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by

Takeshi TOMIOKA and Komei SASAKI

(Graduate School of Information Sciences, Tohoku University)

Abstract: Reviewing critically the Roback type equilibrium model for evaluating local amenities, it is emphasized that regional population should be determined endogenously in a system. In the system of this paper, population size, wage income and land price in a particular city are recursively determined. The model was applied to data from 208 cities in Japan and on the basis of the estimated results, the value of local amenities was calculated. The empirical analysis indicates that the utility of residents largely depends on wage income, land price, and on some local amenities such as sewerage network coverage, university facilities, precipitation and the externality of agglomeration.

Keywords : migration adjustment, urban amenities, economic evaluation,
recursive model, agglomeration externalities.

JEL classification: R13, R23, Q29

Mailing address : Takeshi Tomioka

Graduate School of Information Sciences, Tohoku University,

Aramaki, Aoba-ku Sendai 980-8579, JAPA.

Fax : +81-22-217-4497

E-mail : tomioka@se.is.tohoku.ac.jp

sasaki@se.is.tohoku.ac.jp

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by Takeshi Tomioka and Komei Sasaki

1. Introduction

Interregional migration reacts to such economic factors as interregional discrepancies of income and price levels. However differences in natural and social amenities among regions have also been recognized as contributory factors of interregional migration. Accordingly, research on the methodology of evaluating regional residents' welfare have been actively undertaken .

Rosen[1979] first applied an equilibrium model to amenity evaluation and proposed a hedonic wage function for estimating the implicit prices of amenities. Roback[1982] developed the Rosen's framework, incorporating the behavior of both households and firms into an equilibrium model. A household chooses its residential location so as to maximize the utility from composite goods, housing services, and the location-specific amenities. If interregional migration is cost-less, then an equilibrium obtains through free migration such that the utility level is equalized among regions. A firm produces output with land and labor inputs under constant-return-to-scale technology and chooses its location so as to maximize its profit. If relocation of firms is cost-less also, and entry into and exit from the market are free, then the profit of a firm is zero, in equilibrium, regardless of where it operates. Thus, the equilibrium condition of the Roback model is represented as

$$v(w^i, r^i, \{s^{ih}\}) = v(w^j, r^j, \{s^{jh}\}) \qquad i, j = 1,\ldots, R. \quad i \neq j \tag{1}$$
$$c(w^i, r^i, \{s^{if}\}) = p \qquad i = 1,\ldots, R.$$

in which i is the suffix of a region, v the indirect utility function, c the average cost function r the land rent, $\{s\}$ the natural and social amenities, and p is the national price of output. The implicit price of the m-th amenity is defined as

$$p_{s_m} = \frac{v_{s_m}}{v_w} = \frac{v_r}{v_w}\frac{dr}{ds_m} - \frac{dw}{ds_m}$$

$$= l\,\frac{dr}{ds_m} - \frac{dw}{ds_m} \qquad (2)$$

where l is the lot size of a residence. The endogenous variables of this equilibrium model are wage rate and land rent in each region, and the system for determining those values is derived from (1). The values of dr/ds_m and dw/ds_m in (2) are estimated coefficients of the m-th amenity variable in the reduced form equations where the land rent and wage rate are, respectively, explained variables. Using the estimated implicit prices of amenities, the quality of life index (QOLI) is calculated as

$$QOLI_i = \sum_{m=1}^{M} p_{s_m} s_m^i \qquad (3)$$

Although the Roback equilibrium system has become a fundamental model for evaluating urban amenities, it has a drawback: the model is basically static. It is presupposed in the Roback system that households and firms move instantly in response to interregional differences in utility level and profit, respectively. It is likely that firms react rather promptly to changes in surrounding environment, adjusting their production level and demand for inputs , and relocating themselves so that interregional difference in profit will be eliminated. However, it is less likely that households instantly move to other regions in response to interregional differences in the attainable utility level because of the monetary and psychological costs of moving and institutional restrictions: that is, adjustment to the equilibrium by means of migration takes rather a long time. As formulated in Carlino and Mills(1987), households are hypothesized to adjust to disequilibrium with distributed-lag.

