CIRJE-F-3

Measuring Urban Agglomeration Economies

Takatoshi Tabuchi

The University of Tokyo

May 1998

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May 27, 1998

Abstract

In this paper, we estimated the net agglomeration economies both in production side and in consumption side using Japanese city data around 1990, when interregional net migration nearly ceased. We showed that doubling city size increases the nominal wage about 10% while it decreases the real wage about 4%. A 10% up of the nominal wage is attributed to the productivity increase in production activities while a 4% down of the real wage is a compensation for the net agglomeration economies, which are the benefits from product variety minus the costs of congestion. That is, city bigness not only enhances productivity of firms, but also brings net agglomeration economies to households. In this way, we separated the net agglomeration economies in production side from those in consumption side.

JEL Classification Number: R00, R10

Keywords: agglomeration, urban productivity, product variety, congestion, interregional differential

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*Faculty of Economics, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan. Email: ttabuchi@e.u-tokyo.ac.jp. The author expresses his thanks to Nobuo Akai and participants of the Jūtaku Keizai Kenkyūkai for useful comments and suggestions. Thanks also go to Kazuyuki Tokuoka for providing a data base of the SMEA population in 1990.

1 Introduction

The conventional neoclassical theory tells us that there should not exist price differentials between regions when production factors and/or products are perfectly mobile. According to Heckscher-Ohlin theorem, even if production factors are immobile, no price differentials occur between regions in the end.

In reality, however, per capita income, per area rent and the consumer price index do differ between regions. There are spatial regularities that as city size gets larger, these price levels become higher as will be seen in Section 3. However, these price differences are not proportional. In fact, the consumer price index in large cities is slightly higher than the national average, but the land rent in large cities is much higher than the national average. Due to these variations in the price differentials, it is not certain whether the real income in larger cities is higher or lower.

The real income level is affected by urban agglomeration economies and diseconomies. Urban agglomeration economies exert an influence on profits of firms and utility of households both directly and indirectly. For example, urban agglomeration of firms increases productivity of firms.[1] This increases the demand for labor and raises the wage rate, which would lead to an increase in the demand for land and its rent. That is, pecuniary positive externalities are at work at the city level. On the other hand, agglomeration of households brings about various congestion such as long distance commuting and insufficient housing space, which decrease the level of household utility. These are technological negative externalities.

In addition, economies of variety exist. Consumers can choose more suitable goods and services from a variety of them in larger cities. They can also enjoy the "city lights" effects there as demonstrated by Kelley (1977). Agglomeration economies also work in job search. Since there are diverse job types and various workers having different skills and knowledge in larger cities, jobs and workers tend to match easier.

In this paper, we would like to measure the above agglomeration economies in consumption side. On the other hand, Kanemoto, Ohkawara and Suzuki (1996) estimated

[1] There are many empirical studies showing that agglomeration raises labor productivity in manufacturing industries in the United States, Japan and Sweden. Roughly speaking, the labor productivity increase is about several percent by doubling city size. For more details, see Tabuchi (1986) and Kim (1997).

agglomeration economies in production side by applying Henry George Theorem. Our major question is whether agglomeration economies or agglomeration diseconomies dominate for households in large cities. If agglomeration diseconomies dominate, then we may say that large cities are overpopulated and in-migration to large cities should be restricted. On the contrary, if agglomeration economies are dominant, then further in-migration should be encouraged. In order to answer the question, we conduct an empirical analysis using Japanese city-based data.

In Section 2, we explain our model framework briefly and discuss estimation biases in conducting empirical analysis. In Section 3, we describe the city-based data used in this paper and examine interregional variations in the price data. We then estimate net agglomeration economies for households in Section 4, and report main results in Section 5.

2 Interurban Equilibrium Model

Let us conduct an empirical analysis based on Roback's (1982) model to see whether current city sizes are too large or too small. Roback developed a general equilibrium model of interregional land and labor markets.

There are many homogeneous office firms located at the city center. Each firm uses land and labor as inputs, and produces a numéraire good with constant returns to scale in production. Interurban migration as well as entry of firms is assumed to be free. The land rent and the wage rate in each city are determined endogenously within the model. Each firm maximizes its profit given the land rent, the wage rate and the urban amenities. Solving the first-order conditions for optimum, we obtain the following unit cost function:

$$C(w_f, r_f; \mathbf{z}) = 1, \tag{1}$$

where w_f is the wage rate, r_f is the office rent per area, $\mathbf{z}$ is the amenity vector. Subscripts denoting city numbers are omitted unless necessary. While these variables vary between cities, the unit cost function should be equal to one in each city under free migration of firms.

