연세경제연구 제 Ⅷ권 제 2 호
Yonsei Economic Studies, Vol. Ⅷ, No. 2 (September 2001)

National Urbanization and Primacy: Experiences of Korea

Seoung Hwan Suh and Young Rok Cheong

Factors affecting the urbanization rate are found to be the employment ratio of secondary and tertiary sectors and the per capita *GDP*. In case of Korea, the urbanization rate of around 90% level seems to be the convergence level.

If we consider the reasonable primacy index like *PR*3 of this paper, it will be concluded that the primacy problem becomes serious as the national urbanization proceeds. The primacy indices defined in the usual way have the problems of having no theoretical backgrounds. In order to overcome this problem, the optimal size distribution of cities is analyzed.

Depending upon the degree of externalities and the assumptions on the geographical distribution of cities, optimal size of the prime city, OSP, might be ranged between 79~94% of the current size of the prime city. Also, the welfare cost of the sub-optimal size distribution of cities, *WC*, ranges 2.6~9.1% of the *GDP*.

It is important to understand that the major factor affecting *WC* and OSP is not the absolute size of the externality cost but the relationship between externality costs of cities with different sizes. This may imply that it is most important not to consider separate city but to consider the system of cities all together.

Department of Economics, Yonsei University, 134 Shinchondong, Seodaemoongu, Seoul, 120-749.

Department of Economics, Seoul National University, 56-1 San, Shinlimdong, Kwanakgu, Seoul, 151-742.

I. Introduction

As for the process of national urbanization and the primacy problems, there seem to be common beliefs. The one is that the process of national urbanization follows S-shaped curve, which is very much similar to the biological growth pattern of the most living objects.[1] The other is that, in almost all countries, people believe that the size of their prime city is too large and this kind of primacy problems become more serious as the national urbanization proceeds.[2]

Purposes of this paper are two folds. The one is to find out factors affecting the national urbanization and to estimate the urbanization rate. The other is to clarify the meaning of the primacy problem and to calculate the optimal size of the prime city and the welfare cost of the sub-optimal size distribution of cities.

In estimating the urbanization rate, the convergent process must be clearly considered. Thus, the logistic rather than the linear functional form will be considered. In order to consider the primacy problem, the primacy index is usually defined as the relative size of the prime city with respect to the summation of sizes of total of 'k' largest citites. Here, 'k' is sometimes 5 or the total number of urban areas.[3] It is easy to calculate this kind of primacy index. But, the problem is that it has no theoretical backgrounds.

In order to overcome these problems, the optimal size distribution of cities will be analyzed. Based upon these theoretical analyses, the optimal size of the prime city and the welfare cost of the sub-optimal size distribution of cities will be calculated. In calculating the welfare cost, the externality costs will be explicitly considered. Even though this approach is very complex, results can be easily understood and be well backed up by the strong theory.

---

1) Mills and Hamilton [8], Grihfield and Panggabean [5].

2) Rosen and Resnick [14], Renaud [12].

3) Rosen and Resnick [14].

Ⅱ. National Urbanization Trend and Its Determinants

In this section, the national urbanization trend of Korea and factors affecting it will be analyzed. As usual, the national urbanization is expressed by using the urbanization rate, *UR*, which is the ratio of urban population with respect to the total population. Here, the urban population means those who live in cities, the population of which is over 20,000. The trend of Korean *UR* is shown in ⟨Table 1⟩.

It is well known that the national urbanization follows S-shaped growth pattern, which is exactly the same as the biological growth pattern of the most

⟨Table 1⟩ National Urbanization Trend and Relating Factors

	Urbanization Rate (%)	Non-agricultural Sector Employment Ratio (%)	Per Capita *GDP* (Nominal, US Dollar)
1920	3.3[1)]	n.a.	n.a.
1930	4.5[1)]	n.a.	n.a.
1960	39.1	36.9[2)]	87[3)]
1970	50.1	49.6	249
1980	68.7	66.0	1598
1990	81.9	81.7	5886
1995	85.5(90.5)[4)]	87.5	10823
2000	86.8(90.8)[4)]	89.0	9628

Suorce : MGAHA, Municipal Yearbook of Korea, each year.
BOK, Economic Statistics Yearbook, each year.
1) unofficial data of the Japanese Government General in Korea.
2) 1963.
3) 1962.
4) Numbers in parentheses are UR's considering rural areas, which were merged to cities after 1995.

living objects.[4] At the early stage of urbanization, the urbanization process is very slow. After that, the period of very rapid urbanization follows. And finally, the *UR* converges to a certain level, which in general is between 75% and 90%.

Whether this pattern can be applied regardless of the economic systems seems to be controversial. There are two groups having different opinions.[5] Structuralists or Neo-Marxist stressed the singularities of the socialist experience of urbanization. They argue that the class aspect and the increasing bureaucratisation of Soviet-type societies caused the different track of urbanization compared to the industrialized West. This has become known as the hypothesis of 'under-urbanization'.[6] On the other hand, Neo-Weberians argued that the urbanization took much the same path East and West, the former simply lagging behind the latter and thereby effectively producing a pattern of underurbanization.

