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ACHIEVING INTER-CITY BALANCE IN URBAN DEVELOPMENT BY COUPLING EXPRESSWAY IMPROVEMENT AND LAND PRICE POLICIES IN CHINA

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Abstract

This paper considers the spatial mechanism of land market applying to China where land price is determined by the government and the land sales revenue is used for infrastructure improvement. A spatial model is designed to give an optimal land price as a tool for regional development policy to achieve a well-balanced growth of economy between the cities within a province. This idea is useful to promote a sustainable regional development avoiding serious traffic bottlenecks.

BACKGROUND

During the 1990's, construction of inter-city expressways has been booming in China. Improvement of inter-city transportation can change the competitiveness of each city in attracting industry. On the other hand, each city should not grow too rapidly to avoid bottlenecks and negative impacts brought about by failure to provide adequate urban infrastructure. In China, the land market is very special in that the land prices are established as a value for transacting land use-rights by the local government rather than having the market determine the price. The revenue from selling urban land use-rights by the government is used for financing urban infrastructure, while the pricing could be an effective tool in controlling the amount of industrial locations by encouraging or discouraging industries to locate in a particular place.

The objective of this study is to provide a tool to find optimal combinations of inter-city expressway construction and the relevant land price level to achieve a better-balanced growth between the cities within a region.

BASIC IDEA AND STRUCTURE OF THE MODEL SYSTEM

To seek an optimal inter-city location balance, it is necessary to examine the market-oriented behavior of an enterprise making a location decision and also the governmental behavior. Therefore the model system consists of two parts: 1) enterprise behavior, 2) government behavior.

Regarding enterprise behavior modeling, we need to know the following three items: A). location potential changes due to transportation improvement, in particular, due to construction of inter-city expressways, B). the change in expected profit by each industrial sector in each city, C). consequently, expectation of the amount of new location of industry in each city. This is the behavior of the enterprises. Regarding government behavior, we are sure that the government will behave 1) based on the urban planning law to determine the optimal location balance and 2) based on the urban land administrative law to adjust land price.

The structure of the model being developed is depicted in Figure 1. In enterprise behaviors, which are oriented by market mechanisms, enterprises will pursue maximum benefit based on location potential and production cost. Responding to the improvement of transport infrastructure, the existing inter-urban balance will shift to a new equilibrium. However, as mentioned before, this equilibrium may not satisfy the government, so the government will have to judge whether the equilibrium is permitted or not. If the new equilibrium does not meet the planned urban growth rate, the government is supposed to adjust the market oriented location behavior. However, in China a useful tool for government is to adjust land price in order to affect location cost at each site and thus indirectly adjust location behavior. Moreover, land revenue in China is totally invested in urban infrastructure improvement, therefore the land price adjustment influences location potential as well as profit, as shown in Figure 1.

Location Potential Model

According to the definition of location potential, the market scale in a city is considered as the most important factor of location potential. If a big market exists around a city, the location potential there is considered high. Moreover, this can be realized provided production cost in the city is economical. Transportation convenience is another essential factor for location potential. Transportation convenience means the transportation cost/time and the possibility/reliability of efficient transportation from production site to material/products markets. We can surmise that where there is a huge market geographically close to a city but without reliable accessibility for industries to access the market, location potential will become lower.