Next, there are many homogeneous households. Each household resides outside the central city, works at an office in the central city, and earns the wage income and rental income.

Given the income and the housing rent, each household consumes the numéraire good and the housing service. Similar to the firms, interurban migration of households is assumed to be costless. Maximizing the household utility, we derive the following indirect utility function:

$$U(w_h, r_h; \mathbf{z}) = U_o, \tag{2}$$

where w_h is the per capita income comprising the wage and rental income. r_h is the housing rent per area, or the price of the housing service per unit area. The values of r_h and w_h are different between cities and are determined endogenously as are the values of r_f and w_f. U_o is an equilibrium utility level determined by the entire city system. Each household chooses a city by considering the housing rent, the consumer price index, congestion, environmental quality, and so on. Under free migration of households, the utility level becomes equal between cities in equilibrium.

The amenity vector $\mathbf{z}$ affects not only the utility function but also the production function, and hence shifts the indirect utility function and the unit cost function. The urban amenities affecting production activities are agglomeration of firms, the level of infrastructure, and so on. These would be positively associated with city size, and are exogenous for firms. On the other hand, the urban amenities affecting the utility level are traffic congestion, product variety and so forth, which are also related to city size. To simplify the subsequent analysis, we regard city size as the most important proxy for amenities.

The cost function of equation (1) is called the factor price frontier. We draw it in Figure 1, where the horizontal axis is the wage rate w_f and the vertical axis is the office rent. Normally, the cost function C_o is then monotonically decreasing.

In Figure 1, we can also draw the indirect utility function of (2). Now, the horizontal axis is the income w_h and the vertical one is the housing rent r_h. The indirect utility function U_o is a locus of a constant utility level like an indifference curve showing the trade-off between the income and the housing rent. U_o should be monotonically increasing.

The equilibrium wage rate and the equilibrium housing rent are determined by the intersection E of C_o and U_o. In reality, however, data of point E can be hardly obtained. Since r_f is the office rent in the central city, firms on C_o, would pay the rent r_f and the wage w_f at A. Households on U_o would pay the housing rent r_f in the central city out of

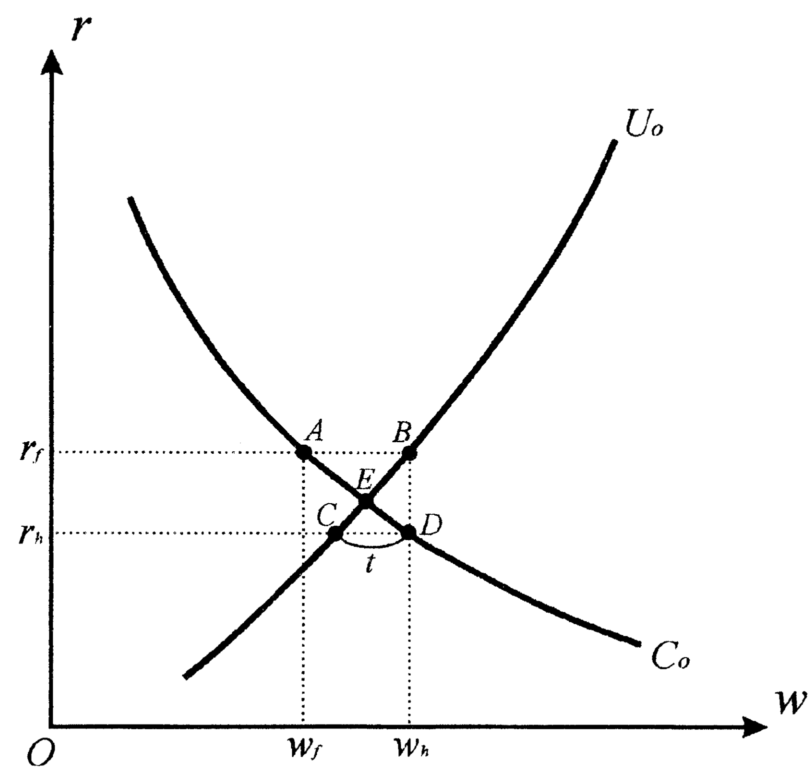

Figure 1: The Wage Rate, Office Rent and Housing Rent

the income w_h at B. By definition, the difference between w_h and w_f is the rental revenue of a household. Consider a household locating at the average distance from the center. In Figure 1, such a household is on C, where the housing rent is r_h and the generalized costs of commuting including congestion are higher by t as compared to the central city. Notice that B and C attain the same level of utility since they are on U_o. Finally, D is the point reading the average rent r_h and the per capita income w_h, which are the existing data. That is to say, while the equilibrium is given by E, the actual data is shown by D. The difference between E and D generates an estimation bias in the following analysis.