But, as is shown in ⟨Table 1⟩, Korean urbanization followed exactly the same S-shaped pattern. Between 1920 and 1930, the *UR* increased only by 1.2% point. 1970's and 1980's were periods of rapid urbanization. In those 20 years, the *UR* increased by 31.8% point and especially in 1970's the *UR* increased by 18.6%. As of now, Korean *UR* seems to reach the convergence point. *UR* is almost fixed around 86～87% since 1995.

The determinants of national urbanization can be found in scrutinizing the process of urbanization. The usual explanation of the process of urbanization is as follows. As income increases due to the economic development, demands for secondary and tertiary products become to increase very fast while the demand for the primary products is stagnating. This will cause the increase in the production and employment of secondary and tertiary sectors.

---

4) Mills and Hamilton [8], Grihfield and Panggabean [5].

5) Enyedi [4], Sjoberg [15].

6) Konrad and Szelenyi [6], Murray and Szelenyi [9].

The highly land intensive primary sector is located in the rural area, where land rent is cheaper than the urban area. Thus, the increase in the employment of the secondary and the tertiary sector will imply the rural-urban migration, i.e., the urbanization. Based upon this, two factors, which can be considered to affect the urbanization, can be classified.

The one is the employment ratio of secondary and tertiary sectors, *RNA*, which is closely related to the degree of migration. The other is the per capita *GDP*, *Y*, which is closely related to the degree of development of the economy. As is shown in 〈Table 1〉, the trends of *RNA* and *Y* are very much similar to that of *UR*. Now, we will check whether *RNA* and *Y* can be a factor explaining *UR* through the regression analysis.

In order to avoid the spurious regression, the unit root test and cointegration test must be proceeded. For this, annual data from 1980 to 2000 are used because data for *UR* were reported irregularly before 1980. Also in both of unit root and cointegration test, tests are made after the log transformation of *UR*, *RNA* and *Y*.

〈Table 2〉 Results of Phillips-Perron Test

UR	ΔUR	RNA	ΔRNA	Y	ΔY
4.26	-2.24	4.16	-1.69	2.82	-2.99

Note : * 1%: −2.65, 5%: −1.95, 10%: −1.62.

〈Table 3〉 Results of Johansen's Cointegration Test for *UR*, *RNA* and *Y*

Eigen Value	Likelihood Ratio	Significance Level (5%)	Significance Level (1%)	Null Hypothesis
0.6299	33.9	24.3	29.8	$h=0$
0.2659	8.1	12.5	16.3	$h\leq 1$
0.0009	0.0	3.8	6.5	$h\leq 2$

Results of the Phillips-Perron test are summarized in ⟨Table 2⟩. In this table, Δ implies the first difference, i.e., $\Delta UR_t = UR_t - UR_{t-1}$. Less than 10% significance level, all three variables of *UR*, *RNA* and *Y* can be concluded as *I* (1). Results of Johansen cointegration test are summarized in ⟨Table 3⟩. In ⟨Table 3⟩ *h* implies the number of cointegrating vectors. When all three variables are used, error terms will be white noise. Thus, we will safely avoid the spurious regression if we use all three variables in the regression analysis.

Before we run the regression, we must consider the functional form in order to consider the convergence of *UR*. Since *RNA* converges, linear functional form of *RNA* can be used. But, as for *Y*, linear funtional form cannot be used since *Y* is monotonically increasing. In order to overcome this divergence of *Y*, logistic functional form is used. The result of regression is as follows.

$$\begin{aligned} \log UR_t = {} & \underset{(3.22)}{0.1745}\log RNA_t + \underset{(4.85)}{1.1051}/[1.0 + \exp\{-\underset{(1.78)}{0.0278}\log Y_t\}] \\ & + \underset{(3.59)}{0.0188}D89 + \underset{(6.20)}{0.0362}D79 + \underset{(10.3)}{0.6860}\log UR_{t-1} \\ & DW\text{: } 1.67,\ adj-R^2\text{: } 0.9984 \end{aligned}$$

Here, *DW* is the Durbin-Watson d-statistics, *adj*-R^2 is the coefficient of determinant adjusted by the degree of freedom and numbers in parentheses are t-statistics. *D79*(*D89*) is the dummy variable, the value of which is 1 in 1979 (1989) and 0 for other years. All coefficients are statistically significant from zero and *DW* implies that there is no serial correlations in error terms. Overall, it can be concluded that the above regression well explains the trend of Korean national urbanization.

In case of Korea, economic variables such as RNA_t and Y_t alone can well explain the national urbanization. Spatial policies such as the decentralization policies upon the Seoul metropolitan area may affect the short-run migration speed. But, they seems not be able to alter the long-run trend of the national urbanization.