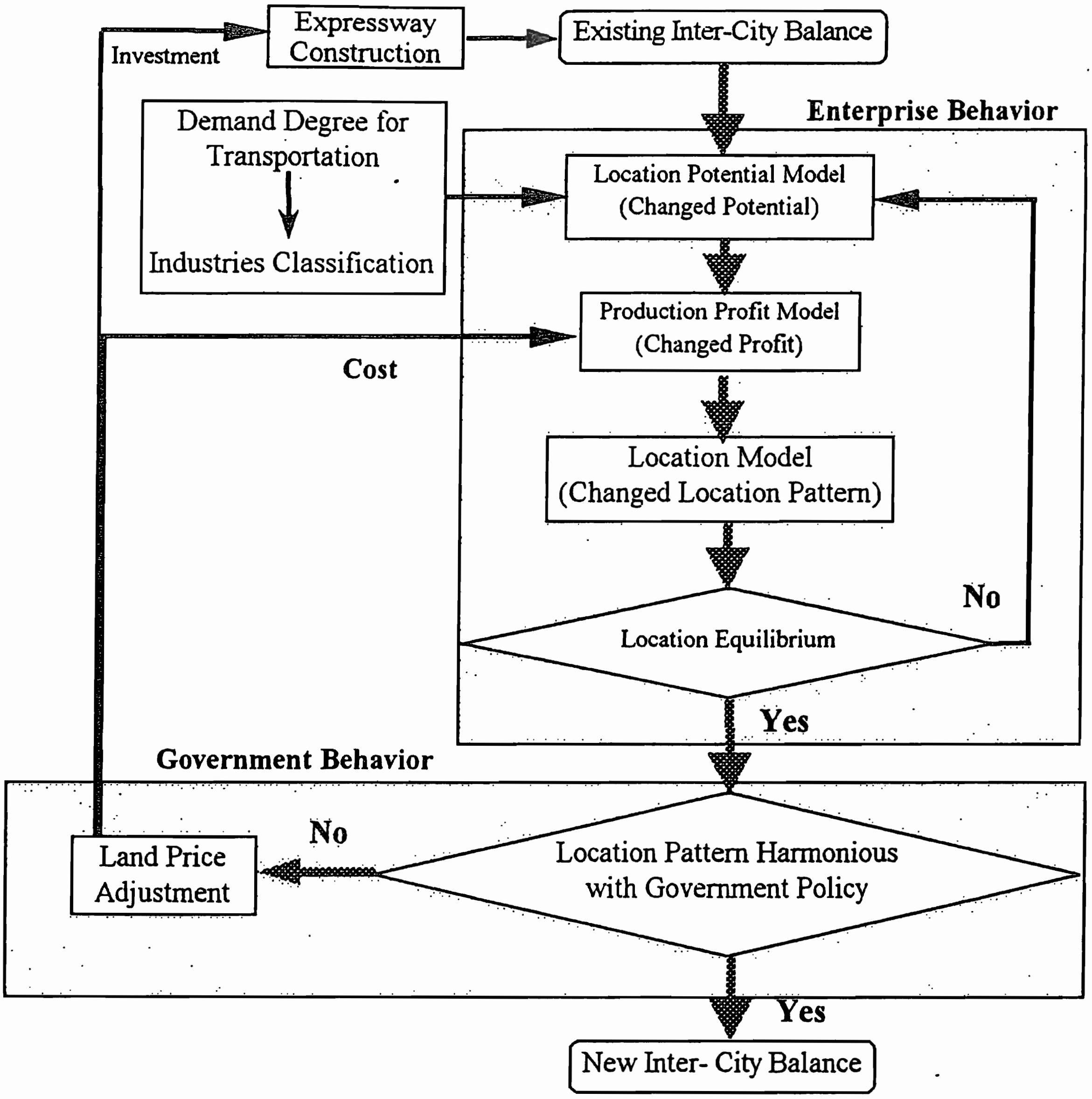

Figure 1 Structure of the Model

Thus we use a compound index which indicates the market scale in a wide area and the accessibility from production sites to the markets by road, representing the location potential. However, different industries have different degrees of demand for transportation. Therefore, the location potential of a site differs between industries. According to the degrees of demand for transportation in China's industries input-output table, we divided the industries into three categories to model the location potential. The classification result is shown in Table 1.

Table 1 Industry Category based on the Degrees of Demand for Transportation

Category	Name of Industry	Attribute
Main Industry (m)	Heavy Manufacturing, Light Manufacturing	Heavily depend on inter-city transportation
Quasi-main Industry (q)	Transportation, Telecommunication, Construction, Domestic Trade	Marginally depend on inter -city transportation
Service Industry (s)	Banking and Insurance, Sports, Health Care and Welfare Service	Hardly depend on inter -city transportation

Hereafter, we have taken a region (consisting of several cities) as the object area of the study. We have modeled the location potential of each industry with the following assumptions.

1. A country consists of several regions and a region includes several cities;
2. Cities in this study are in a developing country, manufacturing industry is the dominant production activity there;
3. Transportation time within a city depends on the diameter of the city and its per capita intra-city road area.
4. Laborers work and live in the same city, no inter-city commuters exist;
5. Cities in a region make contacts with the markets outside the region through harbors or railway terminals.

Location Potential for Main Industry

$$P_{mi} = \sum_j \frac{\phi_1 N_j^{\gamma 1} + \phi_2 F_j^{\gamma 2}}{t_{ij}^{\gamma}} \tag{1}$$

P_{mi}: Location Potential of Main Industries in City i; N_j: Population in City j (million people), j=1,..., n; F_j: Freight handled by the Harbor or Railway Terminal in City j (million tons); t_{ij}: Road Transport Time from City i to City j (hours); $\phi_1, \phi_2, \gamma, \gamma 1, \gamma 2$: Parameters

This function can be explained as follows. Obviously, population of a city can reflect its market scale, therefore, the bigger the population in a city, the bigger the market there is. However, depending only on the product/material markets in the city, enterprises cannot optimize their production activities, they also need the markets in neighboring cities. But as the distance between two cities increases, the attraction of markets in city j to city i will decrease. The second term represents the market scale outside this region and the accessibility to it. It is reasonable to think that the more the freight at a harbor or railway terminal, the larger the market outside it.

Location Potential for Quasi-Main Industry

$$P_{qi} = \sum_j \frac{\phi_3 Q_{mj}^{\gamma 3} + \phi_4 F_j^{\gamma 4}}{t_{ij}^{\gamma'}} \tag{2}$$

P_{qi}: Location Potential of Quasi-main Industries in City i; Q_{mj}: Total National Income of Main Industries in City i; $\phi_3, \phi_4, \gamma', \gamma 3, \gamma 4$: Parameters

Explanation of this function is as follows. From its attributes, we can see that quasi-industry is an added industry, its market scale should be represented by the demand from the main industry. Therefore, market scale is in direct proportion to the main industry and the operated freight in a city and its surrounding cities with the weight of transportation time.