Few studies on amenity evaluation have described this migration adjustment process. It requires a dynamic model. Among the works in this area, Mathur and Stein(1991) analyzed the migration process in a two-region setting. It was shown that the interregional difference in amenity value is exactly reflected in the interregional difference in income and land rent only in equilibrium : in disequilibrium where migrations occur, the formula in (2) overestimates or underestimates the value of amenity. No empirical analysis for amenity evaluation was carried out by Mathur and Stein(1991).

As described above, it is hypothesized that population movement is adjusted to disequilibrium gradually rather than instantly. If so, labor and land markets are affected through such migration adjustment. How those markets operate during the course of adjustment can only be analyzed in a dynamic model. Such analysis is not only interesting but also essential for devising appropriate urban and regional policies.

The present paper therefore attempts to build a dynamic model in which population is an explicit endogenous variable, and to apply the model to Japanese regional data for evaluating local amenities. In section 2 a basic model is presented and section 3 is devoted to empirical analysis.

2. Migration model for amenity evaluation

Suppose a large region consists of many cities, each of which has intrinsic natural and social amenities. The levels of local amenities are supposed to be uniformly distributed at every location within a city but possibly differ among cities. Each household selects the most preferable city in which to live, comparing the locational conditions characterized by the wage rate, land rent and local amenities. It is assumed that commuting cost between different cities is formidably high, so each household's residence and workplace are located in the same city and the commuting cost within the city is negligible.

The behavior of a household

It is assumed that households in the large region have homogeneous preference, and each of them supplies unit labor force to a firm in the city where it resides, and receives the wage rate(which can be different among cities). Each household derives utility from composite goods x, housing service l, and the local amenities in a city, $\{s^{ih}\}$. It is hypothesized that at the beginning of current period, each household compares the utility level it *attained* and the average utility level in other cities it *could have attained* in the previous period, and if the latter exceeds the former, then the household is induced to move to another city. If the former exceeds the latter, then the household will continue to live in the city. Once, at the beginning of time t, a household chooses a city where it lives, it decides on a consumption plan during the period. That is, each household solves the following problem.

$$\max_{\{x,l\}} u(x_t, l_t : \{s_t^{ih}\})$$

$$st. \qquad w_t^i = x_t + r_t^i l_t \tag{4}$$

in which suffix i ($i = 1,..., R$) indicates a specific city, w is the wage rate, r the land rent and $\{s^h\}$ denotes the set of local amenities influencing residents' welfare. The optimal demand for composite goods and residential lot size is derived as

$$x_t = x(w_t^i, r_t^i : \{s_t^{ih}\})$$
$$l_t = l(w_t^i, r_t^i : \{s_t^{ih}\}) \tag{5}$$

and the attained utility level v^i is represented by indirect utility function in the following form:

$$v_t^i = v(w_t^i, r_t^i; \{s_t^{ih}\}) \tag{6}$$

The behavioral hypothesis above implies that the net social movement of population of city i (namely the number of in-migrant to city i minus that of out-migrant from city i) during period t, $\Delta N_t^i = N_t^i - N_{t-1}^i$ is positive when the utility level attained in city i at the previous period exceeds the average utility level in a large region at the previous period. ΔN_t^i is negative when the utility level in city i is lower than the regional average. However, such adjustment towards equilibrium cannot be made instantly since it incurs monetary and psychological movement costs, and adjustment cost for job change, and there are institutional and customary restrictions that must be faced. Population movement for adjustment to disequilibrium takes rather a long time, such that during period t only a fraction of the movement necessary for full adjustment is realized as ΔN_t^i.