If RAN_t converges, UR_t will converge since the logistic function is used as for Y_t. It may not be necessary to consider that the per capita *GDP* expressed in terms of U.S. dollar, Y_t, goes to infinity. To be realistic, Y_t value of $30,000 and RNA_t value of 90% are considered to calculate the convergence value of UR_t. In this case, UR_t is calculated as 90.8%, which is about the same level of the urbanization rate considering the population of merged rural area in 2000. Thus, around 90% can be considered to be the convergent urbanization rate in case of Korea. In other words, Korean urbanization process is almost at the end.

Ⅲ. National Urbanization and the Primacy

In almost all countries in the world, people think that the size of their country's prime city is too large. This is called as the primacy problem. In this section, we will statistically test whether the primacy is related to the progress of national urbanization. Since there is no theoretical background in defining the usual pripacy index, we will consider the following 4 primacy indices.

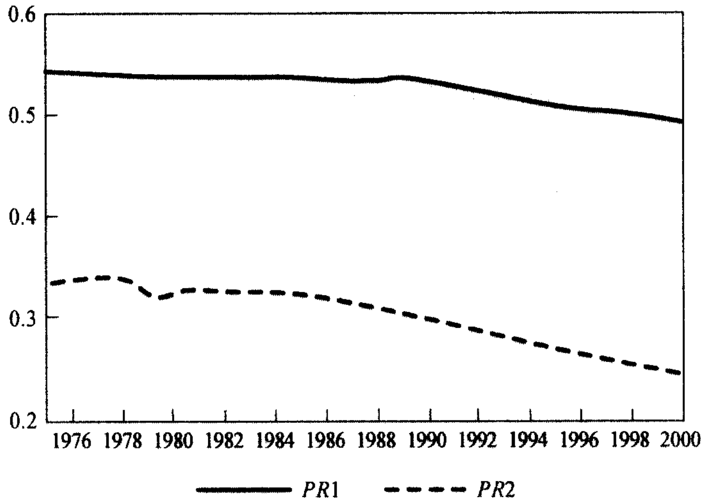
$$PR1 = S_1/[\sum_{(1,5)} S_i]$$

$$PR2 = S_1/[\text{Urban Population}]$$

$$PR3 = [\text{Prime City Territory Population}]/[\sum_{(1,5)} S_i + \text{Kyunggi Province Population}]$$

$$PR4 = [\text{Prime City Territory Population}]/[\text{Urban Population}]$$

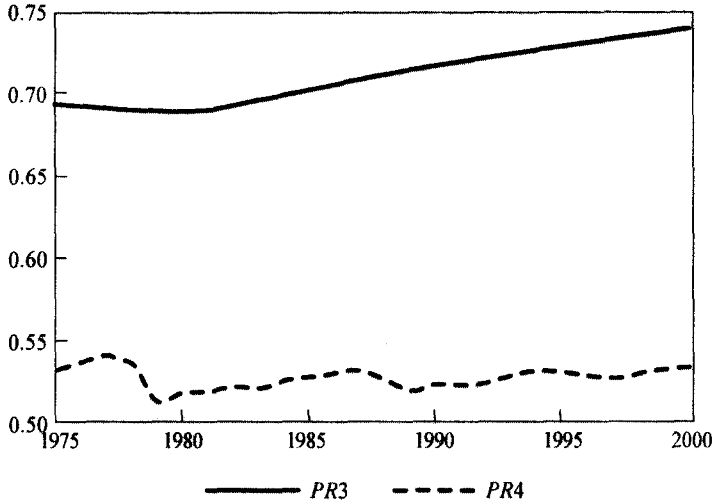
〈Figure 1〉 Trend of Primacy of the Prime City



Here, S_1 is the population size of the city with rank i, and $\sum_{(1,5)}$ implies the summation made from 1 to 5. $PR1$ is the exactly the same primacy index used in Rosen and Resnick [14]. $PR2$ is similar primacy index concept of $S_1/[\sum_{(1,50)} S_i]$, which is also used in Rosen and Resnick [14]. $PR3$ and $PR4$ are considered to reflect the particularities of Korea. In Korea, data for legal concept cities are only possible. No such data similar to *MSA* and *CMSA*, which are cities defined by economic concepts, in case U.S., are available.

The population size of Seoul, which is the prime city of Korea, actually becomes to decrease since 1994. But, it cannot be considered as the mitigation of the primacy problems. The reason is as follows. The decrease in the number of people living within the legal boundary of Seoul metropolitan area was caused by the out-migration of Seoulites. But, the out-migrants simply moved to setallite cities of Seoul, which are very closely located to Seoul Metropolitan area. Thus, if we consider the primacy problems of the legally defined prime city, the conclusions will be quite misled.

〈Figure 2〉 Trend of Primacy of the Prime City Territory



In order to consider the prime city defined by economic concepts, the 'Prime City Territory'(*PCT*) is usually considered. The *PCT* includes Seoul, Inchon and Kyunggi Province. In 2000, the area *PCT* is about 13.8% of the total area of Korea and the population size of *PCT* is about 46.6% of the total population size of Korea. As are shown by 〈Figure 1〉 and 〈Figure 2〉, while *PR*1 and *PR*2 have the decreasing trend, *PR*3 and *PR*4 have the increasing trend. But, it is obvious that *PR*3 and *PR*4 are more meaningful than *PR*1 and *PR*2.

