QUANTIFYING THE INTRA-CITY EXPRESSWAY CONSTRUCTION BENEFITS WITHIN A CHINA'S CITY

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abstract: This study aims to analyze the relationship between transportation time and the land price/salary in a China's city and quantify the road construction benefit with monetary term. Based on the assumption that a city consists of two zones, we model the industries and households location behaviors with considering the limitation from government policies. Then with the model, we quantify the expressway construction benefit which splits from transportation market to the land and labor markets.

1. BACKGROUND

The cities in China now are in the urbanization period, the scopes and populations of China's cities are becoming larger and larger. This means that population and industries would further concentrate in urban areas rather than rural areas. Particularly in China's eastern coastal area, urbanization speed is much faster than in the other areas, cities there attracted not only itself rural population but also the rural population in other areas. Moreover, almost all of the coastal cities in China are designated as the "Opened One (opened to the foreign enterprises)". Common attributes of these cities is that in order to attract foreign investment as well as to rationalize industries location pattern, new zones (economy and technology developing zones which are a little far from their parent cities) were constructed. Because there were not enough financing sources and time during a short period, the transport infrastructure from the city to the new zone was not improved immediately. At the beginning, accessibility from the city to the new zone was sustained by the existing transport infrastructure. As all known, the coastal cities developed so fast that the old parts of the cities reached their limit for further development from the view points of efficiency and environment. Therefore, some of them planned to construct new urban zones around the established developing zones. However, bad accessibility to the developing zones made it difficult and costly for people to access them and limited the development of the new urban zones. In order to remove the bottleneck to promote the new zones' development, toll roads were constructed afterward. Since it is a toll road, the direct developing benefit is recovered

to the constructor through levying a toll on the passing vehicles. However, the indirect developing benefit is not recovered well because it is very difficult to locate and quantify the concrete benefit value.

We think that the indirect benefit is induced by the changes in industries and households locations which are affected by the road construction. It is means that the indirect benefit is the benefit from transportation market spreading to other markets. Therefore, after expressway construction if we make the mechanism of the location changes clear, it will not be difficult for us to calculate the indirect benefit in monetary terms. The aim of this study is to analyze the relationship between transportation time and the land price/salary and quantify the indirect benefit of intra-city expressway construction in a China's coastal city.

2. STUDYING CITY AND THE EXISTING DATA

In this study we select Dalian as a sampled city which is one of the earliest opening coastal cities in China. Figure 1 shows the location of Dalian and its two urban zones (developing zone and existing urban zone). It locates in the southern tip of Liaodong peninsula, Liaoning Province and serves China's North-East and Inner Mongolia areas with China's second largest harbor.

