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# Intra-Urban Growth and Spatial Patterns in Variation of Poupulation Density
## —The Case of Seoul—

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(Contents)



Changing patterns of population densities in urban centers are different between Western countries and non-Western countries. Although Seoul is located in a non-Western country, the result of this study shows that its pattern of population density falls into the category of Western cities. Through the examination of three population density gradient models, it is clear that no model can precisely explain the population distribution of Seoul over time. Some of the models partly indicate the actual population distribution. The Clark model is appropriate to denote population distribution in the center of Seoul at an early stage in development. The Sherratt model cannot adequately explain the population distribution of Seoul.

## 1. INTRODUCTION

The spatial variation of urban population density in a region has been a concern of urban geographers and urban planners. The movement of population out of the central business district (CBD) in a city can be shown in the decline of population in the center of the city, while the surrounding areas experience increases in their population. City growth has been associated with the suburbanization of the urban population. Characteristics of the suburbanization depend on the socioeconomic situations of the city. Urban population density can indicate the characteristics of the suburbanization in the city.

There are many studies on the distribution of population within each city in Western countries. However, the application of population density gradient models to the urban population distribution in non-Western countries has been relatively neglected. Therefore, it is unclear which model can best represent the distribution of population in urban centers in non-Western countries.

The city of Seoul, which is the primate city in Korea, has been chosen for this research. Seoul has a long history as the capital city of Korea since 1392. Despite the fact that Seoul has been a primate urban center for a long time, the city has a short period for a modern city. Seoul has been dominant as a modern giant city since the 1960s with the influx of population from rural areas, establishment of various urban facilities, and a notable process of suburbanization. These circumstances provide an opportunity to figure out the patterns in varia-

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tion of urban population densities.

Based on this situation, the objectives of this research are: to examine changes in urban population distribution in Seoul over time and to analyze which population density gradient model appropriately explains the population distribution in the city.

In this study, because Seoul is growing very fast as a modern giant city, it is expected that population density gradients in Seoul will decrease over a period of time as Western cities have experienced.

1) Concepts of Population Density Gradients

The population density gradient is a mathematical model describing the relationship between population density and the distance from the center of the city. The model has been applied to many research fields such as variations of gradients in urban wage,[1] employment density,[2] density for the manufacturing industry,[3] housing prices,[4] and neighborhood amenities.[5]. These studies focus on different aspects of the same phenomenon using the relationship between density and distance.

In general, three models of population density gradient are considered for examining the spatial variation of population densities: Clark, Sherratt, and Newling model. Colin Clark produced an equation of population density gradients using data on population and distance as follows:[6]

$$D_x = D_o e^{-bx} \qquad (1)$$

Where, $D_x$ = population density at distance x from the center of a city
$D_o$ = population density at the city center
b = density gradient
e = the base of natural logarithm

This equation implies a negative exponential function on population densities along with distance from the center of a city. The equation can be transformed into a logarithm to easily investigate the relationship between density and distance.

$$\mathrm{Ln}\ D_x = \mathrm{Ln}\ D_o - bx \qquad (2)$$

A simple regression equation with distance decay function is derived. The value of the density gradient slope, b, represents the rate of change in population density with unit change in the distance, x.

Sherratt (1960) modified equation (1) from a negative exponential function to a quadratic relationship. The modified exponential model is expanded by multiplying one more distance factor by the distance element in the Clark model.[7]

1) Madden, J.F., 1985, "Urban wage gradient: empirical evidence", *Journal of Urban Economics,* Vol. 18, pp. 291-301.

2) Macauley, M.K., 1985, "Estimation and recent behavior of urban population and employment density gradient", *Journal of Urban Economics,* Vol. 18, pp. 251-260.
Vipond, J., 1984, "The intra-urban unemployment gradient: the influence of location on unemployment", *Urban Studies,* Vol. 24, pp. 377-388.

3) Schmenner, R.W., 1981, "The recent gradient for manufacturing", *Journal of Urban Economics,* Vol. 9, pp. 90-96.
Kemper, P., 1974, "The density gradient for manufacturing industry", *Journal of Urban Economics,* Vol. 1, pp. 410-427.

4) Eberts, R. and Gronberg, T.J., 1982, "Wage gradients, rent gradients, and the price elasticity of demand for housing: an empirical investigation", *Journal of Urban Economics,* Vol. 12, pp. 168-172.

5) Alperovich, G., 1980, "Neighborhood amenities and their impact on density gradients", *The Annals of Regional Science,* Vol. 14, pp. 51-64.

6) Clark, C., 1951, "Urban population densities", *Journal of the Royal Statistical Society,* Series A, Vol. 114, pp. 490-496.