Figure 1 illustrates the equilibrium in a city of a certain size. What if the city size differs? When city size expands, the amenity level changes. Its net effect on the production side would be positive since agglomeration economies prevail in manufacturing industries. Interurban equilibrium by free migration of firms would be such that high productivity with high wage and high rent in large cities while low productivity with low wage and low rent in small cities. In Figure 1, the cost function C_o should shift up in large cities.

An expansion of city size also shifts the indirect utility function U_o. This is due to agglomeration diseconomies of congestion and due to agglomeration economies of product variety. If the congestion (e.g., high commuting costs) dominates, then U_o shifts down. On the other hand, if the product variety (e.g., diverse shops and restaurants) dominates, then U_o shifts up. It is an empirical question whether the shift is up or down. If households consider the city bigness is a disamenity, then U_o shifts down. If households consider the city bigness is an amenity, then U_o shifts up. In this way, we would like to estimate the agglomeration economies in consumption side.

3 Data

We conduct cross-sectional analysis using data of the Standard Metropolitan Employment Areas (SMEAs) of over 100 thousand population.[2] The data set are listed in Table 1. Due to data availability, however, these data are not SMEA based, but city based except population (N). Although there are 118 SMEA in Japan in 1990, our number of observations is 101 because some of the data are missing. We omit the results using the data of the wage rate in manufacturing industry since it behaves very similar to per capita income (w).

The first five price variables are endogenous variables, and the other nine variables are exogenous variables $\mathbf{z}$ as surrogates for urban environments. As discussed in the beginning of this paper, there should be no differentials in the first five prices in the absence of interregional transportation costs. However, the coefficients of variations of the first five price variables are different from zero, which may imply that interregional markets of labor, housing and consumer products are imperfect due to the existence of distance costs.

The coefficient of variations of the consumer price index is much lower than those of the other four price variables. This is because interregional arbitrage takes place easily due to low transportation costs of consumer products. The second lowest one is per capita income. Despite low mobility of labor, per capita income tends to be equalized between regions indirectly through markets for traded goods. On the other hand, the coefficient of variations of the housing rent is relatively high since housing service is non-traded.[3]

[2]Japanese interregional migration became very small in 1990s while more than seven million people had been migrating to the Tokyo Metropolitan Area from 1955 to 1989. And so, we may safely assume that interurban equilibrium is attained in 1990s.

[3]Tabuchi (1997) proved that the coefficient of variations of housing rent necessarily exceeds that of

variable	year	mean	standard deviation	coefficient of variations
consumer price index (p)	1992	101.3	2.28	0.023
per capita income (w)	1990	915	160	0.174
average housing rent (r)	1993	742	194	0.261
average land price for housing (r')	1992	135430	171399	1.266
highest land price for housing (r'')	1992	375742	1127768	3.001
SMEA population (N)	1990	872575	2921558	3.348
nitric monoxide	1991*	11.5	5.66	0.493
nitric dioxide	1991*	16.5	5.29	0.320
sulfur dioxide	1991*	5.92	1.58	0.267
floating particles	1991*	34.8	9.69	0.279
heating degree days	1961-90	1251	588	0.470
cooling degree days	1961-90	121	83.7	0.694
saturation level of drainage	1991*	45.6	23.8	0.523
time distance to Tokyo station	1995	5.13	3.65	0.712
average age	1990	37.6	1.46	0.039

Note: Years with the asterisk are fiscal years.

Table 1: Descriptive Statistics of the Data

In theory, the interregional differential in the housing rent must be proportional to that in the land rent if and only if arbitrage takes place between the land market and the financial market and the interest rate is the same between regions. In reality, however, the land rent varies more than the housing rent according to Table 1. The reason is that land is scarcer than building especially in big cities. Building can be high-rise by capital investment whereas land cannot.