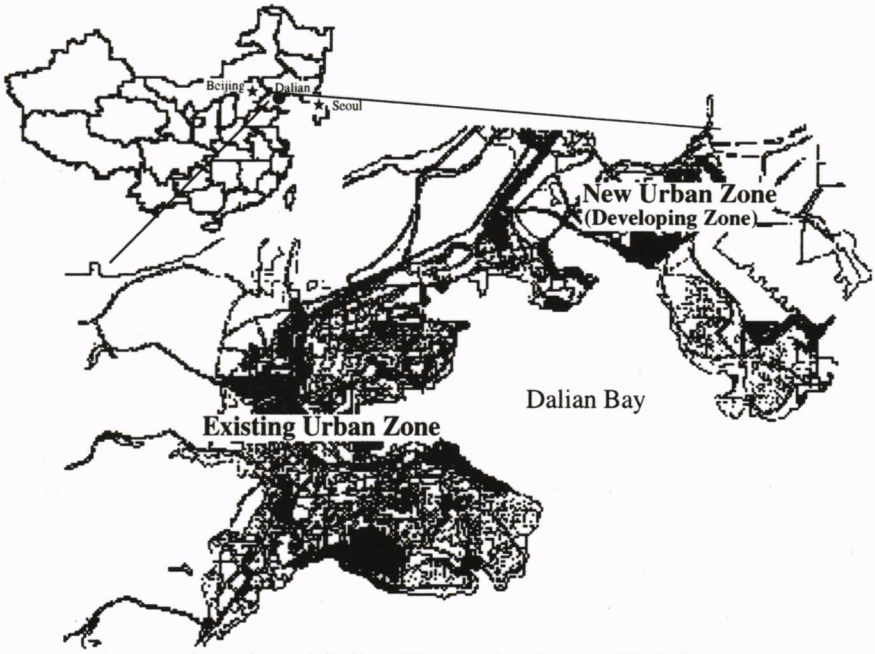

Figure 1 Location of Dalian City and its New and Existing Urban Zones

A little town was selected as the site of Dalian developing zone in 1984 which is 30 kilometer distance from the existing city. Hereafter, we call the developing zone as the "new zone" while the existing city as the "existing zone". Table 1 compares some actual indexes of year 1990 and some government planned indexes for year 2000 between the two zones. From this comparison it is reasonable to think that existing zone is new zone's base for supplying the markets of products, materials and some other services. Therefore, new zone depends on existing zone completely, even in the year 2000, it will still mainly depend on existing zone. As a result, the accessibility from the new zone to the existing zone is an essential factor for new zone's development.

Table 1 Comparison of some Indexes between the New and the Existing Zones

%	Urban Area	Urban Population	GRP
New zone/Existing zone(1990)	1.5	10	5
New zone/Existing zone(2000)	34	18	29

Like in other coastal cities, at the beginning the existing road was use to supply the transportation demand between the two zones. Because of the lower land price and some government policies favorable to enterprises, foreign and domestic enterprises quickly entered into this new zone. Then, the labor resources in the original little town can not match the new labor demand. Therefore, many laborers in existing zone commute to new zone for balancing the gap between labor supply and demand. In 1993, about 25 thousands workers commuted from the existing zone to the new zone, while only 900 commuters in the existing zone are from the new zone.(JICA, 1995). The factor that supports this long commuting time (about 2 hours) is the higher salary level in the new zone. As the improvement of the urban living infrastructure in the new zone, some households moved to new zone, especially the households coming from outside Dalian are much more likely to resident in the new zone. These situations can be verified by the indexes of population, employee and student in the new zone in Figure 2. In order to promote new zone's development then realize the general urban developing plan, government is improving the accessibility between the two zones step by step. At first, in 1990 toll road ("Zhen Xing Road") connecting the two zones was finished. The accessibility will be further improved to supply enterprises, households and commuters a reliable and time-saving transportation by constructing a huge bridge over Dalian bay.

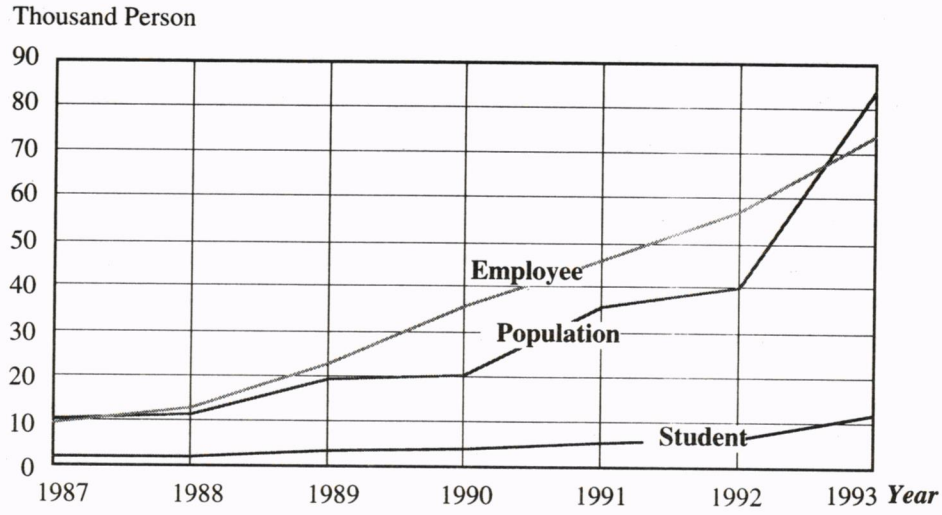

Figure 2 Changed Situations of Population, Employee and Student in New Zone

3. BASIC CONCEPTS OF THE ANALYSIS METHOD

It is well known that land price, salary level and the accessibility to markets are the essential factors for industries location benefit while land price, salary level, commuting time and the accessibility to the living infrastructure are the essential factors for households location utility. Expressway construction between the two zones improved the accessibility from new zone to existing zone. Therefore, it affects surely the location benefit and utility to induce a location pattern differing from before. This changed industries and households location pattern will create a corresponding land prices and salary level. We try to quantify the improvement benefit which spreads to other markets through the changed prices.