From the meaning of "potential" we understand that "location potential" is not the actual location scale of industry. It is just an index representing the possibility for industry to locate. Because service industry serves main and quasi-main industries, we can not model its location potential here. We will calculate its location quantity directly from the quantities of main and quasi-main industries afterwards. In the next section, we use the location potential index together with production costs to model the industry location behavior.

Industries Location Model

We have modeled the location potential index that indicates the market scale and the accessibility to the market. The remaining important factor for location is production cost. We had originally planned to use land price and salary level to indicate this. But when we analyze the land prices and salaries in 14 cities (in the case study area), we found that the gap between the highest and lowest salary is about 40%, while this index of land prices is about 700%. Thus it is rational to think that the difference of production costs between cities is mainly caused by the difference in land prices. As a result, we use land prices together with the location potential index to construct a location scale model. In order to analyze and grasp the interaction between location potential and population in a city, we simulated location process with an iterative method. The process is explained in Figure 2.

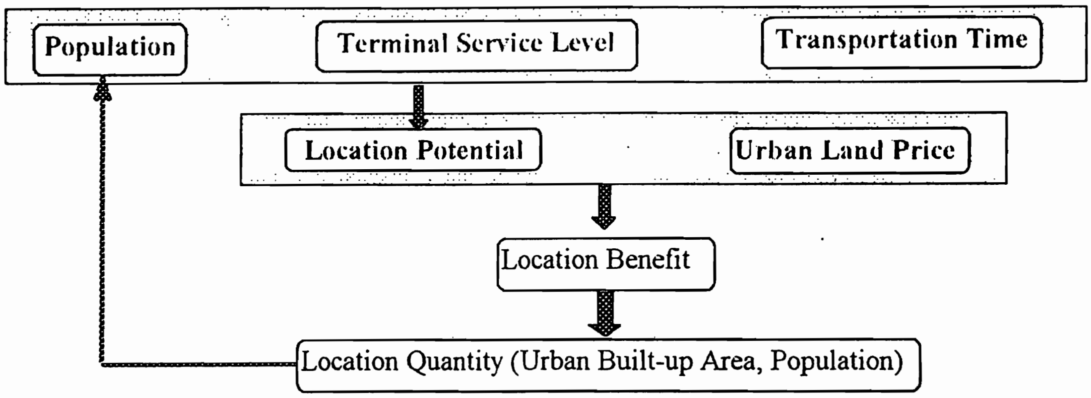

Figure 2 Location Equilibrium Mechanism of Industry Location

After a round of calculation, there is a new population index responding to the location quantity. We will feed this value back into location potential model in order to compare it with the former population so that we can judge whether there is an added potential (ΔP) or not. If there is, another round of calculation will be carried out. We will not stop the iteration and making judgements until the added potential is less than a given tolerance. Then, to model the industry location quantity based on the above analyses, two assumptions are added:

1. Land price differs from city to city, within a city land price does not differ from site to site;
2. Relevant inter-city relocation costs are not included.

Main and Quasi-main Industries Location Model

The location scale and location quantity function of the main and quasi-main industries in city i are as follows:

Main Industry: $\pi_{mi} = \alpha_1 + \beta_1 P_{mi} + \beta_2 C_{mi}$ (3)

π_{mi}: Production Scale of Main Industry in City i (million Yuan); C_{mi}: Land Price for Main Industry in City i (Yuan/Meter^2/Year); $\alpha_1, \beta_1, \beta_2$: Parameters

Location Probability in City i: $\Pr_{mi} = \dfrac{Exp\ (\pi_{mi})}{\sum_j Exp\ (\pi_{mj})}$ (4)

Share of Regional Income of Main Industry in City i: $Q_{mi} = \Pr_{mi} Q_m$ (5)

Q_m : Total Regional Income of Main Industry (Billion Yuan)

Quasi-main Industry : $\pi_{qi} = \alpha_2 + \beta_3 P_{qi} + \beta_4 C_{qi}$ (6)

π_{qi} : Production Scale of Quasi-main Industry in City i (Billion Yuan); C_{qi}: Land Price for Quasi-main Industry in City i (Yuan/Meter^2/Year); $\alpha_2, \beta_3, \beta_4$: Parameters

Location Probability in City i : $\Pr_{qi} = \dfrac{Exp\ (\pi_{qi})}{\sum_j Exp\ (\pi_{qj})}$ (7)

Share of Regional Income of Quasi-main Industry in City i : $Q_{qi} = \Pr_{qi} Q_q$ (8)

Q_q : Total Regional Income of Quasi-main Industry (Billion Yuan)

Employed Population in Main and Quasi-main Industry in City i :

$E_i^m + E_i^q = \zeta + \psi Q_{mi} + \varphi Q_{qi}$ (9)

E_i^m, E_i^q : Employed Population of Main and Quasi-main Industry in City i

ψ, φ : Productivity of Main and Quasi-main Iindustries respectively.