Finally, in order to see empirical regularities of the prices, we computed the correlation coefficients between the SMEA population and the five price variables in Table 1. The values of the correlation coefficients are: 0.965 (the highest land price), 0.943 (the average

per capita income, which always exceeds that of traded good prices with normal consumer preference for housing and traded goods. The reason can be explained as follows. Suppose the housing rent in a big city is twice as large as that in a small city while the consumer price index is the same. If per capita income in a big city becomes double, then its consumer is better off by reducing the housing expenditure while purchasing more consumer goods. And so, to be an equal level of utility, per capita income in a big city should be smaller than double.

land price), 0.753 (the average housing rent), 0.522 (per capita income), and 0.431 (the consumer price index).[4] So, we confirm the spatial regularities that these price variables are positively associated with the city size.

4 Estimation

Using the data, let us now estimate the cost function (1) and the utility function (2). However, the simultaneous equation system was not estimated satisfactorily because there are few exogenous variables **z** which shift the cost function and because the data are not disaggregated by industry. The similar problem occurs in Voith (1991) using data in the United States.

So, we shall estimate the single equation (2) instead of the simultaneous equations. In this instance, we should avoid the correlation between the endogenous variables and the residual term. If we specify that the direct utility function is the Cobb-Douglas type, then the indirect utility function of (2) becomes loglinear. Transposing the endogenous variables to the LHS, we have

$$\log \frac{w_i}{r_i^{\beta_1} p_i^{1-\beta_1}} = -\beta_2 \log N_i - \sum_{j=3}^{J} \beta_j \log z_{ij} + \beta_o, \tag{3}$$

where subscript i denotes the city number, p_i is the consumer price index at city i, N_i is the population of city i, β_j's ($j = 1, 2, ..., J$) are parameters to be estimated. Notice that while the exogenous variables are at the RHS, all the endogenous variables are at the LHS. The term of the LHS can be interpreted as the "real wage" since the nominal wage (w_i) is divided by the rent (r_i) and the consumer price index (p_i).

In computing the real wage, the variable r_i should be the average housing rent inclusive of the imputed rent. However, such data are not available. So, we substituted it for three kinds of similar data: the average housing rent exclusive of the imputed rent (r), the highest land price (r''), the average land price (r'). These data are per one square meters.

It is well know that β_1 at the LHS of (3) is the ratio of the housing expenditure to the household income in the case of the Cobb-Douglas utility function. So, we changed the value of β_1 from 0 to 1 with an interval of 0.01, and ran multiple regressions by the OLS

[4]These values of the correlation coefficients are almost the same if we use the population of the central city instead of the SMEA population.

method for 101 times. The variables used in the analysis are listed in Table 2. The value of β_1 that maximizes the log-likelihood function turned out to be 0.38 when r_i is the average housing rent, 0.09 when r_i is the highest land price, and 0.18 when r_i is the average land price.

According to the Report of National Consumption Survey of 1989, the ratio of the housing expenditure inclusive of the imputed rent to the household income inclusive of the housing loan payment is 0.099. On the other hand, the average price of new housing is 6.7 times as high as the average household annual income. Provided the average length of service is 35 years, then the lifetime ratio of the housing expenditure to the household income is approximately 0.19. Incidentally, using a different data set, Watanabe (1996) estimated the marginal rate of housing expenditure, which was between 0.156 and 0.205. Taking these into consideration, it would be appropriate to adopt the maximum likelihood estimate of $\beta_1 = 0.18$ using the average land price.

The first three columns in Table 2 report the regression results by fixing $\beta_1 = 0.18$ and setting r_i be the average housing rent, the highest land price and the average land price respectively. The fourth column is identical to the third column except that the insignificant independent variables are dropped from the third one. We confirm that the signs of the regression coefficients are almost comparable between the four regressions.

Positive signs of the coefficients imply that these variables are disamenities. This is because it should be compensated for the higher real wage to keep the same utility level. For example, in a city with a high density of nitric dioxide, the real wage should be high so as to make up for air pollution. And, the real wage in a city with very cold or very hot temperature should be high so as to compensate for high air-conditioning costs.