At present semi-planned and semi-marketing economy is implemented in China, therefore different from other countries where marketing economy is implemented, China's government still strictly controls urban development with its authority. The city government there makes detailed indexes as shown above to direct the growth of the city and control the urban pattern. Beside the strict control on the scope and the population of a city, another characteristics of China is its public-owned land system. Government there owns urban land, while sells the land use-right to land users with the decided price. It means that after making a detailed development target in a projected year, the government will use the marketing methods as well as planned methods to realize this target. In this study, under the assumption that Dalian government will make use of road infrastructure and land price to realize its planned indexes, we will analyze the benefit of intra-city expressway construction. Another precondition of this analysis is that total located industries and population of the

whole city are given. Subject to these limitations, we can see that the products can go out the city to other regions, while the land and population can not flow out of the city, therefore, the land and labor markets rather than product market in the new zone became the analyzed objective.

The available data in China's cities for analyzing effects of transportation improvement is so limited, that the first thing we always have to consider when estimating these effects is that the quantification should be able to be realized with a very few data. It requires us to tap the implication of the available data. For instance, it is reasonable for us to take the existing quantity of an index (population, commuter or production scale ect.) in a zone as its location gravity and corresponding gravities will decide related location quantities. We intend to use an iteration process to examine the equilibrium in both labor and land markets. Equilibrium in each market refers to the situation in which the demand equals the supply. The iteration will not stop until equilibrium in both of them is reached. It is obvious that several iteration processes are needed for us to get the final equilibrium results. The final results are expected to be similar to that gained by the average general equilibrium method. In this study, according to the demand degree on transportation in China's industries input-output table, industries are divided into main, quasi-main and service industries like shown in Table 2.

Table 2 Industry Category Based on the Demand Degree on Transportation

Category	Name of Industry	Attribute
Main industry (m)	Heavy Industry, Light Industry	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 InsuranceSports, Health Care andWelfare Service	Hardly depend on inter-city transportation

4. MODEL STRUCTURE

Since the improved area - new zone is comparatively small (as illustrated in Table 1) and the households can change their residence and working place within a city easily even though this change is very difficult between cities in China, the new zone can be considered as an "open and small" area. Therefore, we can take the existing zone as a stable one (namely basic level where the land price and salary will not change after expressway construction) to study the demand and supply situations of land and labor in the new zone. Under the assumption that just labor and land markets are needed to considered, markets equilibriums in the new zone can be simulated through iteration process as shown in Figure 3.