7) Haynes, K.E. and Ruke, M.I., 1973, "Directional bias in urban population density", *Annals of the Association of American Geographers,* Vol. 63, pp. 40-47.

$$D_x = D_o e^{-bx^2} \quad (3)$$

In this equation, the distance function is emphasized more than that in the Clark equation. The population densities are significantly influenced by the increase of distance from the center of a city. In the logarithmic form, the equation is:

$$\text{Ln } D_x = \text{Ln } D_o - bx^2 \quad (4)$$

Newling also extended the negative exponential models to a general quadratic relationship as:[8]

$$Dx = D_o e^{bx - cx^2} \quad (5)$$

Where b is a parameter that measures the change of density at the center of the city, and c is a parameter which measures the change of density away from the center. A multiple regression equation can be obtained by performing a logarithmic transformation as follows:

$$\text{Ln } D_x = \text{Ln } D_o + bx - cx^2 \quad (6)$$

2) Methodology

In order to identify the population distribution in Seoul, the Clark, the Sherratt, and the Newling models are used in this research. Data on population, size of area, and distance in three periods of time (1965, 1975, 1985) are utilized for the three models.

On the basis of transportation networks and new development axes, the area of Seoul is divided into four quadrants. Each quadrant has about forty=one concentric circles which run through several *dongs,* with the same distance interval, 0.449 kilometers. A *dong* is the lowest administrative unit in Korean cities. The size of the population of a *dong* varies considerably. In Seoul, a *dong* contains an average of more than 20,000 residents, while in small cities it has fewer than 5,000 inhabitants. The population and the area of the *dongs* which belong to a given circle are calculated by summing up the population of each *dong* and the size of each *dong* respectively. With the data on population size and area within the given concentric circle, the population density of that area is produced. In the same manner, all forty-one concentric circles have their respective population densities. These densities are drawn, and compared with the results of the three models. At the same time, the variations in each quadrant are analyzed over time.

## 2. POPULATION DISTRIBUTION IN SEOUL

To explain the actual population distribution in the city, the total area and four sectional areas are investigated using graphic forms that make interpretation easier. Then, the three models are utilized to explain the changes in population densities in the city over time.

1) General Trend in the Variation of Densities

The population densities of the city have varied inversely with the increase in the distance from the center as shown in Figure 1. The density of the central city was at its highest at the 1-kilometer area from the center in the 1960s and the 1970s. By contrast, between 3 kilometers and 4 kilometers, the density in 1975 dropped, mostly due to the movement of residents out to the periphery. The city government pushed residents who resided beside the Chonggae Creek to move to the areas of Sungnam and Gyeyondong, which are located just southeast of the Seoul City boundaries, in order to redevelop the central city at the end of the 1960s and at the beginning of the 1970s. At that time, the area was regarded as a squatter section in which the poor were concentrated. The removal of the squatter residents resulted in a low density distribution in that area. However, the position of

8) Newling, B.E., 1969, "Urban growth and spatial structure: mathematical models and empirical evidnece", *Geographical Review,* Vol. 56, pp. 213-225.

the highest density has moved outward to the 4-kilometers area in the 1980s.

The largest increase of population for the last two decades appears in the 8-kilometers area. Large groups of apartments constructed along the southern bank of the Han River have resulted in a high density in that area. For the same reason, the density at 18 kilometers has significantly increased.

Density gradients have had a decreasing function in Seoul as time passes. The changing pattern in the city is very similar to the one Western cities have experienced. However, in general the variation of the population density gradient of Western cities is different from that of non-Western cities over time.[9] The changing shape of Western cities over time denotes that central densities first increase and later decrease, and that the density gradient steadily drops. By contrast, population density in the center of a non-Western city increases steadily at the same rate as the peripheral density increases as time passes.

2) Analysis of Sectional Densities

Seoul is divided into four sections: northwest, northeast, southwest, and southeast. Features of the changing patterns by section are examined below.

(1) Northwestern Section (NW)

Although the central population in this section has decreased, the central area still shows a high population density indicating central city dominance. The highest density has been between 1 kilometer and 2 kilometers from the center. In general, as the central population density decreases, the population density in suburban areas increases. However, the case of this section is different from the general trend despite the fact that almost no suburbanization in this section has occurred for the last two decades. So, it is conceivable that the large

