IMPACT OF A RING ROAD PROJECT IN A MEDIUM CITY - GIFU

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abstract: This study aims at knowing impact of a ring road project in a medium city, where measuring the benefit incidence of each socio-economic sector in each zone by using a benefit measurement model, and where discussing the landowners' share of the total benefit from the viewpoint of the degree of the city's openness or stickiness. The case study is in Gifu City, which is a medium city located at the central part of Japan.

1. INTRODUCTION

There have often been cases in which financial problems prevent the realization of transport project, even if large welfare effects from the project are expected. In that case, the means solving the financial problems may be discussed from the viewpoint of development gains recovery [Hayashi 1989; Ito 1978]. As the first step in establishing the recovery system, this paper tries to measure the benefit incidence of each socio-economic sector.

It is said that all the benefits derived from the project are accrued to the land price or rent increase if and only if the affected area is small-open [Polinsky and Shavell 1976]. A real city, however, is in the intermediate situation between small-open and large-closed, so that some parts of the total benefit result in the increase of land price or rent and the others in the form of transport users' benefit. On measuring the benefits from the project, there are three matters to be considered; the first is to clarify theoretically the mechanism behind the generation, transferal and accrual of the benefit, the second is to express this mechanism, and the third is to construct a practical model for this measurement.

As for the first matter, it has already been shown that all the benefits, including various repercussion effects, can be expressed by the increase in general consumer surplus of transport demand [Kanemoto and Mera 1985; Morisugi 1987]. The second matter can be settled by constructing the so-called benefit incidence matrix [Morisugi and Ohno 1992]. The third matter is crucial in putting the theoretical accomplishment into practice. One of the study fields concerned with this purpose is land use and transport interaction modeling [Webster, Bly and Paulley 1988]. For example, studies within the framework of the general or partial market equilibrium theory have been made by Anas (1984), Geraldes et al. (1978), Hayashi et al. (1989) and others, and studies by Miyagi et al. (1983), Putman (1983) and Wilson et al. (1981) provide the mathematical optimization framework. In particular, the MEP model by Geraldes et al. is based on the same micro-economic theory that this paper follows, and advocates that the total transport benefit is measured by the sum of two consumer surpluses, one in transport demand and the other in space demand. The consumer surplus in space demand, however, should theoretically be canceled out by the producer surplus. The MEP model also seems to take this cancellation into account, however the relationship between land consumer surplus and transport consumer surplus is not clear because of the dynamic nature of the model, where the impact on the land market is assumed to be at a different time period on the transport market. So it does not raise the question of what the landowners' share of the total benefit will be. The Hayashi model does, on the other hand, explicitly raise the same questions as this paper does. However its benefit definition is based on the so-called locational surplus, and it does not refer to the relationship between locational surplus and conventional transport consumer surplus.

This study aims at measuring the benefit incidence of each socio-economic sector in each zone by using a benefit measurement model, and especially discussing the landowners' share of the total benefit from the viewpoint of the degree of the city's openness or stickiness. The case study is on a ring road project in Gifu City, which is a medium city located at the central part of Japan.

2. BENEFIT MEASUREMENT METHOD

2.1. The theory

When the transport service, that is the transport cost and/or the transport time, is changed by the project, the land price or rent and other prices will change according to the market equilibrium. As a result, the land use pattern in this urban area will change because the utility or profit level of each socio-economic sector will change. Increase of the households' and the landowners' utility levels evaluated in monetary terms is called the benefit from the project, and the benefit may be defined by applying the concept of EV (Equivalent Variation) to the socio-economic model, as described in our previous study [Morisugi and Ohno 1992].

The landowners' benefit can be defined as the traditional EV when their utility is assumed to have no random elements and their behavior occurs only to maximize their utility by controlling the land service supply without relocating. As for the households' benefit, however, we cannot use the same procedure as in the landowners' case because we assume that the households have random utility in this socio-economic model, allowing the possibility of relocation. Therefore, we define the households' benefit by using the concept of the expectation value of maximum utility level. It causes every household to be given the same utility level in each case, both with and without the project. Generally, the formula for the expectation value of maximum utility level is called the satisfaction function [Daganzo 1979].

A benefit measurement model can be derived by considering the market equilibrium conditions in the evolution of the benefit definition mentioned above. The derivation of the model has been referred to in the previous study [Morisugi and Ohno 1992].