Expanding the indirect utility function in a Taylor series about the average of each variable, $(\overline{w}_t, \overline{r}_t, \{\overline{s}_t^h\})$, the terms higher than the first order are neglected to obtain the following:

$$v^i = v(\overline{w}_t, \overline{r}_t, \{\overline{s}_t^h\}) + v_w \times (w_t^i - \overline{w}_t) + v_r \times (r_t^i - \overline{r}_t) + \sum_{m=1}^{M} v_{s_m} \times (s_{m,t}^i - \overline{s}_{m,t}) \tag{7}$$

where $v_w = \dfrac{\partial v(\overline{w}, \overline{r}, \{\overline{s}^h\})}{\partial w}$ $v_r = \dfrac{\partial v(\overline{w}, \overline{r}, \{\overline{s}^h\})}{\partial r}$ and $v_{s_m} = \dfrac{\partial v(\overline{w}, \overline{r}, \{\overline{s}^h\})}{\partial s_m}$.

The hypothesis of migration behavior is then represented as

$$\Delta N_t^i = \mu \left(v_{t-1}^i - \frac{1}{R} \sum_{j=1}^{R} v_{t-1}^j \right) \qquad i = 1,..., R \tag{8}$$

in which μ denotes adjustment speed, and R is the total number of cities in the large region. (8) is rewritten as

$$\Delta N_t^i = \mu\Big[v(\overline{w}_{t-1},\overline{r}_{t-1},\overline{s}_{t-1}) + v_w \times (w_{t-1}^i - \overline{w}_{t-1}) + v_r \times (r_{t-1}^i - \overline{r}_{t-1}) + \sum_{m=1}^{M} v_{s_m} \times (s_{m,t-1}^{ih} - \overline{s}_{m,r-1}^{h})$$

$$-\frac{1}{R}\{Rv(\overline{w}_{t-1},\overline{r}_{t-1},\{\overline{s}_{t-1}^{h}\}) + \sum_{j=1}^{R} v_w \times (w_{t-1}^j - \overline{w}_{t-1}) + \sum_{j=1}^{R} v_r \times (\overline{r}_{t-1}^j - \overline{r}_{t-1}) + \sum_{j=1}^{R}\sum_{m=1}^{M} v_{s_m} \times (s_{m,t-1}^{jh} - \overline{s}_{m,t-1}^{h})\}\Big]$$

$$= \mu\left\{v_w \times (w_{t-1}^i - \overline{w}_{t-1}) + v_r \times (r_{t-1}^i - \overline{r}_{t-1}) + \sum_{m=1}^{M} v_{s_m} \times (s_{m,t-1}^{ih} - \overline{s}_{m,t-1}^{h})\right\}$$

$$= A^1(w_{t-1}^i - \overline{w}_{t-1}) + A^2(r_{t-1}^i - \overline{r}_{t-1}) + \sum_{m=1}^{M} A_m^3 (s_{m,t-1}^{ih} - \overline{s}_{m,t-1}^{h}) \tag{9}$$

where $A^1 = \mu v_w$, $A^2 = \mu v_r$, and $A_m^3 = \mu v_{s_m}$

Equation (9) is the basic statistical model to be estimated.

The behavior of a firm and labor market

A firm located in city i produces output employing capital input, k, and labor input, n, under constant return-to-scale technology. Some local amenities, $\{s^{if}\}$ affect the efficiency of production : throughout the present paper, $\{s^{if}\}$ is distinguished from the amenities affecting households' utility, $\{s^{ih}\}$, although some attributes possibly belong to both. Firms' production function is represented as

$$X_t^i = F\left(k_t^i, n_t^i; \{s_t^{if}\}, \frac{N_t^i}{\overline{L}^i}\right) \tag{10}$$

where $\overline{L}$ is the total arable land area. The population density, $\frac{N}{\overline{L}}$, is introduced to represent agglomeration economies in a city.

A firm will employ factors so as to maximize the profit in a city where it operates, and will instantly move its location if the attainable profit differs among cities. Thus, in equilibrium, unit production cost in each city must be equal to the price of output at national market under constant return-to-scale technology. That is,

$$c\left(w_t^i; \frac{N_t^i}{\overline{L}^i}, \{s_t^{if}\}\right) = 1 \tag{11}$$

where national market price of output is assumed to be unity. The wage rate is adjusted in the labor market of each city in such a way that equation (11) holds : the wage rate is higher where amenities, $\{s^f\}$, promote production efficiency, and where large agglomeration economies (i.e. the large effect of $\frac{N^i}{\overline{L}}$) occur.