Among *PR*3 and *PR*4, which is more closely related to the urbanization rate, *UR*, should be determined by the appropriate statistical test. Phillips-Perron test statistics for *PR*4 and $\Delta PR4 = PR4_t - PR4_{t-1}$ are calculated as -3.08 and -4.70 respectively, while the 1% critical value is -3.71. Thus, it can be concluded that *PR*4 is $I(1)$ with less than 1% significance level.

Since *PR*4 and *UR* are all found to be $I(1)$, the Johansen Test has been proceeded in order to test whether they are cointegrated. As is shown by the 〈Table 4〉, we can conclude that *UR* and *PR*4 are $CI(1,1)$ with less than 1%

〈Table 4〉 Results of Johansen's Cointegration Test for *UR* and *PR4*

Eigen Value	Likelihood Ratio	Significance Level (5%)	Significance Level (1%)	Null Hypothesis
0.4777	27.8	19.9	24.6	$h=0$
0.3442	10.9	9.3	13.0	$h\leq 1$

significance level. In order to investigate the relationship between *UR* and *PR*4, the following regression has been run.

$$\log PR4_t = \underset{(8.52)}{-0.9418} + \underset{(2.71)}{0.0684}\log UR_t + \underset{(4.36)}{0.0088}\log UR_t \times SD$$

$$\underset{(8.24)}{-0.0475}D79 - \underset{(4.96)}{0.0119}D89$$

$$\xi:\ \underset{(14.4)}{0.9208} \qquad DW:\ 1.65 \qquad adj-R^2:\ 0.84$$

Here, ξ is the coefficient of the moving average of order 1 and *SD* is the slope dummy variable such that *SD* equals to 1 during 1975~1978 and is 0 for other periods. Based upon the above regression result, it can be concluded that the primacy problem becomes serious as the national urbanization proceeds.

Ⅳ. The Exact Concept of Primacy and Welfare Costs

The merit of primacy indices defined in II is the convenience in the calculation. But, the major problem is that they are *ad. hoc.*, i.e., they have no theoretical backgrounds. In this section, we will construct exact measure of primacy by applying the city size distribution theory. Also, the welfare costs of the sub-optimal size distribution, which is partly caused by the primacy problem, will be calculated.[7)]

I. The Model of Optimal Size Distribution of Cities

The hierarchy model of size distribution of cities will be analyzed with the explicit consideration of the productivity and external diseconomy of cities.

Let k be the hierarchy of a city and x_k be the kth commodity produced by cities: $k = 1, 2, \cdots, K$. Areas with hierarchy 0 are rural areas. A city with hierarchy k produces total of k commodities, $x_1, \cdots, x_k$. $x_1, \cdots, x_{k-1}$ are produced for the local demand and x_k is produced for both the local demand and the demand of cities with hierarchies lower than k.

y_k is the *GRP* of a city with hierarchy k and n_k is the number of cities with hierarchy k. The *GRP* of cities with hierarchy k, Y_k, is $Y_k = n_k y_k$. The national demand for x_k, measured in terms of money, is assumed to be proportional to *GNP*, Y [31]. a_k is the exogenously given proportion of demand for x_k such that $\sum_{(0,K)} a_k = 1$. a_0 is the proportion of demand for rural output. By definition of a_0, $Y_0 = a_0 Y$. Since $x_1, \cdots, x_{k-1}$ are produced for the local demand of cities with hierarchy k, the demand for $x_1, \cdots, x_{k-1}$ is $[Y_k \sum_{(1,k-1)} a_i]$. Also, since x_k is produced for the local demand and the demand of cities with hierarchies lower than k, the volume of demand for x_k is $[a_k \sum_{(0,k)} Y_h]$. Total expenditures for commodities produced by cities with hierarchy k, the sum of volumes of demand, is the same as the income of those cities.

7) This section is based upon Suh [17] [18] [19] [20] among others.

$$Y_k = a_k \sum_{(0,k)} Y_h + Y_k \sum_{(1,k-1)} a_i \tag{1}$$

Even though the intercity transportation cost is not explicitly included in the model, it is assumed that the intercity transportation cost is large enough. Under this assumption, eq. (1) implies that markets are cleared for all commodities. Define b_k as $b_k = 1 - \sum_{(1,k)} a_h$ and $b_0 = 1$. Since $\sum Y_h = (a_0 / b_k) Y$, Y_k can be derived as follows.[8]

$$\begin{aligned} Y_k &= (a_0 a_k / b_k b_{k-1}) Y \\ &\equiv d_k Y \end{aligned} \tag{2}$$

Notice that $\sum_{(1,k)} d_k = 1 - a_0$. Since eqs. (1) and (2) are equivalent, the market clearing condition can be written as $d_k = Y_k / Y (k = 1, \cdots, K)$. s_k is the size of a city with hierarchy k and S_k is the size of cities with hierarchy k, i.e., $S_k = n_k s_k$. Then, the exogenously given total urban population, S, is $S = \sum_k n_k s_k = \sum_k S_k$. p_{ik} is the number of workers employed at the ith industry located in a city with hierarchy k: $1 \le i \le k$, $1 \le k \le K$. Here, $\sum_k$ implies that the summation is over k.

