authorized by the central government to grant land use rights to entities and individuals. According to the Provisions on the Grant of State-owned Construction Land Use Rights through Tender, Auction and Listing issued by Ministry of Land and Resources on 28 September 2007, the grant of land use rights for industrial, commercial, recreational, commodity residence[13] must be conducted through a tender, auction or listing process organized by the relevant Land Bureau or a real estate trading center designated by the relevant Land Bureau. Therefore, we find the transaction area and transaction price value data of state-owned land for construction use granted through a tender, auction or listing from China Land and Resources Statistical Yearbook 2016, then we can compute the average land value of each city. However, there is a possibility that the transaction in some cities has a large proportion of industrial or commercial land use in that year, which results in under or overestimation of the average land price value.

[13]In fact, there are some other land tpyes should also be granted through tender, auction and listing, including for tourism, other profit-making purposes and integrated use.

3.3 The Ratio Between the Total Land Value and the Total Pigouvian Subsidy

We compare the total land value and the total Pigouvian subsidy in 19 cities which in the first tier. Table 5 presents the results for the modified Cobb-Douglas case of equation (9). The total land value is very high as compared to the total Pigouvian subsidy in all cities. On average, the ratio between them is 71.2. The ratio of Beijing is the largest which reaches 315.7, and is about 4.5 times the average ratio while the smallest ratio city is Wuxi which is only 7.5. It is obvious that Beijing is indeed too large compared with all first tier cities. It is not surprising that Beijing, Shanghai, Guangzhou and Shenzhen have larger ratios: the average ratio of these four cities is 212.6, which is about three times the average ratio of all first tier cities. The reason is that these four cities (often abbreviated as BeiShangGuangShen) are the most influential in economy or politic in China. The ratios of the rest of first tier cities are all less than 100 except Xiamen where has a high land price. Most researchers claimed that the Xiamen government controls the supply of land intentionally in order to keep the land price high, creating the so-called "effect of hunger" phenomenon which leads that the supply is not inadequate to meet the demand. Residents in Minnan[14] area always have a profound local complex which should also account for the high land price. After making money outside the city, Minnan people enjoy purchasing houses in their hometown and the best area option is Xiamen, which becomes a convention. Eventually, a large amount of money is concentrated in real estate of Xiamen. Therefore, Xiamen has a ratio 140.2 even larger than that in Guangzhou.

If the public finance expenditure is a pure local public good, we have to substract the value of public finance expenditure from the total land value, but the ratio changes very little as indicated in the last column in Table 5.

[14]Minnan refers to the coastal region in southern Fujian Province, China, which includes the prefecture-level cities of Xiamen, Quanzhou and Zhangzhou.

Table 5
Total Land Values and Pigouvian Subsidies: The Modified Cobb-Douglas Case

City	Total Land Value (billion yuan)	Pigouvian subsidy (billion yuan)	$\frac{TLV}{PS}$	Total Land Value - Public Finance Expenditure (billion yuan)	$\frac{TLV-G}{PS}$
Beijing	49490	157	315.7	48920	312.1
Tianjin	2209	109	20.3	1885	17.3
Shanghai	42750	172	248.9	42310	245.3
Guangzhou	9884	115	86.3	9711	84.8
Shenzhen	23120	116	199.5	22770	196.5
Chengdu	1356	68	20.0	1210	17.8
Hangzhou	2956	62	47.5	2835	45.6
Nanjing	5124	60	86.0	5019	84.2
Wuhan	1598	68	23.5	1464	21.5
Xi'an	1000	35	28.22	908	25.6
Chongqing	2224	104	21.3	1845	17.6
Qingdao	667	58	11.5	45	9.4
Shenyang	584	44	13.2	503	11.4
Changsha	481	52	9.3	388	7.5
Dalian	521	47	11.0	430	9.1
Xiamen	2904	21	140.2	2839	137.1
Wuxi	387	51	7.5	305	5.9
Fuzhou	1039	34	30.7	967	28.6
Jinan	1181	36	32.5	1116	30.7
Average			71.2		68.8

4 Conclusion

The degree of agglomeration economies is estimated by the aggregate production functions of cities in China and these estimates are used to test if Beijing is too large. In the estimation of aggreagate production functions, major findings are summarized as follows.

First, just like other researchers' papers, for example: Chen and Jiang (2000) and Jin (2006), the urban externalities in the 2nd-5th tier cities are larger than those in the 1st tier cities. Second, some cities with a population of more than 5 million exhibit the negative scale economies. One reason is that we use single cities as samples, which do not involve suburbs around cities. Another reason is that capital data use the industrial fixed assets, however, the service sector has a great proportion in larger cities and service sector also can bring the agglomeration economies. Unfortunately, we have to ignore it due to the difficulty in obtaining the captital data of service sector. Third, in the phase of testing if Beijing is too large, the results show that all total land values are very high compared with the total Pigouvian subsidy and the ratio between the total land value and total Pigouvian subsidy in Beijing is the largest in all first tier cities. Therefore, we conclude that there is a possibility that Beijing has a tendency to be large.

Two improvements will be listed. First, the land value estimates in this thesis are rough . What we did is computing the average land price defined by the transacted land value divided by the transacted area, which may lead to the inaccuracy discussed in Section 3.2. Maybe we can calculate the average land price by another way. As we know, there are mainly four types land use in China, so it is better to use the average land price of industrail land, residential land, commercial land and integrated land multiplying the corresponding area of these four types land use, then add the products together, next divided by the sum of four types land use area, we will get the average land price of a city. However, the data of four types land use area is hard to obtain. Second, Chinese government or researchers should speed up the definition about the standard metropilitan areas, which can research the Chinese cities in a more accurate way.

In the last of conclusion, some urban policies should be proposed. At present, people are still willing to migrate to the first tier cities, like Beijing and Shanghai, which indicates the utility of living in first tier cities is higher than that of living in other cities. In other words, the utility is different between hierarchies in China due to the hukou system. Therefore, the conpensation is necessary if Beijing government plans to move non-capital functions away from the city. In order to make these firms have the incentive to migrate, Beijing government should compensate such that the utility is the same with they are in Beijing. For instance, Beijing government can research and establish special compensation fund for relocating the non-capital functions, which helps those functions to select site, grant land and purchase new equipments and so on.

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Appendix. Data Sources

Variable	Description	Source
Y	Gross regional product	China City Statistical Yearbook 2016
K	Total fixed assets	China City Statistical Yearbook 2016
N	Employment	China City Statistical Yearbook 2016
G	Public finance expenditure	China City Statistical Yearbook 2016
B	Accessibility	Google map
Permanent Population	Permanent population of the whole year 2015	China Urban Construction Statistical Yearbook 2016
Transacted Price Land Value	Total transacted value of land granted through tender, auction and listing in 2015	China Land and Resources Statistical Yearbook 2016
Transacted Land Area	Total area of land granted through tender, auction and listing in 2015	China Land and Resources Statistical Yearbook 2016
Area of Urban Construction Land	Urban construction land consists of lands for resident, administration and public services, commercial and bussiness facilities, indstry manufacturing, logtistics and warehouse, municipal utilities, roads, squares and green space	China Urban Construction Statistical Yearbook 2016

Note : All statistical yearbook in 2016, in fact, covers the statistical data in 2015.