2.2. The formula

Equation (1) is the measurement model of the social net benefit (SNB) from the project.

$$SNB = \Sigma_j \Sigma_h \Sigma_O \Sigma_D \left(N^a_{jh} x^a_{jh,OD} + N^b_{jh} x^b_{jh,OD} \right) \left(q^a_{h,OD} - q^b_{h,OD} \right) / 2$$

<1>

$$
\begin{aligned}
&+\Sigma_h\Sigma_m\Sigma_O\Sigma_D\left(M^a_{hm}X^a_{hm,OD}+M^b_{hm}X^b_{hm,OD}\right)\left(q^a_{h,OD}-q^b_{h,OD}\right)/2 \\
&\quad \langle 2\rangle \\
&+\Sigma_j\Sigma_h\left(N^a_{jh}a^a_{jh}+N^b_{jh}a^b_{jh}\right)\left(r^a_j-r^b_j\right)/2 \\
&\quad \langle 3\rangle \\
&+\Sigma_h\Sigma_m\left(M^a_{hm}A^a_{hm}+M^b_{hm}A^b_{hm}\right)\left(R^a_h-R^b_h\right)/2 \\
&\quad \langle 4\rangle \\
&-\left\{\Sigma_j k_j\left(r^a_j-r^b_j\right)+\Sigma_h K_h\left(R^a_h-R^b_h\right)\right\} \\
&\quad \langle 5\rangle \\
&+g_T\Sigma_j\Sigma_h\Sigma_O\Sigma_D\left(N^a_{jh}x^a_{jh,OD}+N^b_{jh}x^b_{jh,OD}\right)\left(c^a_{OD}-c^b_{OD}\right) \\
&\quad \langle 6\rangle \\
&+g_T\Sigma_h\Sigma_m\Sigma_O\Sigma_D\left(M^a_{hm}X^a_{hm,OD}+M^b_{hm}X^b_{hm,OD}\right)\left(c^a_{OD}-c^b_{OD}\right) \\
&\quad \langle 7\rangle \\
&-g_R\left\{\Sigma_j k_j\left(r^a_j-r^b_j\right)+\Sigma_h K_h\left(R^a_h-R^b_h\right)\right\}+\Delta G-\Delta C \qquad (1) \\
&\quad \langle 8\rangle \qquad\qquad\qquad\qquad\qquad\qquad \langle 9\rangle\ \langle 10\rangle
\end{aligned}
$$

where N_{jh}: number of households which live in zone j and work in zone h; M_{hm}: number of private firms which are classified into the industry type m and locate in zone h; $x_{jh,OD}$: road service demand of the households from zone O to zone D; $X_{hm,OD}$: road service demand of the private firms from zone O to zone D; a_{jh}: residential land service demand of the households; A_{hm}: industrial land service demand of the private firms; k_j: supply of residential land service in zone j; K_h: supply of industrial land service in zone h; $q_{h,OD}$: generalized transport cost $(=c_{OD}+w_h t_{OD})$; c_{OD}: gasoline cost in traveling from zone O to zone D; t_{OD}: transport time from zone O to zone D; w_h: wage rate in zone h; r_j: rent of residential land in zone j; R_h: rent of industrial land in zone h; g_T: gasoline tax rate (=0.5); g_R: property tax rate (=0.142); G: tax revenue; C: project cost; ^{a} and ^{b}: superscription denoting the case without and with the road project.

The term <1> of equation (1) indicates the road users' benefit of households. The part in the quadruple Σ of this term is indicated by the shaded part of figure 1. The point A in figure 1 indicates the market equilibrium point without the road project, and B is the point with the road project. The following terms can be indicated in the same way; the term <2> is the road users' benefit of private firms, <3> is the land users' benefit of households, <4> is of private firms, <5> is the land producers' benefit of absentee landowners, <6> is the gasoline tax payment of households, <7> is of private firms, <8> is the property tax payment of absentee landowners, <9> is the tax revenue of government, and <10> is the project cost paid by government.

Equation (1) assumes that the transport project induces only the change in transport conditions and land price or rent, and changes no other prices than the aforementioned two kinds, so that the repercussion of the project affects only the changes in transport demand and relocation behavior. Under this assumption, it can be shown that the total benefit, including relocation benefit, can be expressed by the increase in generalized consumer surplus depicted by terms <1> and <2> in equation (1). Since consumer surplus is equal to producer surplus in the case where price is determined by market equilibrium, the total benefit or loss on property value are also equal to zero. In addition, the total benefit or loss with regard to tax is equal to zero because tax revenue comes from the tax payments of households, private firms and absentee landowners.