Labour force participation rate, ρ, is defined as the ratio of workers with respect to the size of a city. For simplicity, it is assumed that ρ is the same for all cities. By definition of ρ, it must be satisfied that $\sum_i p_{ik} = \rho s_k$.

In the production of commodities, the agglomeration economy is assumed to exist. But, no scale economy is assumed for each industry. Intercity transportation cost is assumed to be large enough so that the degree of agglomeration economy does not surpass the transportation cost. Thus, there does not exist the possibility of the largest city's producing all commodities.

8) Suh [18].

$g_i(s_k, p_{ik})$ is the average productivity of the ith industry located in a city with hierarchy k, which is measured in terms of money. The existence of the agglomeration economy and the non-existence of the scale economy imply that $\partial g_i(s_k, p_{ik})/\partial s_k \equiv g_{is} > 0$ and $\partial g_i(s_k, p_{ik})/\partial p_{ik} \equiv g_{ip} < 0$.

By definition of $g_i(s_k, p_{ik})$, $y_k = \sum_i g_i(s_k, p_{ik}) p_{ik}$. Even if there does not exist the scale economy, it may be natural that the output of the ith industry, $g_i(s_k, p_{ik}) p_{ik}$, increases as p_{ik} increases. In order to guarantee this, it is assumed that the worker's elasticity of productivity is inelastic, i.e., $|(\partial g_i/\partial p_{ik})(p_{ik}/g_i)| < 1$. Under this assumption, $\partial(g_i(s_k, p_{ik})p_{ik})/\partial p_{ik} = g_i [1 + g_{ip}(p_{ik}/g_i)] + (1/\rho) g_{is} p_{ik} > 0$. The effect of change in p_{ik} upon y_k can be derived as follows.

$$\partial y_k/\partial p_{ik} = (g_i + g_{ip} p_{ik}) + (1/\rho) \sum_i g_{is} p_{ik} \tag{3}$$

Here, $g_i + g_{ip} p_{ik}$ is the direct effect upon the ith industry and $(1/\rho) \sum_i g_{is} p_{ik}$ is the indirect effect through the agglomeration economy.

Costs of all external diseconomies such as pollutions, congestions, $\cdots$, etc. are aggregated. $f(s_k)$ is the per capita cost of external diseconomies of a city with hierarchy k. It is assumed that $df(s_k)/ds_k \equiv f'(s_k) > 0$.

The externality cost of a city with hierarchy k, c_k, is $c_k = s_k f(s_k)$. Since $f'(s_k) > 0$, $dc_k/ds_k > 0$. It is assumed that c_k increases in increasing rate, i.e., $d^2 c_k/ds_k^2 > 0$. The externality cost of cities with hierarchy k, C_k, and that of all cities, C, can be expressed as $C_k = n_k c_k$ and $C = \sum_k C_k$.

The welfare of a city with hierarchy k, w_k, is defined as the *GRP* net of the externality cost; $w_k = y_k - c_k$. The welfare of cities with hierarchy k, W_k, and that of all cities, W, can be expressed as $W_k = n_k(y_k - c_k)$ and $W = \sum n_k(y_k - c_k) = Y - C$.

The size distribution of cities is defined at optimum if W is maximized under conditions such that the market clearing and the full employment conditions are satisfied and the total size of urban area is given. By solving the constrained optimization problem, the following properties for the optimal size distribution of cities can be derived.[9]

PROPERTY 1 In allocating workers to different industries located in the same city, it is optimal so that the marginal effects upon the *GRP* are the same.

PROPERTY 2 In allocating workers to the same industry located in cities with different hierarchies, as the hierarchy increases, the marginal effect upon the welfare must increase so as to compensate the increasing externality cost.

PROPERTY 3 At optimum, weights of cities with lower hierarchies must be larger than those of cities with higher hierarchies.

2. The Calculation of Welfare Cost and the Optimal Size of the Prime City

In order to analyze the effect of external diseconomies upon the welfare cost, *WC*, and the optimal size of the prime city, *OSP*, it is necessary to simplify the model. For this, define $g_i(s_k, p_{ik})$ as $g_i(s_k, p_{ik}) = C_i s_k^a p_{ik}^{-b}$: $a>0$, $1>b>0$, C_i is some constant. Also, $f(s_k)$ is simplified as $f(s_k) = Bs_k^e$. After some calculations, $WC = WCI + WCE$ can be derived as follows.[10] Here, WCI is the

9) See Suh [19] [20] for the details.
10) See Suh [20] for the detailed derivation.

welfare cost from distorted income distribution and *WCE* is the welfare cost from the externalities.