The variables of the time distance to Tokyo and the average age are also significant. Their economic interpretations are not so straightforward partly because the true utility function may be very complex, and partly because they may be proxies for unobservable environmental variables.[5]

We now turn to the regression coefficient of the population (β_2), which is the major focus of this paper. We observe from Table 2 that the sign of β_2 is negative for every case

[5]The time distance to Tokyo is a proxy for market potential (Harris, 1954) or accessibility in economic geography. The accessibility as an index of agglomeration economies is positively associated with population density as an index of agglomeration diseconomies as shown by Tabuchi (1982).

	average housing rent	highest land price	average land price	average land price
SMEA population	-0.0096	-0.0823	-0.0419	-0.0355
($-\beta_2$)	(-0.65)	(-5.26)	(-3.22)	(-3.17)
nitric monoxide	-0.0469	-0.0271	-0.0543	
	(-1.00)	(-0.54)	(-1.31)	
nitric dioxide	0.1923	0.1109	0.1432	0.0592
	(2.32)	(1.26)	(1.87)	(1.96)
sulfur dioxide	-0.0065	-0.0757	-0.0415	
	(-0.13)	(-1.44)	(-0.95)	
floating particles	-0.0027	0.0546	0.0166	
	(-0.05)	(0.96)	(0.35)	
heating degree days	0.0182	0.0217	0.0211	0.0187
	(4.41)	(4.95)	(5.80)	(5.95)
cooling degree days	0.0045	-0.0003	-0.0002	
	(2.56)	(-0.15)	(-0.22)	
saturation level	0.0241	0.0180	0.0185	
of drainage	(1.34)	(0.95)	(1.17)	
time distance to	-0.0174	-0.0089	-0.0111	-0.0108
Tokyo station	(-3.51)	(-1.68)	(-2.28)	(-2.54)
average age	-1.4049	-1.1601	-1.3360	-1.3018
	(-5.02)	(-3.90)	(-5.41)	(-5.62)
constant	4.5622	3.6867	3.9804	3.9500
	(4.14)	(3.15)	(4.09)	(4.45)
adjusted $\bar{R}^2$	0.493	0.375	0.385	0.391

Note: All variables are transformed into logarithm. t-ratios are shown in parentheses.

Table 2: Multiple Regressions Whose the Dependent Variables are Real Wages ($\beta_1 = 0.18$)

and that its estimate is significantly different from zero at the 1% level for the cases of the land prices.

The multicolinearity would not exist in the regressions. This is because the simple correlation coefficients between the population and the other independent variables are at most 0.466, and because the multiple correlation coefficients between the population and linear combinations of the other independent variables are at most 0.552. Note that these are logged variables. In addition, these results are robust against sample selections. For example, omitting the outliers like Tokyo and Osaka, omitting cities with population more than a million, or omitting cities with population less than 500 thousand hardly alters the estimate and the t-ratio of β_2. Hence, we may conclude that the estimate of β_2 in Table 2 is reliable.

The negative sign of β_2 in Table 2 means that the larger the city size is, the lower the real wage. This is understood since the amenities z_{ij} are controlled in the regressions and the utility level is the same between cities. We may thus interpret that the net agglomeration economies are compensated by the low real wage in large cities. In other words, the agglomeration economies due to product varieties outweigh the agglomeration diseconomies due to congestion for households residing in large cities.

The estimates of β_2 are between -1.0% and -8.2% in Table 2. It implies that doubling city size, the real wage decreases by several percent. Since the estimates of β_2 vary considerably between the regressions, let us examine possible estimation biases below.

The first regression using the average housing rent (the first column in Table 2) corresponds not to point E, but to point D in the previous Figure 1. Since the value of r_i is smaller and the value of w_i is larger at D, the real wage $(w_i/r_i^{\beta_1}p_i^{1-\beta_1})$ tends to be larger. This bias is amplified for large cities with high commuting costs t, which leads to overestimation of the population coefficient β_2.

One way to avoid this bias is to use the data of the housing rent in the central city. Unfortunately, such data do not exist in Japan. So, we used the data of the highest land price instead, which is the second column in Table 2. The problem of the highest land price is lack of data reliability since there is only one sample for one city. That is, the highest land price would vary more than the average land price owing to random shocks. In addition, as mentioned at the end of Section 3, the land price is likely to vary between cities more than the housing rent. Consequently, the real wage gets lower for larger cities with the highest land price causing underestimation of the population coefficient β_2. This is a reverse bias to the case of the average housing rent.