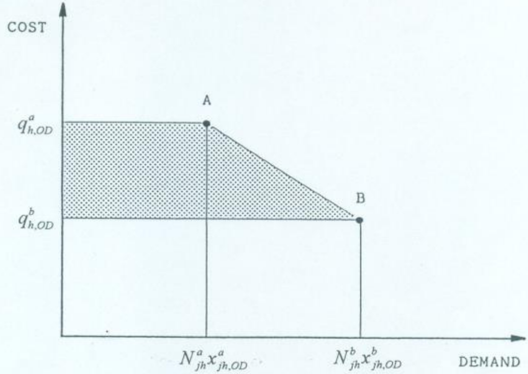

Fig. 1. Road users' benefit of households

2.3. Benefit incidence matrix

In order to make the structure intelligible, which is between the benefit generation and incidence calculated by equation (1), we have introduced the benefit incidence matrix shown in table 1. The numbers in <*> of table 1 indicate the figures of terms in equation (1). When the value of parentheses <*> in table 1 is positive it means the benefit, and when it is negative it means the loss. The total value of each column is the net benefit or loss of each sector; household, private firm, absentee landowner and government. The total value of each row is that of each item; road benefit, land benefit, gasoline tax, property tax and project cost. The grand total of these values, namely the SNB, is indicated at the bottom right corner.

Tab. 1. Benefit incidence matrix for road project

Item \ Sector	Household	Private firm	Landowner	Government	Total
Road benefit	⟨1⟩	⟨2⟩			⟨1⟩ + ⟨2⟩
Land benefit	⟨3⟩	⟨4⟩	⟨5⟩		0
Tax:					
Gasoline tax	⟨6⟩	⟨7⟩			
Property tax			⟨8⟩	⟨9⟩	0
Project cost				⟨10⟩	⟨10⟩
Total	⟨1⟩ + ⟨3⟩ + ⟨6⟩	⟨2⟩ + ⟨4⟩ + ⟨7⟩	⟨5⟩ + ⟨8⟩	⟨9⟩ + ⟨10⟩	SNB

3. IMPACT OF A RING ROAD PROJECT

3.1. The region: a medium city - Gifu

The studied region is the Gifu City which is located in Japan as shown in figure 2. In 1989, the population was 1,264,403 people or 366,496 households, the area is 131,479ha, and the core is Gifu City which has a population of 407,861 people. Zoning of this region is shown in figure 3,

Fig. 2. Location of Gifu City in Japan

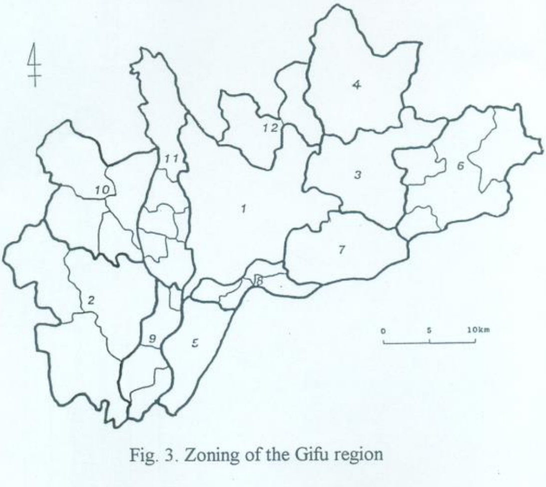

Fig. 3. Zoning of the Gifu region

where zone 1: Gifu C.(City); 2: Ogaki C., Yoro T.(Town) and Tarui T.; 3: Seki C.; 4: Mino C.; 5: Hashima C.; 6: Minokamo C., Sakahogi T., Tomika T. and Kawabe T.; 7: Kakamigahara C.; 8: Kawashima T., Ginan T., Kasamatsu T. and Yanaizu T.; 9: Hirata T., Wanouchi T., Anpachi T. and Sunomata T.; 10: Godo T., Ibigawa T., Ono T. and Ikeda T.; 11: Kitagata T., Motosu T., Hozumi T., Sunami T., Shinsei T. and Itonuki T.; 12: Takatomi T. and Mugegawa T..

3.2. The project: a ring road project

The project to be analyzed is the inner-city ring road construction in Gifu City, which is the toll free road, as shown in figure 4. The parts with the number <*> in figure 4 will be or have been completed by the year <*>, and roads without the number were completed by 1980. The total length of this ring road is 25km, and the total construction cost is 54.4 billion yen. The purpose of the study is to identify the benefit incidence from the ring road construction over the span of 30 years, in a simulation time period of every 5 years.