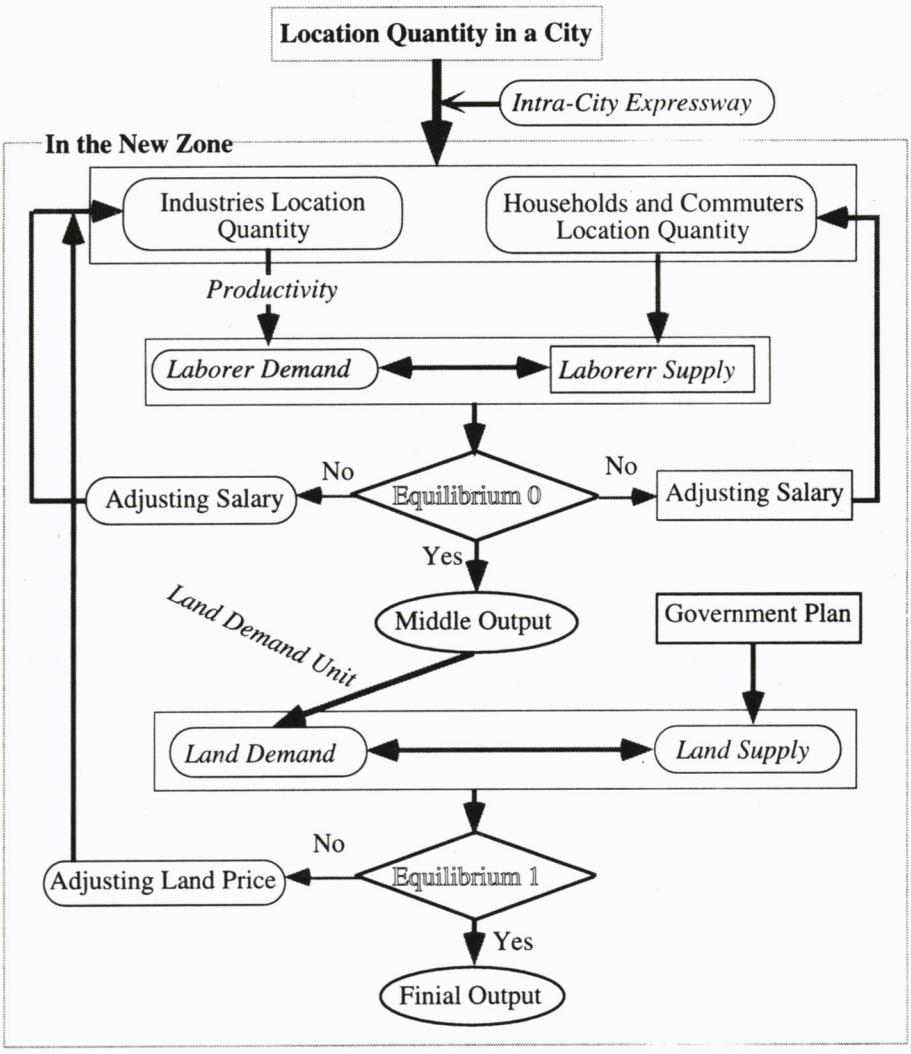

Figure 3 Structure of the Model

In this study we consider the location attractions in two zones as their location benefit functions, and the existing location quantities in each zone are considered as the gravities of location attractions respectively. If nothing happens, the attractions of two zones will be kept unchanging. If transportation cost or time from the new zone to the existing zone is improved because of the intra-city expressway construction, industries, households and commuters will redistribute between the two zones according to the changed location attractions. Moreover, the difference of the transportation time between the situations with and without expressway can be considered as the adjustment coefficient of location attractions. Then, because of the changed quantities of production, households and commuters, a corresponding labor demand and supply patterns are induced, the equilibrium

between the labor demand and supply is call as equilibrium 0. Salary level (labor price) will be decided in equilibrium 0. After equilibrium 0, the located households will induce a corresponding land demand in the new zone. Because there is a planned land supply, so government will adjust land price to reach equilibrium 1 in land market. Equilibrium 1 might change the equilibrium 0, therefore, we have to feedback equilibrium 1 to equilibrium 0 for iteration till equilibriums in both markets are reached.

4.1 Equilibrium in Labor Market

1). Change of Labor Demand

Because both the materials/products movement and the commuting/business trips create transportation demand between the two zones, if the transportation time is shortened while the other factors do not change, industries location attractions in both zones can be described as the formulas below:

Attraction of New Zone on Main Industry: $$Am_1 = M_1^0 \frac{N_1^1 / f(c_{11}^1) + N_1^1 / f(c_{01}^1)}{N_1^0 / f(c_{11}^0) + N_1^0 / f(c_{01}^0)} \quad (1)$$

Attraction of Existing Zone on Main Industry: $$Am_0 = M_0^0 \quad (2)$$

Attraction of New Zone on Quasi-Main Industry : $$Aq_1 = Q_1^0 \frac{N_1^1 / f(c_{11}^1) + N_1^1 / f(c_{01}^1)}{N_1^0 / f(c_{11}^0) + N_1^0 / f(c_{01}^0)} \quad (3)$$

Attraction of Existing Zone on Quasi-Main Industry: $Aq_0 = Q_0^0$ (4)

M_i^j, Q_i^j: Quantity of the main and quasi-main industries production respectively, N_i^j: Population, (i,j=0,1).