Land market

Since households are homogenous, the equilibrium of the residential land market in city i is represented as

$$L_t^{Di} = N_t^i \times l(w_t^i, r_t^i, \{s_t^{ih}\})$$
$$= \overline{L}^i \qquad (12)$$

where L^D is aggregated demand for residential land. Per capita land demand, $l(w_t^i, r_t^i, \{s_t^{ih}\})$, in (12) was derived in (5). Equilibrium land rent is, therefore, obtained as

$$r_t^i = r\left(\frac{N_t^i}{\overline{L}^i}, w_t^i, \{s_t^{ih}\}\right) \qquad (13)$$

In (13), land rent is increasing with w^i, and the large value of $\frac{N^i}{\overline{L}^i}$ increases demand for land, so heightening land rent. The effect of amenities on the land market is not unidirectional : if residential lot size and the m-th amenity are complementary (that is $\frac{\partial l}{\partial s_m^h} > 0$ in (5)) then a resident in a city with larger s_m^h will demand a larger lot so the land rent will be increased. If they are substitutable (i.e., $\frac{\partial l}{\partial s_m^h} < 0$), then a resident in a city with larger s_m^h decreases its lot size, and thus land rent is lowered .

An example of complementary amenity is commuting time : in a city where average commuting time is longer, a resident demands larger residence. Park size is regarded as a substitutable amenity : a resident in a city with more park land tends to be satisfied with a smaller residential lot.

The system consisting of (9), (11) and (13) is recursive : firstly, urban population at time t is determined by (9) ; secondly wage rate at t is determined by (11) ; and finally land rent at t is determined by (13). Therefore, on the assumption that no correlation exits among disturbances, the OLS model can be used for estimating the three equations.

3. Empirical analysis

The statistical model of migration equation (9) is specified as follows.

$$\Delta N_t^i = A^1 \Delta w_{t-1}^i + A^2 \Delta r_{t-1}^i + \sum_{m=1}^{M} A_m^3 \Delta s_{m,t-1}^{ih} + e_{1t}^i \tag{14}$$

in which $\Delta w_t^i = w_t^i - \overline{w}_t$, $\Delta r_t^i = r_t^i - \overline{r}_t$, $\Delta s_{m,t}^{ih} = s_{m,t}^{ih} - \overline{s}_{m,t}^{h}$ and e_{1t}^i is disturbance. It is expected that $A^1 > 0$, $A^2 < 0$ since $\mu > 0$, $v_w > 0$ and $v_r < 0$; $A_m^3 > 0$ if s_m^h is amenity and $A_m^3 < 0$ if s_m^h is disamenity to residents.

The wage rate model (11) is specified in the following form.

$$w_t^i = \alpha + \sum_{m=1}^{M'} \beta_m s_{m,t}^{if} + \gamma \frac{N_t^i}{\overline{L}^i} + e_{2t}^i \tag{15}$$

If s_m^f is favorable amenity to a firm, then $\beta_m > 0$; if s_m^f is disamenity to a firm, then $\beta_m < 0$. γ is expected to be positive because of agglomeration economies.

The rent function (13) is specified as follows.

$$r_t^i = a + b w_t^i + c \frac{N_t^i}{\overline{L}^i} + \sum_{m=1}^{M} d_m s_{m,t}^{ih} + e_{3t}^i \tag{16}$$

In (16) b and c are expected to be positive. As described above, $d_m > 0$ if s_m^h is complementary to lot size, and $d_m < 0$ if s_m^h is substitutable for lot size.

Evaluating the marginal value of each amenity around the means of wage rate, land rent, and amenity levels, equation (9) is used to derive the following :

$$p_{s_m} = \frac{v_{s_m}(\overline{w}, \overline{r}, \{\overline{s}^h\})}{v_w(\overline{w}, \overline{r}, \{\overline{s}^h\})} = \frac{A_m^3}{A^1} \qquad (m = 1, \ldots, M) \tag{17}$$

It is noted that the implicit price of each amenity can be *directly* derived from the estimates of migration model (14), while the RHS of (2) needs to be calculated using the estimates of wage and land rent regressions to obtain the implicit prices of amenities in the Roback type equilibrium model. On the assumption that marginal and average values are approximately equal, the total value of amenities in city i is calculated as

(3).