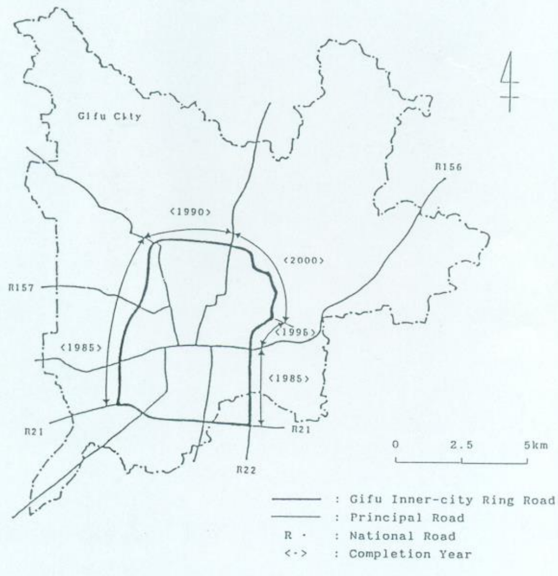

Fig. 4. Gifu inner-city ring road

3.3. Benefit incidence of each socio-economic sector

(1) Estimation of socio-economic model

The framework of a simple and practical socio-economic model for this study is shown in figure 5, which consists of four sectors: the household, private firm, absentee landowner and government sectors, and four markets: the residential land, industrial land, labor and transport markets. In this framework there are some assumptions. The two land markets are equilibrated by the land rent, where any interaction between the markets is not considered and each land supply is assumed fixed. The labor market is determined by the labor demand of the private firms regardless of wage rate, where the level of wage rate is fixed due to the fact that it is uniform over the studied region.

Residential location model

The exogenous variable of the residential location model is the number of households N'_{ig} which commute from zone i to zone g in period t-1. The endogenous variables are the number of households N_{jh} which commute from zone j to zone h in period t, the residential land rent r_j and some kinds of demand. The number of households N_{jh} in period t can be calculated by applying this location model to the number of households N'_{ig} in period t-1. This model is described as

$$N_{jh} = \Sigma_i \Sigma_g P_{j,ih} P_{h,ig} N'_{ig} \tag{2}$$

where $P_{j,ih}$: probability that the household would change its residential zone from zone i to zone j, with a fixed working zone h; $P_{h,ig}$: probability that the household which change its working zone from zone g to zone h, with a fixed residential zone i. Though these two kinds of movement are made simultaneously in actuality, we divide equation (2) in two steps as shown in figure 5; firstly the household may change its working zone due to the firm's strategy, then change its residential zone due to the environmental change, for example change of working zone. This is described as

$$N_{ih} = \Sigma_g P_{h,ig} N'_{ig} \tag{3-a}$$

$$N_{jh} = \Sigma_i P_{j,ih} N_{ih} \tag{3-b}$$

Estimation of N_{ih} in equation (3-a) at the first step is actually done by the present pattern method so as to meet the labor supply $\Sigma_i N_{ih}$ and the labor demand $\Sigma_m M_{hm} L_{hm}$ in each working zone h without constructing any model of probability $P_{h,ig}$, where M_{hm} is the number of private firms which are classified in the industrial type m and locate in zone h in period t, and L_{hm} is labor demand of each private firm. A model of probability $P_{j,ih}$ in equation (3-b), on the other hand, has been constructed by using the random location theory, which is in the form of the following Nested Logit Model.

$$P_{j,ih} = \left[\begin{array}{ll} P_{j,ihB} P_{B,ih}, & (j \neq i) \quad (4\text{-a}) \\ P_{A,ih}, & (j = i) \quad (4\text{-b}) \end{array} \right.$$

where $P_{j,ihB}$: probability that the household which has decided to relocate would change its residential zone from zone i to zone j, with a fixed working zone h; $P_{A,ih}$: probability that the household would not relocate; $P_{B,ih}$: probability that the household would relocate,