Now we have established the model for main and quasi-main industries, but the mechanism for the service industry is different because it hardly needs transportation. We have to model its location behavior in another way.

Service Industry Location

Because service industry supplies services for main and quasi-main industries, its scale closely depends on the employed population of the main and quasi-main industries. Its change is mainly decided by the change of the employed population in main and quasi-main industries. Its location behavior is modeled as follows:

$$E_i^s = \alpha_3 + \beta_5(E_i^m + E_i^q) + \lambda E_i^s \quad (10)$$

E_i^s: Employed Population in Service Industry in City i; λ : Coefficient of Self-demand of the Service Industry in Iuput-Output Table; α_3, β_5 : Parameters

Built-up Area of Each City i

After the above steps, we can obtain the total employed population. Then with the employment rate, we can calculate the total population in each city. In addition, unit of land required per capita is regulated by China's urban planning law. These units change according to the scales of the cities. They are 80 m^2/capita, 100m^2/capita and 100-120m^2/capita respectively for cities with populations over 1 million, 0.5-1 million and less than 0.5 million. Therefore, we can calculate the built-up urban area for each city as follows;

Total Population of City i : $N_i = \alpha_4 + \beta_7(E_i^m + E_i^q + E_i^s)$ (11)

β_7 : Employment Rate in this Region.

Built-up Urban Area of City i : $A_i = \mu_i N_i$ $\quad$ μ_i : required Unit of Land /Capita

Sub-model of Intra-city Transportation Time

It is rational to consider that intra-city transportation time is the function of the urban radius, average intra-city transportation speed and the road area/capita. We established a simple formula as follows:

$$\text{Intra-city Transportaion Time: } t_{ii} = \frac{R_i}{AverageSpe\ ed} \times \left(\frac{(\sum S_j)/n}{S_i}\right) \quad (12)$$

R_i : Radius of City i; S_i : Road Area/Capita in City i .

If the government invests 40% of the land revenue into road infrastructure as mentioned, road area will change according to land price change as follows:

$$\Delta S_i = (L_i^1 \times R_i^1 - L_i^0 \times R_i^0) \times 0.4 / \kappa \quad (13)$$

κ : Construction Cost of Unit Road Area (m^2/10,000Yuan); L_i : Urban Area of City i ($L_i = \pi R_i^2$).

We call the equation (1)-(13) the industry location model. By solving this group of equations we obtain the location quantity of each city, namely production of main and quasi-main industries, total population and the built-up area. These location quantities resulting from enterprise behavior may harmonize with the location policy, or it may contradict the location policy. After expressway construction, the government must use its land market power to control the changed inter-city location balance to the desired one, which would be considered the optimal inter-city location balance

Government Behavior and the Power of Land Market

After improvement of the transport infrastructure, location potential in each city will change, therefore, enterprise behavior oriented location quantity in each city can be calculated with the established model. This means that the existing inter-city location balance would be broken down, and a new one would appear. The difference between the two location balances is the inter-city growth pattern. The first thing the government ought to do is to judge whether this pattern conforms to its location policy or not. If it coincides with the government requirement, government will confirm it. Otherwise, the government will disrupt the growth pattern. Generally, government makes use of infrastructure improvement, subsidies or tax reformation to carry out this disruption. However, in China, government has a more powerful method, namely the power of the land market. This is because in China, land price is decided by the government, so the government can adjust the land price to affect enterprise location so as to disrupt the location change. The situation in which government will not adjust land price and enterprises will not change location is called harmony between government and enterprises. Under this condition a new inter-city location balance will appear.

From the viewpoint of urban planning, government in all countries aims at constructing a rational inter-city balance. This balance has functions of 1) Preventing population or production from concentrating too much in mega cities; 2) Reducing the disparity among cities; 3) Promoting a rationally distributed urban function. Even though urban planning projects have been implemented just recently, China attempts to use its strong planned structure to create an optimal inter-city balance. Especially, there are big surplus labor forces in its countryside, during the urbanization process they will definitely immigrate to urban areas. If they move to mega cities, the mega cities will become even larger causing general problems such as traffic congestion, long commuting time and environmental issues. Therefore, concerning urban growth rate, China's government formulates policies in its "Urban Planning Law". Article 4 of Chapter 1 of this law states that "1) government strictly controls the scale of the big cities, rationally develops middle sized and small cities, so as to realize a rational inter-city balance of production and population; and 2) Big, middle sized and small cities mean those cities with populations of over 0.5 million, 0.2 - 0.5 million and under 0.2 million respectively".

To control a city's scale can be explained as controlling the location quantity of industries. Because without industry, no employment chance exists, as the population will not immigrate to a city where a job can not be found. Based on our analysis, we explain the government requirement for urban growth with Figure 3.