The data

This empirical analysis treats 208 cities in the Kanto and Tohoku region (the northern part of *Honshu*, Japan). Table 1 shows the size distribution of these cities. Nearly 60% of the cities have a population of less than 0.1 million and the availability of data on various amenities is limited in such small-sized cities. The period for analysis is from 1991 to 1995. In particular, the data on net in-migrant is the social change in population between 1991 and 1995. The data on wage rate, land price and local amenities are summarized in Table 2. [1]

The only natural amenity is precipitation, and other amenity variables express social attributes of each city. Variables 13 through 16 can represent level of consumption in a city. That is, the larger values of variables 13 through 16 indicate conveniency of consumption, and in this sense these variables serve as amenities. On the other hand, their larger values are sometimes associated with noise, congestion, and high crime rate ; in this situation they serve as disamenities. Variables 13 through 16 are closely related to each other, so principal component analysis was applied to them, avoiding the multicollinearity problem, so as to process composite variables as orthogonal to each other. For the subsequent analysis, only the first principal component was selected, its contribution rate being 73%.

The coverage rate of sewerage network and the area of park in a city are introduced to express the degree of comfort of life. The number of beds in hospitals denotes the level of medical service, and the amount of damages by fires serves as a proxy of safety in a particular city.

Four amenity variables are categorized as ones affecting production efficiency of industry, $\{s^f\}$: they are : number of university and collage students; time distance to the seat of the prefectural government; the time distance to Tokyo; and the population density. The number of university and collage students is introduced to represent human capital stock. For expressing the ease of face-to-face communication with customers and firms, two time distance variables (i.e. time distance to prefectural government office and to Tokyo) are introduced.

The data on net in-migrant, ΔN_i , was taken from the “Census” by the Prime Minister’s Office. As a proxy of the wage rate , the data on per capita received income was used, the source of which is the "Personal Income Index" published by the Japan Marketing Education Center. This data is employed for estimating the models in (14) and (16). The dependent variable, w_i , in (15) denotes the wage payment, that is, the cost of labor input for production. Under the assumption of no inter-city commuting in the model, the received wage income of a household and the wage payment of a firm are equal within each city. However, in reality, inter-city commuting exists, and it is desirable to use the wage payment rather than the received wage income as the dependent variable in (15) where the share of inter-city commuting in total labor force in a city is significantly high. Thus we processed the data on wage payment per worker in each city from the "Industry Census" conducted MITI. The rank-correlation coefficient and the simple correlation coefficient between the series of received wage income and wage payment were calculated. They are, representatively, 0.757 and 0.727, indicating that the two series are closely related in both rank and size. In this sense, the wage effect in the model is not affected *qualitatively* by the discrepancy between received and paid wage income in a city, although the estimate of the *quantitative* effect of the wage variable might be biased.[2] As a proxy of residential land rent in a particular city, the present study employed the mean of land prices at predetermined locations in the city (published by Toyo-Keizai Shinposha).

According to the variation coefficient in Table 2, net in-migrant shows the largest inter-city difference, followed by population size. Land price differs among cities largely in relative to wage income. The amenities differing largely among cities are: the number of university students; the coverage rate of sewerage network, park land area; and the amount of damage by fires.

Estimation results

The models were estimated for various combinations of amenity variables, and the result was selected for each of (14), (15), and (16) as shown in Tables 3 through 5. These will be examined in turn, below.