Superscript 1,0: Represent the situations with and without the expressway respectively.

Subscript 1,0: Represent the new zone and the existing zone respectively.

c : Represents the transportation time between zones or within a zone ($f(x)=x^2$).

New Location Quantity in the New Zone: $$M_1^1 = M \frac{Exp(\theta Am_1)}{Exp(\theta Am_1) + Exp(\theta Am_0)} \quad (5)$$

$$Q_1^1 = Q \frac{Exp(\theta Aq_1)}{Exp(\theta Aq_1) + Exp(\theta Aq_0)} \quad (6)$$

New Demand for Labor in the New Zone:

Main and Quasi-main Industries $$E_1^m + E_1^q = (\alpha_1 + \beta_1 M_1^1) + (\alpha_2 + \beta_2 Q_1^1) \quad (7)$$

Service Industry $$E_1^T = \zeta + \psi(E_1^m + E_1^q) + \lambda E_1^T \quad (8)$$

Total $$E_1^d = E_1^m + E_1^q + E_1^T \quad (9)$$

M, Q : Total quantity of main and quasi-main industries production respectively.

$\alpha_i, \beta_i, \zeta_i, \psi_i$: Parameters (HAYASHI *et,al,* 1996)

λ : Self-demand coefficient of service industry.

We have analyzed the situation of labor demand in the new zone, what is the supply situation is further studied below.

2). Change of Labor Supply

From relationship between the two zones, we can reasonably suppose that in new zone the labor supply comes from two aspects. First aspect is the households who are living here, and second one is the commuters from existing zone. After expressway construction, it became more convenience and time saving for residents in the new zone to access the existing zone where has plentiful living infrastructures like shopping center, hospital and some other recreation equipments which are considered as factors for attracting people to live in a big city. The probability of households to select the new zone for living will increase, it means more households would immigrate to the improved zone. At the same time, because of the increment of industries location quantity, opportunity for finding a job also increases. This is another reason for promoting people to immigrate to the new zone. Therefore, after transportation improvement, the changed labor supply can be modeled as follows:

Attraction of New Zone on Households: $$Ar_1 = N_1^0 \frac{N_1^1 / f(c_{11}^1) + N_1^1 / f(c_{01}^1)}{N_1^0 / f(c_{11}^0) + N_1^0 / f(c_{01}^0)} \times (E_1^d / E_1^0) \quad (10)$$

Attraction of Existing Zone on Households: $$Ar_0 = N_0^0 \quad (11)$$

Location Population in New Zone : $$N_1^1 = N \frac{Exp(\theta Ar_1)}{Exp(\theta Ar_1) + Exp(\theta Ar_0)} \quad (12)$$

Supplied Laborers:: $$E_1^{s1} = \alpha_3 + \beta_3 N_1^1 \quad (13)$$

N : Total Population, N_i^j : Population of Zone i in situation j (i,j=0,1), E : Working Labor. Subscript and Superscript have the same meaning as before.

Labor supply from commuters will also increase as follows because of the shortened commuting time.

Attraction of New Zone on Commuter: $$Ac_1 = E_{1c}^0 (f(c_{10}^1) / f(c_{10}^0)) \quad (14)$$

Attraction of Existing Zone on Commuter: $$Ac_0 = E_{0c}^0 \quad (15)$$

Total Labor in the Existing Zone: $$E = \alpha_3 + \beta_3 N_0^1 \quad (16)$$

Supplied Labors: $$E_1^{s2} = E_{1c}^1 = E \frac{Exp(\theta Ac_1)}{Exp(\theta Ac_1) + Exp(\theta Ac_0)} \quad (17)$$

E_{1c} , E_{0c} : Labors Commuting to New Zone and within Existing zone respectively.