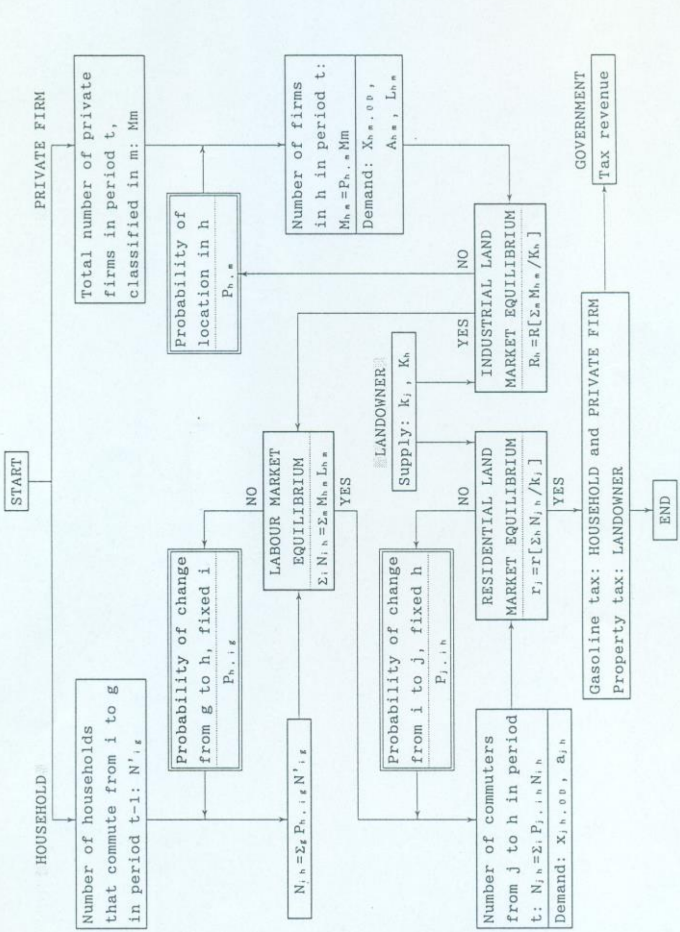

Fig. 5. Framework of socio-economic model

$$P_{j,ihB} = \frac{\exp \omega_2 V_{j,ihB}}{\Sigma_k \exp \omega_2 V_{k,ihB}} \tag{5-a}$$

$$P_{A,ih} = \frac{\exp \omega_1 V_{A,ih}}{\exp \omega_1 V_{A,ih} + \exp \omega_1 V_{B,ih}} \tag{5-b}$$

$$P_{B,ih} = 1 - P_{A,ih} \tag{5-c}$$

where ω_1: parameter concerned with the variance of random variables added to the utility $V_{A,ih}$ and $V_{B,ih}$ with the Gumbel distribution; ω_2: parameter concerned with the variance of random variables added to the utilities $V_{k,ihB}$ with the Gumbel distribution; $V_{k,ihB}$: utility of the household which has decided to relocate its residential zone from zone i to zone k, with a fixed working zone h; $V_{A,ih}$: utility of the household which would not relocate; $V_{B,ih}$: utility of the household which would relocate. The utility function $V_{k,ihB}$ in equation (5-a) is specified by the linear function of residential attributes of each zone. The utility function $V_{A,ih}$ is assumed to be measured by the sum of the residential location utility $V_{i,ihB}$ and the threshold of consciousness δ_i, and the utility $V_{B,ih}$ is defined by the expectation value of maximum utility level on those alternatives. The value of δ_i should be concerned with the households' relocationability as an index of the stickiness of city.

$$V_{k,ihB} = \Sigma_L \alpha_L z_{L(k,ih)} \tag{6-a}$$

$$V_{A,ih} = V_{i,ihB} + \delta_i \tag{6-b}$$

$$V_{B,ih} = \frac{1}{\omega_2} \ln \Sigma_k \exp \omega_2 V_{k,ihB}, \quad (k \neq i) \tag{6-c}$$

where α_L: parameter concerned with $z_{L(k,ih)}$; $z_{L(k,ih)}$: Lth attribute of the household which works in zone h and would change its residential zone from zone i to zone k.

From the residential land market equilibrium conditions, the residential land rent function $r[*]$ can be derived as

$$r_j = r\left[\Sigma_h N_{jh} / k_j\right] \tag{7}$$

where the residential land market is assumed to be independent of the industrial land market and the supply of land k_j should be equal to the residential site area in zone j because only in this case can it maximize the absentee landowners' utility. This function is specified by the linear function of residential density $\Sigma_h N_{jh} / k_j$. If the supply function k_j should be assumed to have some socio-economic factors which influence the landowners' supply behavior, the land rent function $r[*]$ might have those factors. We call the simultaneous equations with respect to N_{jh} which consist of equation (3-b) and (7) the residential location model.

Suppose that $\omega_1 = \omega_2 = 1$ and $\delta_i = \delta; (^\forall i)$. By using the disaggregate survey data on residential location, the residential location model is estimated as shown in table 2.