In the in-migration model (14), the coefficient of received wage income, A^1 , is positive as expected and significant at the 1% level. The coefficient of land price, A^2 , is negative as expected and highly significant. Among the amenity variables, the coverage rate of sewerage network, area of park land, the number of beds in hospitals, and the number of university students have positive coefficients as expected. In particular, the coverage rate of sewerage network is significant at 5% and the number of university students is significant at 10%.[3] The amount of damages by fires and precipitation are regarded as disamenity and their estimated coefficients were negative with the fire-damage variable being significant at 10%. The composite variable is closely related to the extent of agglomeration of finance, retail, restaurant, and service industries. If the "conveniency" effect of this variable prevails, then the expected sign is positive. However, the estimate of its coefficient was negative and significant at the 1% level. This implies that the composite variable serves as disamenity which causes neighborhood externality.[4, 5]

In sum, the estimation result of (14) shows that inter-city migration reacts sensitively to inter-city differences in wage income, land price and some local amenities, although the coefficient of determination of the model is not very high (0.45).[6]

Regarding the estimation result of (15), the coefficient of $\frac{N}{L}$ is positive and significant at the 1% level, reflecting agglomeration economies. The number of university students, a proxy of human capital stock, has a positive sign expected and significant at the 1% level. The time distance to the seat of prefectural office and that to Tokyo were introduced to measure the ease for face-to face communication with customers and other firms, and thus their coefficients are expected to be negative. The time distance to Tokyo has a negative sign which is significant at the 1% level. However, the coefficient of time distance to the seat of prefectural government is insignificant although negative. This suggests that accessibility not to the local center but to Tokyo affects the efficiency of an individual firm.

About 85% of the inter-city variance of wage rate was explained by the adopted structure.

Finally, the estimation result of (16) is examined. In accordance with the theoretical prediction, coefficients of both wage income and population density are positive and highly significant. As discussed above, it can be judged from the sign of the coefficient of amenity variable whether that amenity is complementary or substitutive to demand for residential lot size. Since the sign of the coefficients of the amenity variables cannot be determined a priori, the two-sided test was applied. All the amenities except for the composite variable are considered to be complementary since then coefficients are positive. In particular, the coefficient of number of university students is significant at the 5% level. An interpretation is that the average residential lot size becomes larger to accommodate more university students no matter where students reside. The composite variable is judged to be substitutive to lot size since its coefficient is negative and significant at 1% : a person tends to demand small residence in return for living in a convenient city. However, most of the amenity variables in the model have insignificant coefficients, and therefore, they are judged to be neutral to residential lot size. The explanatory power of the model is very high.

Value of amenities

Following the formula in (17), the value of amenities in each city was calculated using the estimates of (14). Cities in the sample were ranked according to the calculated amenity value.[7] Nineteen of the cities rating in the top twenty for amenity values have populations less than 0.25 million, and most of them are located within the Tokyo Metropolitan area. On the other hand, the bottom twenty cities have populations less than 0.1 million and most of them are located in the Tohoku area (far from Tokyo). It is commonly observed that the cities with higher amenity values have less agglomeration diseconomies, large number of university students, lass damages by fires, and high coverage rate of sewerage network. Also, those cities are close to large cities, and the wage rate in those cities is higher. However, in those cities, the number of beds in hospitals and the area of park land are below average.

Treating the amenity value, $QOLI^i$, as an aggregated variable, the following regression was estimated.

$$\Delta N_t^i = B^1 \Delta w_{t-1}^i + B^2 \Delta r_{t-1}^i + B^3 \Delta QOLI_{t-1}^i \tag{18}$$

The coefficient B^3 was positive and significant at the 1% level and the coefficient of determination was 0.433. The model without $\Delta QOLI$ in (18) was also estimated, and its coefficient of determination was 0.332. Thus nearly a quarter of the variance in net in-migrant is due to the variance in local amenity values.

4. Concluding remarks

Reviewing critically the Roback type equilibrium model for evaluating local amenities, we have emphasized that regional population should be determined endogenously in a system. In the system of this paper, population size, wage income and land price in a particular city were recursively determined. It was hypothesized that people decide on migration in response to the inter-regional difference of utility level in the previous period. The model was applied to data from 208 cities and on the basis of the estimated results, the value of local amenities was calculated. The empirical analysis indicates that the utility of residents largely depends on wage income, land price, and on some local amenities such as sewerage network coverage, university facilities, precipitation and the externality of agglomeration.