3). Equilibrium in Labor Market

Till now we have analyzed the supply and demand situations respectively in new zone's labor market. If the supply equals to the demand, equilibrium in labor market is reached, it is not necessary to analyze the salary. Then we should go to the next step to analyze the demand and supply in land market. If labor supply and demand are not equal to each other, the salary (s) in labor market must change to balance the demand and supply. Based on this process, we set $\alpha = E_1^d /(E_1^{s1} + E_1^{s2})$ and then divide α into three kinds of situations to analyze the equilibrium in labor market.

Case 1: $\alpha = 1$ This is the equilibrium situation, then go to next step to analyze land market.
Case 2: $\alpha < 1$ Demand is smaller than supply, salary in the new zone should be decreased.
Case 3: $\alpha > 1$ Demand is bigger than supply, salary in the new zone should be increased.

In cases 2 and 3, according to the changed salary level households and commuters will change their location pattern as well as main, quasi-main and the other service industries do. The location models have the same form as the formulas (1) - (17). However, this time the adjusting coefficient is not the improved transportation time but the adjusted salary level, furthermore, this adjusting coefficient acts on the labor demand and supply reversely. We list the formulas of the attraction model as follows.

Attraction of New Zone on Main Industry: $$Am_1 = M_1^1(s_1^0 / s_1^1) \quad (18)$$

Attraction of Existing Zone on Main Industry : $$Am_0 = M_0^1 \quad (19)$$

Attraction of New Zone on Quasi-main Industries : $$Aq_1 = Q_1^1 (s_1^0 / s_1^1) \quad (20)$$

Attraction of Existing Zone on Quasi-main Industries: $$Aq_0 = Q_0^1 \quad (21)$$

Attraction of New Zon on Households: $$Ar_1 = N_1^1 (s_1^1 / s_1^0)(E_1^d / E_1^1) \quad (22)$$

Attraction of Existing Zone on Households: $$Ar_0 = N_0^1 \quad (23)$$

Attraction of New Zone on Commuters $$Ac_1 = E_{1c}^1 (s_1^1 / s_1^0) \quad (24)$$

Attraction of Existing Zone on Commuters: $$Ac_0 = E_{0c}^1 \quad (25)$$

Because of the changed attraction, new labor demand and supply pattern will appear for us to judge whether the equilibrium in labor market is reached or not. This iteration will not stop until $\alpha = 1$. It is noted that after the expressway opening the location process does not happen iterately but finish at the same time. Because we have not enough data to calculate this equilibrium process we use the iteration method to simulate the equilibrium process. In the situation of $\alpha = 1$, we get the location quantities of industries, households and commuters in both zones within the equilibrium 0. We call these location quantities as the middle output.

The next study we should do is to judge whether the gotten middle output can satisfy the equilibrium in land market .

4.2 Equilibrium in Land Market

1). Land Demand

When the equilibrium 0 reached, population in the new zone N_1^1 can be calculated with formation (12). A "per capita land demand unit" η is decided in "China's Urban Planning Law" according to the scale of a city. Then demanded land in new zone can be estimated as $L_1^s = \eta \times N_1^1$.

2). Land Supply

In China, governments have to control the spread of the urban scopes rationally, then city government has to make a detailed plan to control the scope of its each zone. The factors affecting the plan might be total commuting time, land price revenue, employment rate and environment ect. which are beyond the scope of this study. Here we just simply assume that the area of the new zone after a certain time has been decided by government plan as L_1^d.

3). Equilibrium 1

Land demand and supply are known values, moreover the supply is fixed by the government plan. What we will do is to judge whether land demand equals its supply as we have done in the labor market. If they equal to each other, the equilibrium in land market is reached, otherwise, the government will be believed to adjust the land price to make land demand matching its planned supply. We can also divide relationship between land demand and supply into three cases. If we set β= (Land demand L_1^d) / (Land supply L_1^s), then there should be the following cases.

Case 1: $\beta = 1$ This is the equilibrium situation, then go to next step.
Case 2: $\beta < 1$ Demand is smaller than supply, land price in new zone should be decreased.
Case 3: $\beta > 1$ Demand is bigger than supply, land price in new zone should be increased.