Industrial location model

The exogenous variable of the industrial location model is the total number of private firms M_m in period t. The endogenous variables are the number of private firms M_{hm} which are classified in the industrial type m and locate in zone h in period t, the industrial land rent R_h and some kinds of demand. The number of private firms M_{hm} can be calculated by applying this location model to the total number of private firms M_m in period t. This model is described as

$$M_{hm} = P_{h,m} M_m \tag{8}$$

where $P_{h,m}$: probability that the private firm classified in the industry type m would locate in zone h. A model of probability $P_{h,m}$ in equation (8) has been also constructed by using the Logit Model. The profit function $\Pi_{h,m}$ is specified by the linear function of industrial attributes of each zone.

$$P_{h,m} = \frac{\exp \theta \Pi_{h,m}}{\Sigma_k \exp \theta \Pi_{k,m}} \tag{9}$$

$$\Pi_{k,m} = \Sigma_L \beta_L Z_{L(k,m)} \tag{10}$$

where $\Pi_{k,m}$: profit function of the private firm classified in the industry type m which would locate in zone k; θ : parameter concerned with the variance of random variables added to the profit function $\Pi_{h,m}$ with the Gumbel distribution; β_L : parameter concerned with $Z_{L(k,m)}$; $Z_{L(k,m)}$: Lth attribute of the private firm.

From the industrial land market equilibrium conditions, the industrial land rent function R[*] can be also derived as

$$R_h = R[\Sigma_m M_{hm} / K_h] \tag{11}$$

This function is also specified by the linear function of the industrial density $\Sigma_h M_{hm} / K_h$. We call the simultaneous equations with respect to M_{hm}, which consist of equation (8) and (11) the industrial location model.

Suppose that $\theta = 1$. By using the aggregate survey data on industrial location, the industrial location model is estimated as shown in table 3.

Road service demand model

Define transport distribution as

$$x_{OD} = \Sigma_j \Sigma_h N_{jh} x_{jh,OD} \tag{12-a}$$

$$X_{OD} = \Sigma_h \Sigma_m M_{hm} X_{hm,OD} \tag{12-b}$$

where x_{OD}: road service demand of the households from zone O to zone D, which consists of the transport demand to work place, to school, on private business and to home; X_{OD}: that of the private firms, which includes the transport demand on business. Theoretically the transport demand functions x_{OD} and X_{OD} should be derived from the specified utility and profit functions, however it is almost impossible to specify the utility and profit functions which derive transport distribution with statistical significance. In this paper, therefore, the transport demand models are constructed independently of the residential and industrial location models.

The road service demands x_{OD} and X_{OD} are estimated in two steps. At the first step, transport generation X_O or attraction X_D for each trip purpose is estimated by the Cobb-Douglas model, controlled by total transport demand estimated by the trend of tendency. This Cobb-Douglas model is defined by

$$X_O \text{ or } X_D = e^{\gamma 0} Y_1^{\gamma 1} Y_2^{\gamma 2} \tag{13}$$

where Y_1: population in each zone; Y_2: number of the 3rd industry workers in each zone; γ_0, γ_1 and γ_2: parameters. At the second step, transport distribution X_{OD} for each trip purpose is estimated by the gravity model, controlled by both transport generation and attraction. The gravity model is defined by

$$X_{OD} = \frac{e^{\lambda 0}(X_O X_D)^{\lambda 1}}{t_{OD}^{\lambda 2}}, \quad \left(\Sigma_D X_{OD} = X_O, \Sigma_O X_{OD} = X_D\right) \tag{14}$$

where t_{OD}: transport time from zone O to zone D; λ_0, λ_1 and λ_2: parameters. Note that the number of households N_{jh} which commute from zone j to zone h is not always equal to the number of trips to work place x_{jh} (x_{OD}; O=j and D=h) because each household may not always have one worker, that is $x_{jh,jh} \neq 1$ in equation (12-a). So we estimate the transport demand to work place independently of N_{jh}.

The estimated parameters of the Cobb-Douglas models are shown in tables 4 and 5, and those of the gravity models are in table 6, where we use the Person Trip Census carried out in 1981.

Labor market

The labor demand is derived from the profit function (10) by applying the Hotelling's Lemma, that is

$$L_{h,m} = -\frac{\partial \Pi_{h,m}}{\partial w_h} \tag{15}$$

where $L_{h,m}$: labor demand of the industrial type m in zone h; w_h : wage rate in zone h. In the labor market the value of $L_{h,m}$ is assumed to reflect the change in sum of each column in $P_{h,ig}N'_{ig}$ in equation (3-a), that is

$$\Sigma_m M_{hm} L_{h,m} = \Sigma_i \Sigma_g P_{h,ig} N'_{ig} \qquad (16)$$

where assuming the wage rate remains constant regardless of the project.