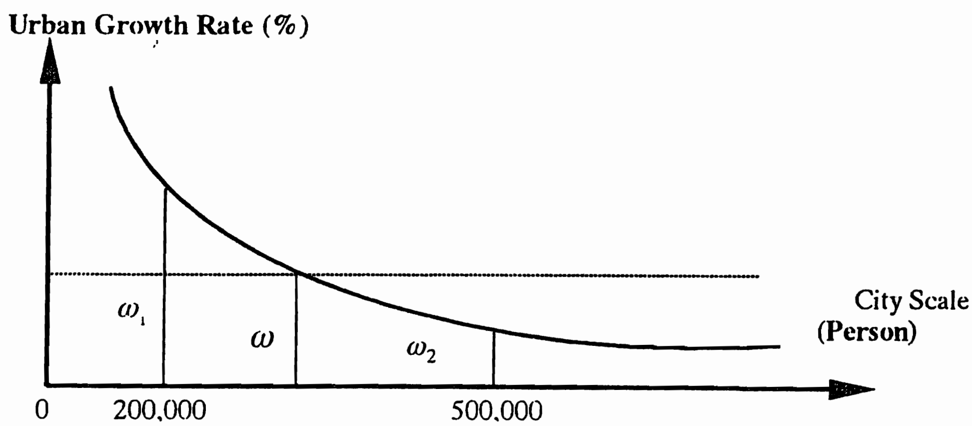

Figure 3 Requirement of Government for Urban Growth Rates

In Figure 3 ω is the average growth rate of a region, the required urban growth pattern should be so that the bigger the city, the slower the growth rate. Therefore, growth rates of small cities have to be bigger than ω_1, rates of middle sized cities have to be between ω_1 and ω_2, while for the big cities the rates should be smaller than ω_2. What government will do is induce the urban areas to increase in this way after an expressway construction. Accordingly, we can depict the behavior of government in China with Figure 4.

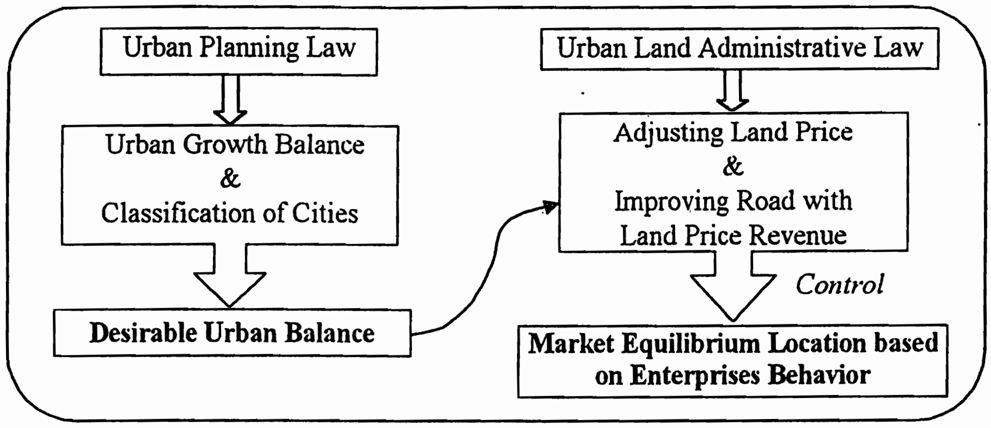

Figure 4 Behavior of Government during Industrial Location Process

The principles to guide governemnt behaviors are urban planning and urban land administration laws. Govenment will decide a desirable urban balance in the region and divide the cities into several categories, then transfer the information into land price policy to control enterprise location behavior. If government is not satisfied with market equilibrium location, it will adjust the land prices and use the land price revenue to improve the infrastructure in order to affect enterprise behavior oriented location change to its planned target.

SIMULATING EFFECTS OF LAND PRICE POLICY ON URBAN GROWTH AFTER EXPRESSWAY CONSTRUCTION IN LIAONING PROVINCE

Estimation of the Parameters

Here we take Liaoning province, which is one of China's 30 provinces, as the study area to simulate our developed model. Liaoning province, which consists of 14 cities, is located in Northern-Eastern China. In this region, China's first and longest expressway was constructed in 1990 to connect Shenyang (capital of the province) and Dalian (China' s second largest harbor). The data needed for estimating the parameters are mainly from Liaoning Stastic Year Book (1991, 1994). In order to do our study, we revised the classification of the city scale to : population over 1 million, population from 0.5 to 1 million and population under 0.5 million for big, middle sized and small cities respectively. Among the 14 cities, 4 cities (Shenyang, Dalian, Ansan, Fushu) are big, another four (Panjin, Tieling, Chaoyang, Jinxi) are small and the remaining six (Benxi, Dandong, Jinzhou, Yingkou, Fuxin, Liaoyang) are middle sized. When we substitute (1), (2) into (3), (6) respectively, the following equations can be obtained

$$\pi_{mi} = \alpha_1 + \beta_1(\phi_1 \sum_j \frac{N_j^{r1}}{t_{ij}^{\gamma}} + \phi_2 \sum_j \frac{F_j^{\gamma 2}}{t_{ij}^{\gamma}}) + \beta_2 C_{mi} \tag{14}$$

$$\pi_{qi} = \alpha_2 + \beta_3(\phi_3 \sum_j \frac{Q_{mj}^{r3}}{t_{ij}^{\gamma'}} + \phi_4 \sum_j \frac{F_j^{\gamma 4}}{t_{ij}^{\gamma'}}) + \beta_4 C_{qi} \tag{15}$$

Their estimated parameters are illustrated in Table 2. Estimated parameters of the employed population model (9), (10) and the population model (11) are as shown in Table 3.