In cases 2, 3 because the government adjusts land price, main and quasi-main industries will change their location pattern accordingly. However, this time the adjusting coefficient is not the improved transportation time but the adjusted land price (r). On the other hand since the households and commuters in China get house from their companies, it is reasonable to assume that land price has no direct effect on the locations of them. Except attraction model, the other models have the same formulas, therefore, we just give the attraction model as follows and will not rewrite the models which have the same formulas

Attraction of New Zone on Main Industry: $Am_1 = M_1^1(r_1^0 / r_1^1)$ (26)

Attraction of Existing Zone on Main Industry : $Am_0 = M_0^1$ (27)

Attraction of New Zone on Quasi-Main Industry: $Aq_1 = Q_1^1(r_1^0 / r_1^1)$ (28)

Attraction of Existing Zone on Quasi-Main Industry: $Aq_0 = Q_0^1$ (29)

Attraction of New Zone on Households: $Ar_1 = N_1^1(E_1^d / E_1^1)$ (30)

Attraction of Existing Zone on Households: $Ar_0 = N_0^1$ (31)

The new land demand pattern will appear for us to judge whether the equilibrium 1 is reached or not. This iteration will not stop until $\beta = 1$.

4.3 General Equilibrium in Both Land and Labor Markets

Equilibrium in land market might change the labor demand and supply, it means the former equilibrium 0 in labor market may be broken down. Therefore, it is necessary to analyze the equilibrium 0 again. This iteration process will not stop until both $\alpha = 1$ and $\beta = 1$ are reached simultaneously. Then the labor amount, built-up urban area, salary and land price in the situation of general equilibrium can be gained, we call them the final output.

5. SIMULATING THE EFFECTS OF INTRA-CITY EXPRESSWAY

With the developed method, we take use of "with and without" method to analyze the effects of an intra-city expressway on land and labor markets, and then estimate the improvement benefits. The information of the expressway has been explained in section 2. In order to clear the relationship between the transportation market and the labor and land markets, we suppose several cases as follows to analyze the effects of the expressway.

Case 0: Transportation time between two zones is kept 120 minutes as that before 1990. This can be considered as the situation without expressway

Case 1: Transportation time between two zones is shortened from 120 to 80 minutes.

Case 2: Transportation time between two zones is shortened from 120 to 60 minutes. This is the case similar to the situation after 'Zhenxing Expressway" was constructed.

Case 3: Transportation time between two zones is shortened from 120 to 40 minutes. This is the case similar to the situation when the huge bridge over Dalian bay will be constructed.

In addition to the improvement of road, city government made also a detailed plan to guide the development in two zones. These targeted indexes which are considered as the preconditions in the model are quoted as Table 3 (JICA, 1995). From Table 3, we can see that the land price and salary level in year 2000 are unknown. What we will do is to decide the equilibrium prices under the constraints of government plan. In the situation of keeping the land price unchanged, calculated results are shown as follows: 1).New zone would attract only 0.078 million of population, thus 13.6 km^2 land there is needed to support the production and living activities. 2).Salary level there would increase by 12% to 290 Yuan/Month. It is obvious that the location target of government for the new zone can not be reached. To realize it, in case 0, land price in the new zone needs to be decreased from 20 Yuan/Year/m^2 to 7.2 Yuan/Year/m^2, the decreasing rate is about 65%. Then the population of the new zone will be 0.29 million while the needed land area will be 51 km^2 (the planned indexes is 0.3 and 52.2 respectively).

Table 3 Actual and Planned Indexes in the New and Existing Zones

Item \ Year	1990			2000		
	New Zone	Existing Zone	Total	New Zone	Existing Zone	Total
Main Industry Output (0.1billion Yuan)	9.4	188	197.4	98.2	321.3	419.5
Quas-main Industry Output (0.1billion Yuan)	1.5	44.9	46.4	23.2	113.7	136.9
Population (Million)	0.0205	1.49	1.51	0.3	1.7	2.0
Urban Area (km^2)	10	104.8	115	52.2	152.9	205
Needed Land /Capita (m^2)		71		174	90	
Productivity (1000Yuan/Labor)				Main: 4.5	Quasi-Main: 2.2	
Salary (Yuan/Month)	250	150				
Land Price(Yuan/Year/m^2)	20	30				