Empirical analysis of the wage payment function confirms that the time distance to Tokyo, a proxy of ease for face-to-face communication, greatly affects the production efficiency. Estimation of the land price function (16) enables us to identify the complement or substitute relation between amenity variable and residential lot size. Except for the density of institution of higher education and the agglomeration diseconomies, most local amenities were found to be neutral to lot size.

Since more than half of the cities treated in the empirical analysis are small ones with populations less than 0.1 million, the availability of data was limited so that data on various other amenity variables could not be incorporated. Finally it is pointed out that some social amenities intrinsically depend upon population size, and thus their values need to be endogenously determined to avoid estimation bias.

population size (millions)	N≧5	2≦N<5	1≦N<2	0.5≦N<1	0.25≦N<0.5	0.1≦N<0.25	0.05≦N<0.1	N<0.05	Total
number of cities	1	1	1	4	21	55	78	47	208

Table 1. Size distribution of cities

Variable		Maximum	Minimum	Mean	Standard variance	Variation coefficient
1. Net in-migrant ΔN (unit)		25016	-243173	-95.5961	17615.89	-184.274
2. Population N (unit)	1990 1995	8006386 7817332	20312 19111	184356.913 188087.947	603180.78 594089.453	3.2718 3.1586
3. Received wage income, w(yen)	1990 1995	2326000 2494000	638000 889000	1298235.577 1552639.423	367674.816 344312.547	0.2832 0.2218
4. Wage payment per worker	1995	8530058	2072718	4234029.754	996324.453	0.2353
5. Land price, r (yen/m^2)	1990 1995	1290100 585000	15000 16200	205854.327 153632.211	204758.643 120010.414	0.9947 0.7812
6. Area of available land $\overline{L}$ (km^2)	1995	612.36	5.1	75.424	71.933	0.9537
7. Precipitation, s^h (mm)	1990 1995	2277 2177	882 910	1393.07 1422.688	232.332 221.079	0.1668 0.1554
8.Coverage rate of sewerage network, s^h (%)	1990 1995	100 100	0 0	39.01 50.549	29.977 30.464	0.7684 0.6027
9. Area of park land, s^h (km^2/thousand heads)	1990 1995	51.88 53.7	0.36 0.38	6.4838 7.7486	6.456 7.257	0.9958 0.9366
10. Number of beds in hospitals, s^h (per thousand heads)	1990 1995	53.35 48.25	0.9 0.8	15.6763 15.2799	8.484 8.196	0.5412 0.5364
11. Amount of damages by fires, s^h (yen per head)	1990 1995	52721.215 5780.081	322.502 322.654	1567.961 1516.796	3658.050 879.772	2.3330 0.5800
12. Number of financial institutions, s^h (per thousand heads)	1990 1995	0.4734 0.4546	0.0643 0.0504	0.2137 0.2149	0.086 0.085	0.4008 0.3944
13. Number of retail stores, s^h (per thousand heads)	1990 1995	64.0125 64.2344	5.5670 5.3805	12.7095 12.4602	5.175 5.327	0.4071 0.4275
14. Number of restaurants, s^h (per thousand heads)	1990 1995	11.8217 11.6541	2.3502 2.5164	6.1713 6.1643	2.051 1.990	0.3323 0.3227
15. Number of firms in service industry, s^h (per thousand heads)	1990 1995	25.2560 27.3141	5.5566 6.7712	12.8264 13.2834	3.532 3.573	0.2754 0.2690
16. Number of university and college students , s^h and s^f (per thousand heads)	1990 1995	136.781 174.393	0 0	12.7263 15.1107	23.542 26.295	1.8498 1.7402
17. (shortest)time distance to Tokyo, s^f (minute)	1995	466	0	129.2644	86.640	0.6703
18. (shortest)time distance to the seat of prefectural office, s^f (minute)	1995	263	0	71.3365	50.974	0.7146
19. ratio between day-time and night-time populations	1990 1995	1.383 1.405	0.623 0.643	0.942 0.945	0.128 0.126	0.1362 0.1334