Table 2 Estimated Parameters of Benefit Models

Main Industry				Quasi-main Industry		
Parameter	α_1	β_1	β_2	α_2	β_3	β_4
Value (t Value)	1.32	0.14 (7.68)	-0.19 (-1.85)	0.07	0.005 (7.3)	-0.11 (-1.92)
R	0.93			$\phi_1, \phi_2, \phi_3, \phi_4, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma', \gamma$ are given so that the pararmeters in the models of production scale obtain a good t Value		

ϕ_1	ϕ_2	ϕ_3	ϕ_4	γ_1	γ_2	γ_3	γ_4	γ'	γ
1	0.2	0.3	1	2	1	2	1	1.2	1.5

Table 3 Parameters of Employee and Total Population Model

Main, Quasi-main Employee				Service Employee		Total Pupolation	
Parameter	ζ	ψ	φ	α_3	β_5	α_4	β_7
Value (t Value)	0.17	0.088 (7.68)	0.066 (-1.85)	-0.008	0.184 (7.3)	4.29	2.05 (24.9)
R	0.97			0.96		0.99	

Equilibrium Location in the Case Where There is no Land Price Adjustment

As described in Figure 5, before the expressway opened (1990), GRP growth rate in the five cities which are along the constructed expressway is less than that of the other cities, while after the expressway opened, annual average growth rate in the five cities is 5% higher than in the other cities.

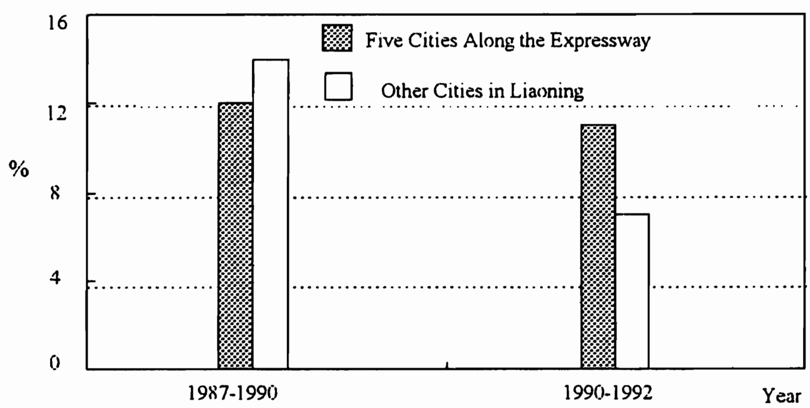

Figure 5 Annual Average Growth Rates of GRP in Liaoning

Therefore, we used GRP of 1993 to represent the situation with expressway and this figure less 5% represents the situation without expressway, then we calculated each city's location quantity for with and without the expressway situation. The different location quantities are the inter-city growth pattern caused by the expressway construction. We selected the urban built-up area as one location quantity index and illustrated its growth rates in Figure 6.

According to the city classification, we can see that this inter-city growth pattern contradicts the regulations controlling big cities and rationally developing middle sized and small cities. Figure 6 is not the result desired by the government as mentioned in Figure 3.

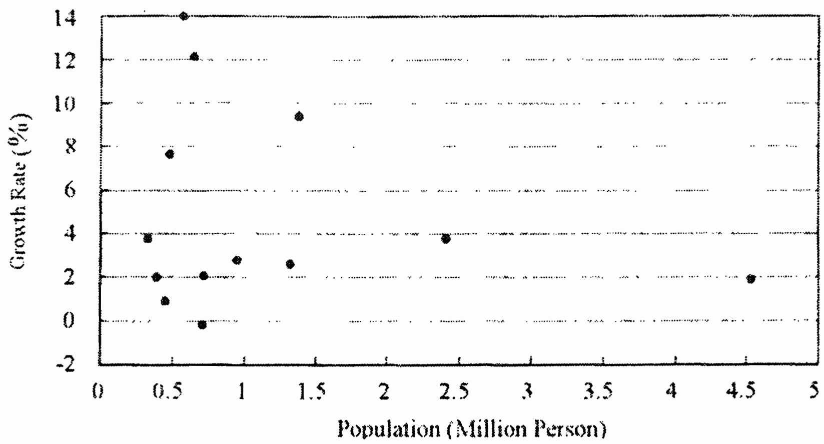

Figure 6 Urban Built-up Area Growth Rates After Expressway Construction (without land price adjustment)

Power of Land Price Policy

We have concluded that after expressway construction inter-city growth pattern does not conform to government requirements, the government has to use land price policy to guide this change. We suppose that the government would adjust land price as shown in Figure 7.