Tab. 2. Parameters of residential location models

Utility function		Land rent function	
Attributes	Parameters	Attributes	Parameters
Ln[Generalized transport cost]	$-4.18*10^{-1}$ (13.8)	Constant term	$7.57*10^{2}$ (18.1)
Ln[Land rent]	$-1.63*10^{-1}$ (4.87)	Household number/ Residential area	$7.56*10^{5}$ (2.41)
Threshold of consciousness	$9.72*10^{-1}$ (4.37)	Dummy on zone 1	$1.25*10^{3}$ (3.15)
Correlation coefficient	0.906	Correlation coefficient	0.851

Tab. 3. Parameters of industrial location models

Profit functions				Land rent function	
Attributes	Parameters 1st ind.	2nd ind.	3rd ind.	Attributes	Parameters
Ln[Transport cost]	−3.03 (3.67)	−3.60 (3.71)	−2.84 (4.45)	Constant term	$3.09*10^{4}$ (8.50)
Ln[Land Rent]	−1.59 (2.48)	−1.25 (1.66)	$-5.20*10^{-1}$ (1.05)	Firm number/ Industrial area	$1.49*10^{1}$ (2.21)
Ln[Commuter cost + wage rate]	−4.36 (2.17)	−5.94 (2.32)	−8.48 (4.28)	–	–
Dummy on zone 1	1.64 (10.2)	1.55 (11.6)	2.31 (25.7)	–	–
Correlation coeff.	0.823	0.928	1.000	Correlation coeff.	0.844

Tab. 4. Parameters of road service demand models (transport generation)

Parameters	X_O				X_O
	to work place	to school	on private business	to home	on business
γ_0	−1.73 (4.47)	−1.43 (5.24)	−0.97 (1.39)	0.56 (1.30)	0.97 (1.72)
γ_1	1.06 (11.3)	0.97 (14.6)	0.67 (3.96)	0.60 (5.79)	0.35 (2.56)
γ_2	0.02 (0.26)	−0.04 (0.78)	0.38 (2.84)	0.39 (4.80)	0.56 (5.18)
Corr.	0.991	0.995	0.976	0.990	0.982

Tab. 5. Parameters of road service demand models (transport attraction)

Parameters	X_D				X_D
	to work place	to school	on private business	to home	on business
γ_0	−1.09 (1.55)	−0.23 (0.48)	−0.70 (0.84)	0.08 (0.26)	0.70 (1.07)
γ_1	0.59 (3.50)	0.58 (5.02)	0.43 (2.17)	0.93 (12.6)	0.37 (2.32)
γ_2	0.44 (3.28)	0.36 (3.92)	0.62 (3.95)	0.08 (1.35)	0.56 (4.49)
Corr.	0.976	0.986	0.971	0.994	0.976

Tab. 6. Parameters of road service demand models (transport distribution)

Parameters	X_{OD}				X_{OD}
	to work place	to school	on private business	to home	on business
λ_0	−9.36 (20.8)	−11.30 (16.8)	−9.38 (16.2)	−7.61 (18.1)	−11.00 (33.4)
λ_1	1.09 (32.4)	1.19 (25.2)	1.01 (25.6)	0.94 (32.1)	1.02 (50.3)
λ_2	0.48 (8.98)	0.71 (8.06)	0.51 (8.67)	0.48 (9.58)	0.17 (5.61)
Corr.	0.934	0.902	0.897	0.939	0.969

(2) Estimated benefit incidence matrix

Table 7 shows the estimated benefit incidence matrix of the ring road construction project from 1985 to 2015 for the whole studied region. These benefits are calculated every 5 years for the simulation period of 30 years, the life span of the project. Thus, the project benefit is 56.2 billion yen when we assume that the project life is within this term (1985-2015).

Tab. 7. Benefit incidence matrix for the Gifu ring road project (1985-2015)

ItemSector	Household	Private firm	Landowner	Government	Total
Road benefit	29.7	26.5			56.2
Land benefit	−23.7	−23.2	46.9		0.0
Tax:					
Gasoline tax	−1.4	−1.2		9.3	0.0
Property tax			−6.7		
Project cost				−54.4	−54.4
Total	4.6	2.1	40.2	−45.1	1.8

3.4. Discussion

Because the social net benefit is shown as 1.8 billion yen and the benefit cost ratio is about 1.03 (see table 7), this project may be efficient. From the viewpoint of equity, however, this project might not be adequate, because there are great differences of the benefit incidences among the socio-economic sectors as shown. The absentee landowners' share of the total benefit is 83.5% (46.9/56.2), while 79.8% (23.7/29.7) of the households' benefit and 87.5% (23.2/26.5) of the private firms' are transferred to the absentee landowners'. However the absentee landowners return only 14.3% (6.7/46.9) of their gains through property tax. From these estimated figures, the concept of a recovery system of development gains must be worthwhile and considered in order to set the policies for financing road projects such as this one.