$$
\begin{aligned}
WC &= WCI + WCE \\
&= \eta\Psi[\sum_{(1,k)} n_k(s_k - s_k^*)]/Y + \eta B[\sum_{(1,k)} n_k(s_k^{(1+e)} - s_k^{*(1+e)})]/Y
\end{aligned}
$$

Here, s_k^*, the optimal size of the cith with hierarchy k, can be derived by using the following relationships. Also, the OSP is, by definition, s_K^*.

$$
\begin{aligned}
s_k^* &= y_k/(\zeta_k^*\rho) \\
\zeta_k^*\rho &= (i_k/i_1)\Pi_k\zeta_1^*\rho \\
\zeta_1^*\rho &= \Psi[1 - \sum_k \Psi_k(1+e)\{(f(s_k)/\Psi) - (f(s_1)/\Psi)\}] \\
\Pi_k &= \frac{\mu + f(s_1)\mu + (1+e)f(s_k)}{\mu + f(s_k)\mu + (1+e)f(s_1)} \\
\Psi &\equiv \sum \Psi_k i_k \\
\Psi_k &\equiv n_k/(\sum_{(1,k)} n_h)
\end{aligned}
$$

Calculating exact values of *WC* and s_K^* is not possible since there are no data for externality costs of cities. Therefore, numerical solutions of the model is derived. Data for rank, size and *GRP* of cities can be obtained. "Municipal Yearbook of Korea, 1986", "Annual Report on the Family Income and Expenditures Survey, 1986" and "1985 Housing and Population Census Report" are used for obtaining rank, size and *GRP* for 57 cities.

In the model of section IV.1., the number of cities with hierarchy k, n_k, was endogenous. If n_k is endogenized in the empirical model, the model will be too complicated to be calculated. In order to avoid the complexity of endogenizing n_k and indirectly considering this endogeneity, *WC* and s_K^* will be calculated for three cases of square, hexagonal and octagonal geographical distributiion of cities. $n_k = t(1+t)^{K-k-1}$, where t equals to 1, 2 and 3 when the geographical distribution of cities is square, hexagon and octagon respectively. Average values of sizes and *GRP's* are used for representing each hierarchy. For obtaining average values of sizes and *GRP's* of cities with hierarchy 1, the method of extrapolation is used.

PECS is defined as the ratio of per capita externality cost of a city with hierarchy 1 to the weighted average of per capita *GRP*: $PECS \equiv f(s_1)/\Psi$. Per capita externality cost might be much smaller than the weighted average of per capita *GRP*.[11] Therefore, five values of *PECS*, 0.02, 0.04, 0.06, 0.08 and 0.10, might include most cases.

If the value of *PECS* is given, $f(s_K)/\Psi$ can be calculated as $f(s_K)/\Psi = PECS(s_K/s_1)^e$. For given value of *PECS*, e increases from 0.01 by 0.01 until the value of $REXT = [f(s_k)/\Psi]/PECS = (s_K/s_1)^e$ reaches to 10. Notice that *REXT* is the ratio of the per capita externality cost of the prime city to that of a city with hierarchy 1. If $PECS = 0.1$ and $REXT = 10$, $f(s_k)/\Psi = 1.0$. This means that the prime city's per capita externality cost is the same as the weighted average of per capita *GRP*. Thus, these values of e might include most cases. Given values of *PECS* and e, Π_k can be expressed by using $f(s_1)/\Psi$, $f(s_k)/\Psi$ and μ/ϕ.

Results of simulation are summarized in ⟨Table 5⟩. Since values of *REXT's* are obtained by increasing e by 0.01, those are not necessarily integers. For example, in square case of Korea with $PECS = 0.02$ and $e = 0.34$, $REXT = 5.22$. But, this case will be said that the per capita externality cost of the prime city is about 5 times greater than that of a city with hierarchy 1 for the purpose of explanatory convenience.

---

11) Lave [7], Palmquist [10], Polinsky *et al.* [11], Rosen [14], Shechter *et al.* [16].

〈Table 5〉 The Effect of External Diseconomies (Korea)