The third column in Table 2 is the regression using the average land price. The merit of the average land price is the data reliability because of many observations. The last column is the same as the third one except that statistically insignificant variables in the third regression are dropped. The estimate of β_2 is therefore -4.2% or -3.56% using the average land price.[6]

[6]So far, N_i is the SMEA population while the other variables are central city data in the regressions in Table 2. If we use the population in the central city instead of the SMEA population, then the estimate

Summarizing the foregoing, we can say that the estimate β_2 of -1.0% using the average housing rent is overestimated whereas that of -8.2% using the highest land price is underestimated. On the other hand, it is approximately -4% using the average land price. Since -4% is in between, the above discussion on possible estimation biases is consistent. Thus, we may roughly state that doubling city size pushes down the real wage about 4% due to net agglomeration economies.

However, it is also true that doubling city size pushes up the nominal wage. When logarithm of the nominal wage w_i defined by per capita income is regressed by logarithm of the population N_i, the estimate of the simple regression coefficient turns out to be +9.9%.[7] So, doubling city size raises the nominal wage by about 10%, which is due to an increase in labor productivity.[8] This is in accord with the empirical studies that doubling city size increases labor productivity in manufacturing industries in the United States, Japan and Sweden about several percent (Kim, 1997).

It should be noticed that firms care for the nominal wage while households care for the real one. The simple regression for the nominal wage expresses the behavior of firms whereas the multiple regression (3) describes the behavior of households. So, the 10% up of the nominal wage is attributable to the productivity increase in production activities. On the other hand, the 4% down of the real wage is compensated by the net agglomeration economies, which are the benefits from product variety minus the costs of congestion. We thus confirm that while city bigness enhances productivity of firms, it also brings net agglomeration economies to households.

5 Conclusion

In this paper, we attempted to quantify agglomeration economies and agglomeration diseconomies both in production side and in consumption side. We showed that when city size

of β_2 become -5.4% and -4.8% in the third and fourth regressions respectively. The t-ratios and the other estimates are similar to the cases of the SMEA population.

[7] If we use the population in the central city instead of the SMEA population, then this increase becomes 9.0%, which is similar too.

[8] Likewise, we found by simple regressions that doubling city size raises the average land rent by 51% and the consumer price index by 1.3%. The economic reason for these differences is explained in footnote 3.

becomes double, the nominal wage goes up about 10% whereas the real wage goes down about 4%.

Our conclusion is shown by the schematic diagram of Figure 2. The 10% difference in production side is reflected to the nominal wage differential while the 4% difference in consumption side is captured by the real wage differential. In this way, the net agglomeration economies in production and in consumption can be econometrically separated.[9]

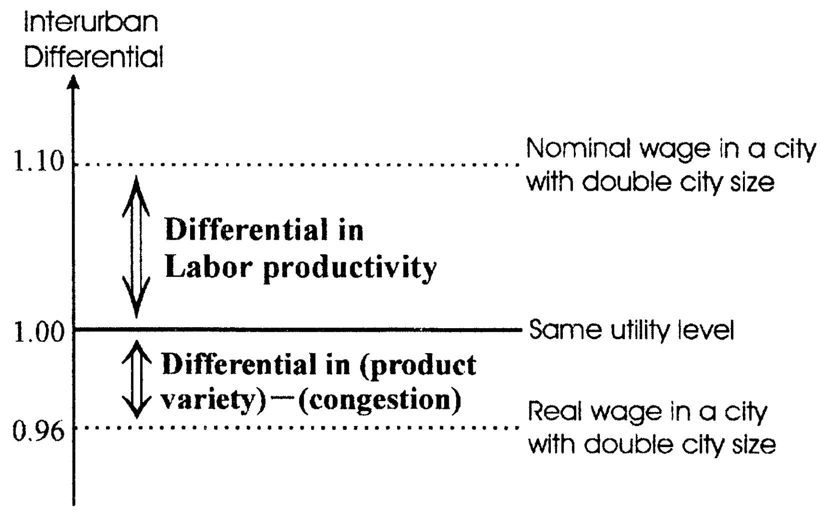

Figure 2: Nominal Wage Differential and Real Wage Differential

Data Sources

- Consumer price index (p): consumer price index excluding the housing rent, *Zenkoku Bukka Tōkei Chōsa Hōkoku* (National Survey of Prices), Volume 1, Management and Coordination Agency, Statistics Bureau, 1992.
- Per capita income (w): tax-based income divided by population with the national average of 1000, *Shichōsonzei Kazei Jōkyō tou no Sirabe* (Survey of Municipal Taxation), Ministry of Home Affairs, 1990.