Looking at the benefit incidence by zone level, the above situation becomes more complicated. Figure 6 shows the road users' benefit (ROAD BENEFIT) and the land users' benefit (LAND BENEFIT) of the household sector and those of the private firm sector in each zone. In only three zones (zone 1, 8 and 12), can the households obtain a positive net remaining benefit, while the rest show a negative benefit. This may be caused by the fact that the main effect of the project is the access improvement in the north and south direction. As a result of a balance between the attractiveness of transport improvement and the unattractiveness of the land rent increase caused by the immigration pressure into those attractive zones, the residential location tends to suburbanize. Looking at zone 1 (Gifu City) where the project has been carried out, the absentee landowners' share is 31.1% (6.8/21.9) and relatively lower than the grand total figures shown in table 7. This may lead to Gifu City becoming a relatively closed city. If this studied region was perfectly sticky, that is to say, every household had the highest threshold of consciousness on its relocation behavior or the lowest relocationability, the absentee landowners' share in each zone should be almost equal to 0% because nowhere should the land rent be varied between the cases with and without the project. On the other hand, if the region was not perfectly sticky, that is to say, every household would relocate sensitively according to differences of the utility level in each zone, the share should be relatively high, although it should depend on certain characteristics of the project, such as its scale and location.

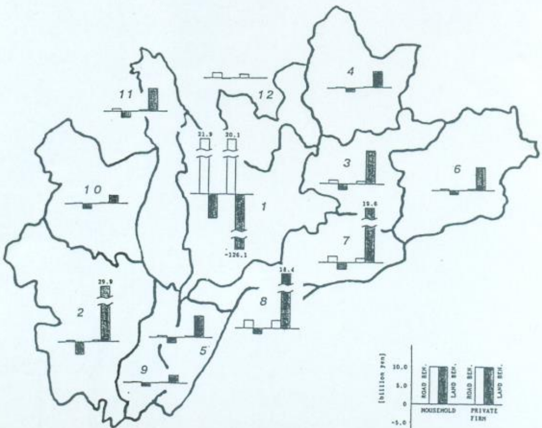

Fig. 6. Benefit incidence in each zone

The characteristics of benefit incidence in the private firm sector are quite different from that of the household sector. In this case, only the land users' benefit in Gifu City is negative while all the rest are positive. Moreover, the private firms in zone 1 are the only ones who cannot enjoy a positive net remaining benefit, while all the rest can. The rationale of this phenomenon may lie in the structure of the industrial location models, because the models have the tendency to concentrate in zone 1, caused by the Dummy variable as shown in table 3. The landowners' share in zone 1 is 627.4% (126.1/20.1), which shows that the sensitivity of the industrial land rent to the project is extremely high. According to this fact, it seems fair to establish a recovery system of development gains which has a higher recovery rate for industrial land and a lower one for residential land.

4. CONCLUDING REMARKS

The results of this experimental study on analyzing the Gifu ring road project are summarized as follows.

1) The results show that this project is worthwhile from the viewpoint of efficiency, because the social net benefit is positive, or because the benefit cost ratio is greater than 1.0. From the viewpoint of equity, however, this project might not be adequate, because there are great differences of benefit incidence among socio-economic sectors.
2) The absentee landowners' share of the total benefit is 83.5%, while 79.8% of the households' benefit and 87.5% of the private firms' are transferred to the absentee landowners'. However, the absentee landowners return only 14.3% of their gains through the property tax system. Therefore, it would be worthwhile to establish a recovery system of development gains.
3) The main effect of this project may be the access improvement for interaction among zones near the center of this studied region. As a result of a balance between the attractiveness of transport improvement and the unattractiveness of the land rent increase caused by the immigration pressure into those attractive zones, the residential location tends to suburbanize.
4) The industrial location models have the tendency to concentrate in zone 1, caused by the Dummy variable. As a result, the private firms in zone 1 are the only ones who cannot enjoy a positive net remaining benefit, while all the rest can.
5) The sensitivity of the industrial land rent to the project is much higher than that of the residential land rent, therefore it seems fair to establish a recovery system of development gains which has a higher recovery rate for industrial land and a lower one for residential land.

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