PECS	square($K=6$)					hexagon($K=5$)					octagon($K=4$)				
	e	$REXT$	s_K^*/s_K	WC	WCI	e	$REXT$	s_K^*/s_K	WC	WCI	e	$REXT$	s_K^*/s_K	WC	WCI
	BM		0.8519	0.0671	0.0671	BM		0.9308	0.0313	0.0313	BM		0.9438	0.0261	0.0261
0.02	0.01	1.05	0.8520	0.0685	0.0671	0.01	1.05	0.9309	0.0319	0.0312	0.01	1.05	0.9439	0.0266	0.0261
	0.08	1.48	0.8525	0.0686	0.0668	0.07	1.42	0.9312	0.0318	0.0310	0.06	1.31	0.9441	0.0266	0.0259
	0.14	1.98	0.8521	0.0690	0.0666	0.11	1.73	0.9309	0.0319	0.0309	0.10	1.57	0.9439	0.0266	0.0259
	0.34	5.22	0.8395	0.0746	0.0685	0.33	5.15	0.9158	0.0368	0.0337	0.36	5.12	0.9263	0.0317	0.0290
	0.48	10.31	0.8102	0.0871	0.0737	0.47	10.33	0.8819	0.0485	0.0404	0.51	10.12	0.8899	0.0433	0.0360
0.04	0.01	1.05	0.8521	0.0698	0.0670	0.01	1.05	0.9310	0.0325	0.0312	0.01	1.05	0.9440	0.0271	0.0261
	0.09	1.55	0.8532	0.0701	0.0663	0.07	1.42	0.9316	0.0324	0.0307	0.06	1.31	0.9444	0.0270	0.0257
	0.15	2.07	0.8523	0.0710	0.0661	0.11	1.73	0.9312	0.0326	0.0306	0.11	1.65	0.9439	0.0272	0.0256
	0.34	5.22	0.8317	0.0814	0.0688	0.33	5.15	0.9054	0.0418	0.0351	0.36	5.12	0.9139	0.0367	0.0307
	0.48	10.31	0.7903	0.1042	0.0757	0.47	10.33	0.8562	0.0636	0.0447	0.51	10.12	0.8609	0.0583	0.0406
0.06	0.01	1.05	0.8523	0.0711	0.0670	0.01	1.05	0.9311	0.0331	0.0311	0.01	1.05	0.9441	0.0276	0.0260
	0.09	1.55	0.8539	0.0716	0.0658	0.07	1.42	0.9321	0.0329	0.0304	0.06	1.31	0.9447	0.0274	0.0255
	0.17	2.29	0.8520	0.0735	0.0654	0.12	1.82	0.9312	0.0333	0.0302	0.11	1.65	0.9441	0.0276	0.0253
	0.34	5.22	0.8275	0.0872	0.0683	0.33	5.15	0.8985	0.0461	0.0356	0.36	5.12	0.9054	0.0410	0.0315
	0.48	10.31	0.7830	0.1181	0.0746	0.47	10.33	0.8440	0.0760	0.0458	0.51	10.12	0.8463	0.0707	0.0419
0.08	0.01	1.05	0.8524	0.0725	0.0669	0.01	1.05	0.9312	0.0336	0.0311	0.01	1.05	0.9441	0.0281	0.0260
	0.10	1.63	0.8547	0.0731	0.0652	0.07	1.42	0.9326	0.0334	0.0301	0.06	1.31	0.9451	0.0279	0.0253
	0.18	2.40	0.8520	0.0758	0.0646	0.12	1.82	0.9316	0.0339	0.0298	0.12	1.72	0.9439	0.0282	0.0250
	0.34	5.22	0.8261	0.0922	0.0671	0.33	5.15	0.8946	0.0497	0.0355	0.36	5.12	0.9001	0.0447	0.0316
	0.48	10.31	0.7839	0.1286	0.0715	0.47	10.33	0.8406	0.0853	0.0447	0.51	10.12	0.8412	0.0801	0.0410
0.10	0.01	1.05	0.8525	0.0738	0.0668	0.01	1.05	0.9313	0.0342	0.0310	0.01	1.05	0.9442	0.0286	0.0259
	0.10	1.63	0.8556	0.0745	0.0647	0.08	1.49	0.9331	0.0339	0.0297	0.07	1.37	0.9455	0.0282	0.0250
	0.20	2.64	0.8513	0.0788	0.0637	0.13	1.91	0.9316	0.0346	0.0293	0.13	1.80	0.9437	0.0288	0.0246
	0.34	5.22	0.8270	0.0962	0.0652	0.33	5.15	0.8929	0.0525	0.0347	0.36	5.12	0.8974	0.0475	0.0310
	0.48	10.31	0.7906	0.1353	0.0667	0.47	10.33	0.8434	0.0913	0.0419	0.51	10.12	0.8427	0.0862	0.0383

BM indicates the benchmark case, where the external diseconomies are not considered. By definition of *BM*, $WC = WCI$ for this case. It is found that $\partial[s_K^*/s_K]/\partial e > 0$ and $\partial WC/\partial e < 0$ if e is less than about 0.08. This value of e indicates that *REXT* is less than about 1.5. The size of the prime city, s_K, is 9.5 million in case of Korea.

If values of e are larger than mentioned above, cases of $\partial WC/\partial B < 0$ are found only in the square case with *PECS* equals to 0.10. In the square case, s_1 is 71,200. The probability of this size urban area's per capita externality cost being 10% of the weighted average of per capita *GRP* might be minimal. Therefore, it might be generally concluded that *WC* increases and s_K^* decreases as the degree of external diseconomies increases.

Depending upon values of *PECS*, *REXT*, e and the assumption on the geographical distribution of cities, optimal size of the prime city might be ranged between 79～94% of the current size of the prime city. Also, *WC* ranges 2.6～9.1% of the *GDP*.