Table 2. Summary of data

Dependent variable : ΔN		
Explanatory variables	Estimates	t-value
Received wage income	0.0350	5.0346***
Land price	-0.1130	-10.7466***
Precipitation	-5.8104	-1.3018*
Coverage of sewerage network	118.018	2.5389***
Area of park land	0.1418	0.8920
Number of beds in hospitals	159.216	1.2178
Amount of damages by fires	-0.1076	-0.4123
Number of university and college students	63.7394	1.3874*
Composite variable	-4099.45	-5.4894***

Coefficient of determination = 0.445
F- value = 19.946
Significance test : two-sided test for composite variable and one-sided test for other explanatory variables
*** : Significant at the 1% level
* : Significant at the 10% level

Table 3. Estimation result of (14)

Dependent variable : w		
Explanatory variables	Estimates	t-value
Population density	54.0903	13.1379***
Number of university and college students	1730.32	4.4191***
(shortest)time distance to the seat of prefectural office	-55.6841	-0.2339
(shortest)time distance to Tokyo	-1862.20	-11.3875***
Constant term	1.60E+06	52.3675***

Coefficient of determination = 0.844
F- value = 273.921
Significance test : one-sided test for all the explanatory variables
*** : Significant at the 1% level

Table 4. Estimation result of (15)

Dependent variable : r

Explanatory variables	Estimates	t-value
Received wage income	**0.1446**	**11.1295***
Population density	**21.7799**	**18.1786***
Precipitation	**2.9368**	**0.3070**
Coverage of sewerage network	**69.2320**	**0.6744**
Area of park land	**0.2710**	**0.9081**
Number of beds in hospitals	**374.178**	**1.3167**
Amount of damages by fires	**0.3039**	**1.4722**
Number of university and college students	**202.833**	**2.4435**
Composite variable	**-4030.29**	**-2.6209***
Constant term	**-162711**	**-8.2217***

Coefficient of determination = 0.951
F- value = 353.256
Significance test : two-sided test for all amenity variable
and one-sided test for wage income and population density
*** : Significant at the 1% level
** : Significant at the 5% level

Table 5. Estimation result of (16)

Footnotes

1. The details on the variables and data are available from the authors upon request.

2. As shown in Table 2, the ratio between day-time and night-time populations is very close to unity in both 1990 and 1995. This might permit the assumption that people work in the city where they reside.

3. In contrast to our results, in Akai and Ohtake(1995) precipitation was judged as amenity to residents, and area of parkland was treated as disamenity to residents.

4. It can be hypothesized that the effect of the composite variable on residents, utility is not monotonous, but takes an invested-U shape: up to a certain level of the composite variable its "convenience effect" prevails, and after that level its "congestion effect" prevails. From the definition of v_{s_m} in (7), the estimation result is , thus, interpreted as showing that the "congestion effect" of the composite variable prevails around the mean values of attributes of the cities studied.

5. Examination of value distribution of the composite variable indicates that larger values of the composite variable were observed in most cities in Tohoku district with population less than 0.1 million and negative ΔN while smaller values of the composite variable were observed in most cities near Tokyo with population between 0.1 million and 0.5 million and with positive ΔN . In view of the measurement of composite variable in Table 2, its value becomes larger with population decrease (namely, net out-migration). Thus, due to this correlation between disturbance and the composite variable in (14), there is a possibility of estimation bias of the coefficient.

6. In our model, the commuting cost within a city is assumed to be zero. But, in reality, commuting cost is not negligible. We thus introduced into (14) a variable of the average commuting time of residents in a city as a disamenity representing the physical and psychic disutility due to commuting. But the coefficient of that variable was positive contrary to our expectation. Also, the availability of highway

and highspeed train service in each city was introduced in (14) as an amenity to provide convenient transportation network. However, its coefficient was negative against our expectation.

7. In culculating the amenity value of each city, namely QOLI in (3), only the amenities whose coefficients in (14) were significant should have been selected. However, the value of all amenity variables in (14) were aggregated in the calculation of QOLI. In this sense the result here is less reliable. The calculated amenity value for each city is available from the authors upon request.

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