Cases 1, 2 and 3 can be considered as the situations with the expressway. For each case we also further simulate two kind of situations. 1). If government makes its location target to be definitely realized, then what kind of land price and salary level there should be. 2). If the government remains land price in the new zone unchanged then what will be the location pattern in the new zone. The calculated results based on four cases and two kind of situations are summarized in Figures 4, 5. In cases 1 and 2, even though the expressway was constructed, the attraction in new zone is still not big enough for attracting location quantity to satisfy government plan. In order to reach its targeted location pattern, government has to decrease the land price by 56% and 37% respectively. However, if government can shorten the transportation time from 120 minutes to 40 minutes like in case 3, the location population will be 5% more than the planned one, as a result, government may increase the land price by 12% to reach its targeted location pattern. From the above analysis, it is obvious that

subject to satisfying the government location target, transportation improvement between two zones will directly affect land price and salary level in the new zone. Based on the equilibrium land price and salary level, land price revenue and salary income in the new zone are calculated for the four cases as Table 4.

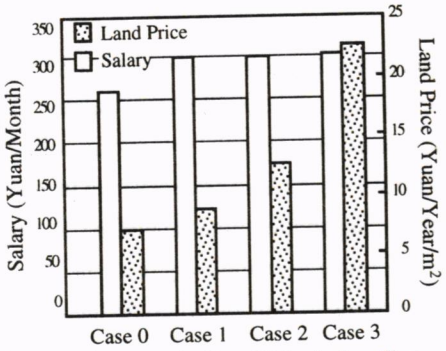

Figure 4 Salary and Land Price in four Cases for Realization of Location Target

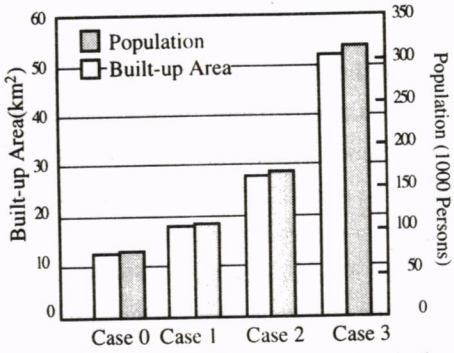

Figure 5 Built-up Area and Population in the Situation of keeping Land Price Unchanged

Table 4 Land Price Revenue and Salary Income in the New Zone

Billion Yuan	Case 0	Case 1	Case 2	Case 3
Land Price Revenue	2.2	2.7	3.9	7.02
Salary Income	0.54	0.63	0.63	0.65

Because the built-up area and population in the new zone after a certain period are decided by the government, the differences in revenue and income between the situations with and without the expressway are considered as the monetary term of development benefit splits from transportation market to other markets. Take case 2 as an instance, with the intra-city expressway, the benefits induced to the land and labor markets are 170 and 9 million Yuan respectively, while if take case 3 as another example, with the intra-city expressway, the benefits induced to the land and labor markets are 482 and 11 million Yuan respectively.

6. CONCLUSION

We analyzed whereabouts of the intra-city expressway construction benefit and established the model to quantify the benefit within a China's city. We pointed out that in the context of its planned economy, the improvement benefit is spread from transportation market to land and labor markets within the city.

Even though the model is based on equilibrium theory, because in a China's city land price is controlled by the government as part of its location plan and the available data is not enough for us to estimate the utility functions, we used the location attraction index which can be represented by the existing location quantities combined with some adjustment coefficients to calculate the location probability of each zone.

From the simulation, we can see that land price and salary level in the new zone differ with the various transportation improvements subject to satisfying planned location targets. Then the difference of land price revenue and salary income between the situations with and without expressway are the improvement benefit. However, the land price revenue increased much faster than salary income as the shorten of the transportation time. Therefore, it can be said that it is very essential for city government to construct the expressway from the existing zone to the new zone. We can suggest that it is also necessary to construct the huge bridge over Dalian Bay to connect the two zones, while the financing sources can be covered by the increasing land price revenue.

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