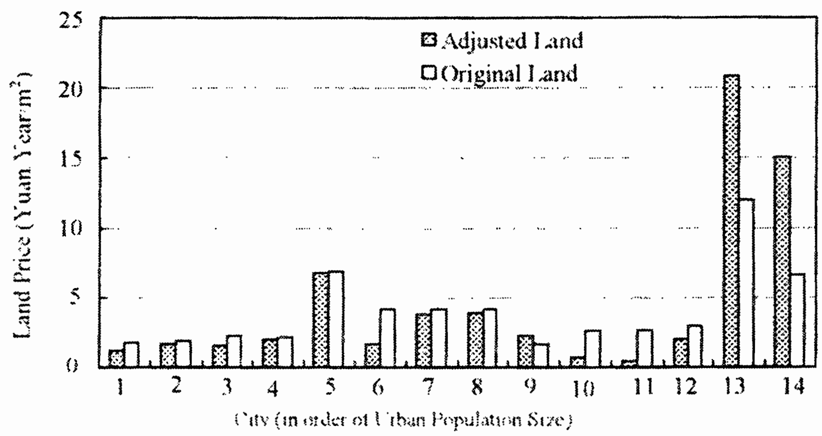

Figure 7 Comparison of the adjusted and Original Land Price

Then built-up areas of the big, middle sized and small cities will increase with the rates 0-3%, 3%-5% and over 5% respectively as illustrated in Figure 8. Inter-city growth pattern, which is based on government policy, is reached through adjusting the land price and can be called the new inter-city balance.

Effects of Land Revenue as Investment in Intra-city Road Improvement

After expressway construction, if the government does not revise the land price s in each city, land revenues in the situations with and without the expressway are illustrated in Figure 9. First, total land revenue in the region inceased by 2.2 billion Yuan. Secondly, except for two cities (6 and 9), land revenue in the other cities also increased. However, after expressway construction government will adjsut land price to control the location change. Corresponding to the adjusted land prices, total land revenue of the region in the situation with the expressway increased by 45 billion yuan compared to the situation without the expressway. However, as shown in Figure 10, except for land revenue in two big cities (13 and 14) which increased about 1.8 and 2.4 times respectively, land revenues in as many as 8 cities decreased

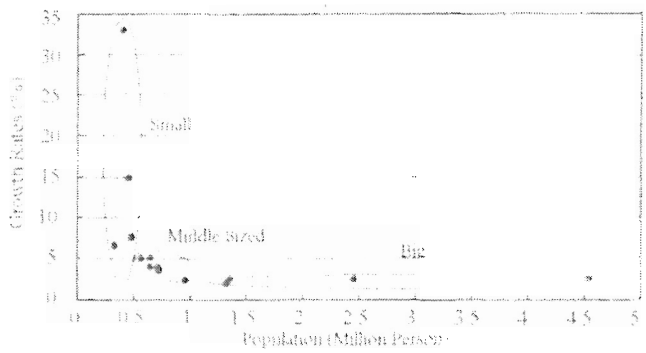

Figure 8 Urban Built-up Area Growth Rates After Adjusting Land Price (with land price adjustment)

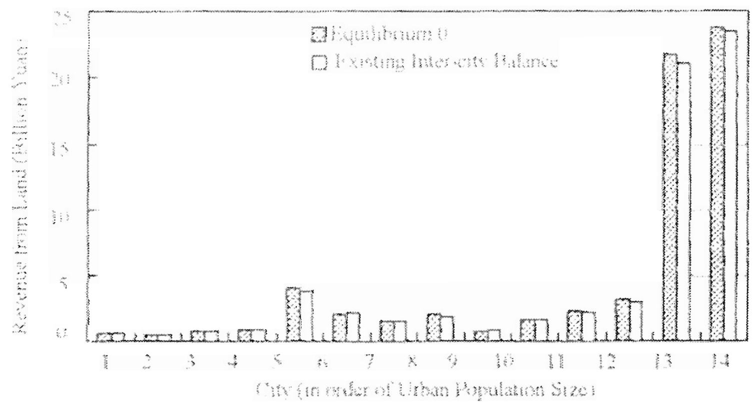

Figure 9 Effects of Expressway Improvement on Land Revenue (without land price adjustment)

In China, land revenue accrued to city government is specially used for urban infrastructure. The increase of land revenue in the two big cities means that they will have plentiful investment to improve urban infrastructure. Contrarily, cities with a little or even minus increase of land price revenue will be short of investment to improve their roads. We suppose that 40% of the land revenue will be invested in road infrastructure and the road construction period is 3 years. After 3 years of location change, the road conditions within each city are shown in Figure 11. If there is no new inter-city road constructed and the government no longer adjusts land price in each city, this inner-city road improvement will be the unique factor in changing the location potential to induce new urban growth rates. The urban growth rates since the new inter-city balance are shown in Figure 12.