[9]It should be noted that these conclusions are with reservations because urban hierarchical systems, where different goods and services are produced between large and small cities, are out of consideration in this paper. Furthermore, recently increasing interurban division of labor is not considered here. When production processes are divided into several plants located in various cities, the notion of urban agglomeration economy may be extended to that of network economy, or international increasing returns to scale (Ethier, 1982).

- Average housing rent (r): monthly housing rent per m^2, *Jūtaku Tōkei Chōsa* (Housing Survey of Japan), Statistics Bureau, 1993.

- Average land price (r'): average price of land per m^2 in a residential area, *Chika Kōji* (Official Posted Land Price), National Land Agency, 1992.

- Highest land price (r''): highest price of land per m^2 in a residential area, *Chika Kōji* (Official Posted Land Price), National Land Agency, 1992.

- SMEA population (N): population in the Standard Metropolitan Employment Area (SMEA) derived from Tokuoka (1991) using the National Census, Statistics Bureau, 1990.

- Nitric monoxide (z_1): $0.001ppm$, *Nippon no Taiki Osen Jōkyō* (Air Pollution in Japan), Environment Agency, *Gyōsei*, 1991.

- Nitric dioxide (z_2): $0.001ppm$, *Nippon no Taiki Osen Jōkyō* (Air Pollution in Japan), Environment Agency, *Gyōsei*, 1991.

- Sulfur dioxide (z_3): $0.001ppm$, *Nippon no Taiki Osen Jōkyō* (Air Pollution in Japan), Environment Agency, *Gyōsei*, 1991.

- floating particles (z_4): $0.001mg/m^3$, *Nippon no Taiki Osen Jōkyō* (Air Pollution in Japan), Environment Agency, *Gyōsei*, 1991.

- Heating degree days (z_5): calories for heating up to 14°C in a year, *Rika Nenpyō* (Chronological Scientific Tables), National Astronomical Observatory, *Maruzen*, average from 1961 to 1990.

- Cooling degree days (z_6): energies for cooling down to 24°C in a year, *Rika Nenpyō* (Chronological Scientific Tables), National Astronomical Observatory, *Maruzen*, average from 1961 to 1990.

- Saturation level of drainage (z_7): percentage, *Chiiki Keizai Sōran* (Regional Statistics Data Bank), *Tōyō Keizai Shinpōsha*, 1991.

- Time distance to Tokyo station (z_8): Shortest time to the Tokyo station by train, *Eki Supāto Zenkokuban*, Val Kenkyūsho, 1995.

- The average age (z_9): National Census, Statistics Bureau, 1990.

References

[1] Ethier, W.J. (1982) "National and international returns to scale in the modern theory of international trade," *American Economics Review,* 72, 389-405.

[2] Harris, C. (1954) "The markets as a factor in the localization of industry in the United States," *Annals of the Association of American Geographers,* 64, 315-348.

[3] Kanemoto, Y., T. Ohkawara and T. Suzuki (1996) "Agglomeration economies and a test for optimal city sizes in Japan," *Journal of the Japanese and International Economies,* 10, 379-398.

[4] Kelley, K.C. (1977) "Urban disamenities and the measure of economic welfare," *Journal of Urban Economics,* 4, 379-388.

[5] Kim, S.-J. (1997) *Productivity of Cities,* Ashgate, Aldershot.

[6] Roback, J. (1982) "Wages, rents and the quality of life," *Journal of Political Economy,* 90, 1257-1278.

[7] Tabuchi, T. (1982) "Optimal distribution of city sizes in a region," *Environment and Planning A,* 14, 21-32.

[8] Tabuchi, T. (1986) "Urban agglomeration economies, capital augmenting technology, and labor market equilibrium," *Journal of Urban Economics,* 20, 211-228.

[9] Tabuchi, T. (1997) "Why interregional price differentials differ," CCES Discussion Paper No.A-11, Institute of Economic Research, Kyoto University.

[10] Tokuoka, K. (1991) "Nippon no daitoshiken: 1985 nenni okeru SMEA no settei to toshika no dōkō," *Kagawa Daigaku Keizai Gakubu Kenkyū Nenpō,* 30, 139-210.

[11] Voith, R. (1991) "Capitalization of local and regional attributes into wages and rents: Differences across residential, commercial and mixed-use communities," *Journal of Regional Science,* 31, 127-145.

[12] Watanabe, N. (1996) "Jūtakuhi futanritsu no kōsatsu," *Jūtaku Tochi Keizai,* 20, 21-33.