V. Concluding Remarks

Factors affecting the urbanization rate are found to be the employment ratio of secondary and tertiary sectors and the per capita *GDP*. In the estimation, the functional form must be chosen so as to consider the convergence in the urbanization rate. In case of Korea, urbanization rate of around 90% level seems to be the convergence level. Compared with the current urbanization rate of around 86%, it can be concluded that the Korean urbanization rate is almost at its convergent level.

If we consider the reasonable primacy index like *PR*3 of this paper, it will be concluded that the primacy problem becomes serious as the national urbanization proceeds. This may imply that the appropriate national spatial policies must be designed from at the early stage of urbanization in order to decrease the social cost of primacy and related problems.

The primacy indices defined in the usual way have the problems of having no theoretical backgrounds. In order to overcome this problem, the optimal size distribution of cities is analyzed. By using properties of the optimal size distribution of cities, the optimal size of the prime city and the welfare cost of the sub-optimal size distribution of cities can be calculated. Depending upon the degree of externalities and the assumptions on the geographical distribution of cities, optimal size of the prime city, *OSP*, might be ranged between 79～94% of the current size of the prime city. Also, welfare cost of the sub-optimal size distribution of cities, *WC*, ranges 2.6～9.1% of the *GDP*.

It is important to understand that the major factor affecting *WC* and *OSP* is not the absolute size of the externality cost but the relationship between externality costs of cities with different sizes. This may imply that any spatial policies targeting a few cities, especially the prime city alone, will be doomed to be failed. In designing and practicing national spatial policies, it is most important not to consider separate city but to consider the system of cities together.

▣ *REFERENCES* ▣

1. Alperovich, G., "Scale Economies and Diseconomies in the Distribution of City Size," *Journal of Urban Economics*, 1982, pp. 202～213.
2. Beckmann, M. J., "City Hierarches and the Distribution in a Central Place Hierarchy," *Economic Development and Cultural change*, 1958, pp. 243～248.

3. ________ and J. C. McPherson, "City Size Distribution in a Central Place Hierarchy," *Journal of Regional Science*, 1970, pp. 25 ~ 33.

4. Enyedi, G., "Specific Urbanization in Eastcentral Europe," *Geoforum* 21, pp. 163 ~ 172, 1990.

5. Grihfield, J. B. and M. P. H. Panggabean, "Growth and Convergence in U.S. Cities," *Journal of Urban Economics*, 1995, pp. 138 ~ 165.

6. Konrad, G. and I. Szelenyi, "Social Conflicts of Underurbanization," in A. A. Brown *et al.* (ed.), *Urban and Social Economics in Market and Planned Economies: Policy, Planning and Development*, vol. 1, Parger, New York, 1974.

7. Lave, L. and E. Seskin, *Air Pollution and Human Health, Baltimore*, MD, The Johns Hopkins University Press, 1977.

8. Mills, E. S. and B. W. Hamilton, *Urban Economics*, 5th ed., Harper Collins, 1994.

9. Murray, P. and I. Szelenyi, "The City in the Transition to Socialism," *International Journal of Urban and Regional Research* 8, 1984, pp. 90 ~ 107.

10. Palmquist, R. B., "Valuing Localized Externality," *Journal of Urban Economics*, 1992.

11. Polinsky, A. M. and D. Rubinfeld, "Property Values and the Benefits of Environmental Imporvement: Theory and Measure," in L. Wingo and A. Evans (ed.), *Puflic Economics and Quality of Life*, Baltimore, MD, The Johns Hopkins University Press, 1977.

12. Renaud B., *National Urbanization Policy in Developing Countries*, World Bank, 1981.

13. Richardson, H. W., "Theory of the Distribution of Cities: Review and Prospcts," *Regional Studies*, 1973, pp. 239 ~ 251.

14. Rosen, K. and M. Resnick, "The Size Distribution of Cities: An Examination of the Pareto Law and Primacy," *Journal of Urban Economics*, vol. 8, No. 2, 1980, pp. 165 ~ 186.

15. Sjoberg, O., "Shortage, Priority and Urban Growth: Toward a Theory of Urbanization under Central Planning," *Urban Studies*, December, 1999.

16. Shechter, M. and M. Kim, "Valuation of Pollution Abatement Benefits: Direct

and Indirect Measurement," *Journal of Urban Economics*, 1991.

17. Suh, Seoung Hwan, "On the Size Distribution of Cities: an Economic Interpretation of the Pareto Coefficient," *Environment & Planning A*, 1987.
18. ______, "The Optimal Size Distribution of Cities," *Journal of Urban Economics*, September, 1991.
19. ______, "Welfare Costs of the Sub-Optimal Size Distribution of Cities," *Journal of Urban Economics*, January, 1993.
20. ______, "The Primacy and Welfare Costs of the Sub-Optimal Size Distribution of Cities under External Diseconomies," *Yonsei Economic Studies*, November, 1994.
21. Vining, D. R., "Autocorrelated Growth Rates and the Pareto Law: A Further Analysis," *Journal of Political Economy*, 1976, pp. 369~380.