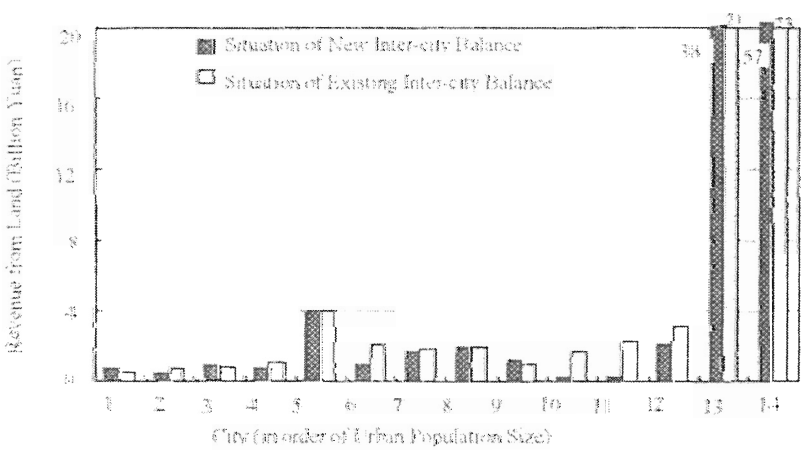

Figure 10 Effects of Expressway Improvement and Land Policy on Land Revenue

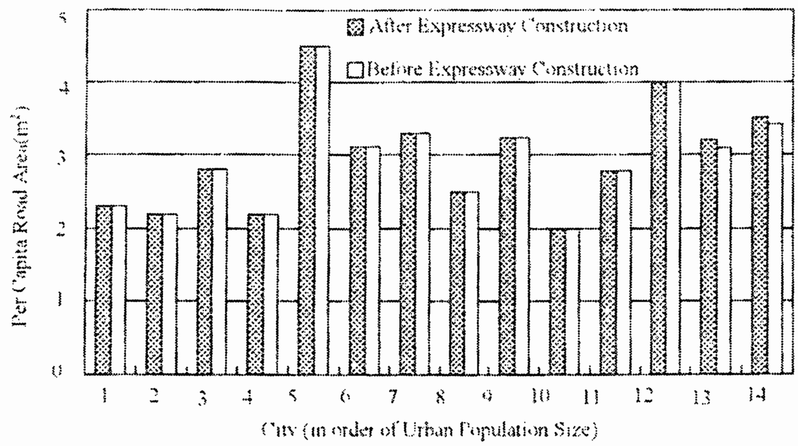

Figure 11 Per Capita Road Area before and after Expressway Construction

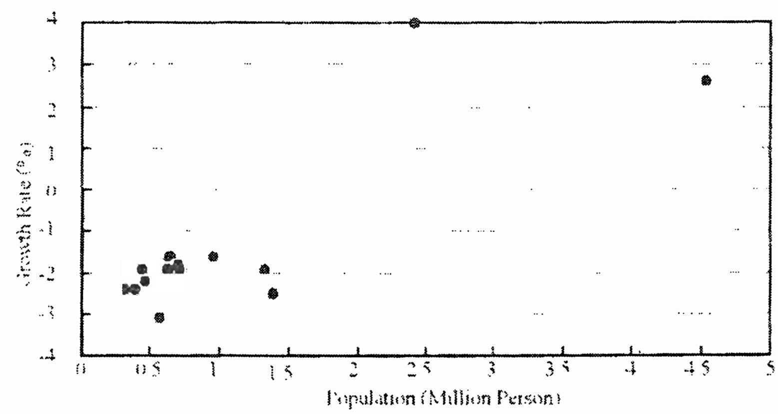

Figure 12 Growth rates of Urban Built-up Area since New Inter-city Balance

DISCUSSION

This study which connects the market mechanism with planning is useful for the government. First, when government plans to carry out a transport project, it can use this study to forecast urban growth rates. This kind of forecasting is important. The case study shows how the government can use the land market to balance the impact of the transport infrastructure improvement on industry location in order to achieve social goals. It is also possible to use this model to examine where to locate the new transport infrastructure projects in order to achieve such balance and goals.

Secondly, even though the government determines from a feasibility study that a project is reasonable, after its implementation there are also some undesired results because every project has its minus impact. For instance, the production/population will further concentrate to big cities in Liaoning after the expressway cosntruction. How to reduce this side-effect using the land market is an essential problem facing China's government. In China, land price has two kinds of functions, 1) to change the enterprise location utility and 2) increase governmental financing ability for transport infrastructure. Both of them have the effect of inducing location shift. Therefore, the government can make full use of its authority on land price to correct the side-effects. This study can help government to make suitable decisions on land market policies. More rationally, the government can combine land market policies and infrastructure investment allocation strategies.

CONCLUSION

In this study, we developed a model which can analyze the balance between land price policy and infrastructure improvement planning in the context of realizing an optimal inter-city balance. From the case study we understood that after the opening of expressways in a region, industry location potential in big and middle sized cities increases faster than in small cities. As a result, indudstry location further concentrates into big cities.

In order to induce an optimal inter-city location balance, government should increase the land price in big cities. As a result of the land price increase, the land revenues in big cities increased much faster than in middle sized and small cities. At present since land revenue belongs totally to city government, middle sized and small cities do not benefit from inter-city expressways construction evenly. It is, therefore, necessary for the upper-level government to reform the land revenue allocating system after inter-city expressway cosntruction.

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