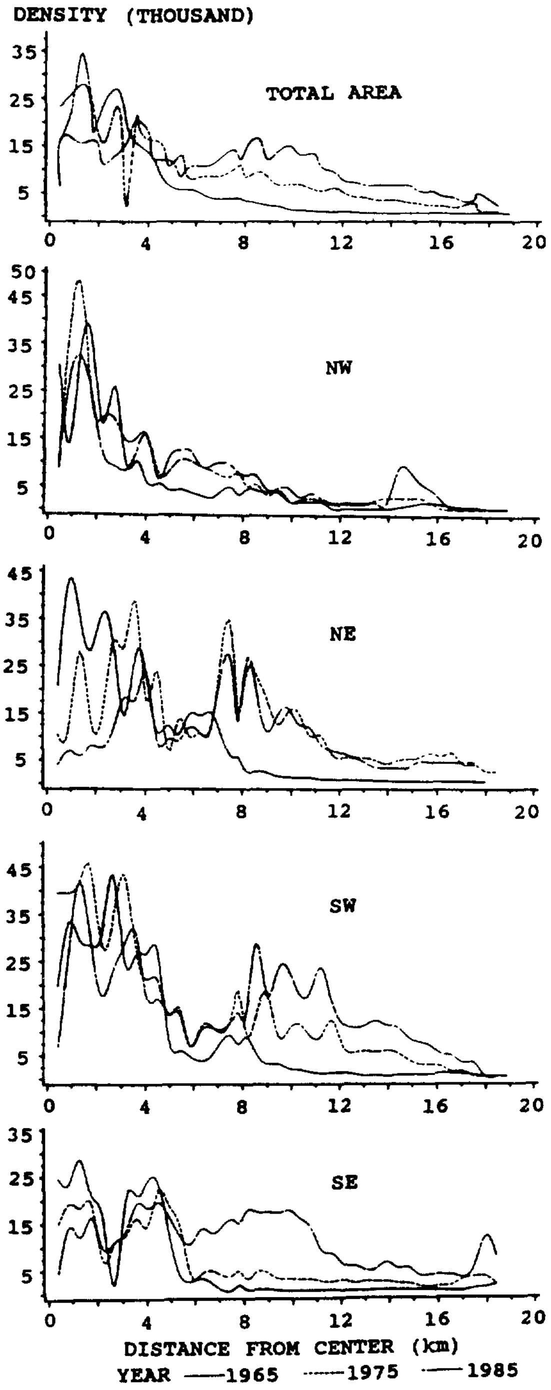


FIG. 1. CHANGES IN DENSITIES

9) Berry, B.J.L.; Simmons, J.W.; and Tennant, R.J., 1963, "Urban population densities structure and change", *Geographical Review*, Vol. 53, pp. 389-405.

portion of residents who intended to move out of the central area of this section have moved into other sections and this movement has contributed to the suburbanization of other sections.

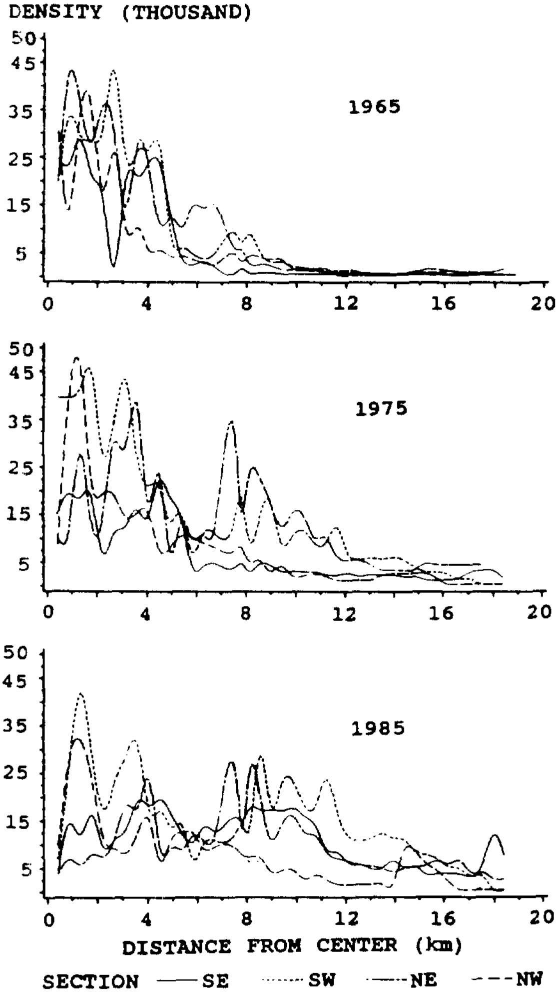


FIG. 2. SECTIONAL POPULATION DENSITIES

The dominant reasons for the lack of suburbanization are physical and psychological. The Bukak mountain ranges which are scattered between 9 and 14 kilometers in this section are a physical hindrance to suburbanization. Only two main roads connect the central area with the periphery in this section. Furthermore, this section is the closest to the Demilitarized Zone (DMZ), located 36 kilometers away. On the other hand, considering the psychological point of view, people did not feel comfortable residing in this section because they felt vulnerable to attacks by North Korea. At the end of the 1960s, there was a serious attack by communist armed guerillas from North Korea in this section. However, the area located between 14 kilometers and 16 kilometers has developed with the establishment of a new county (Unpyong-ku— in the beginning of the 1980s. This setting up of a new administrative unit is consistent with raising the population density in that area. Public concerns for multiplier effects in this area might induce the private sector to invest in commercial, industrial, cultural, educational, and residential facilities.

(2) Northeastern Section (NE)

The population distribution in the northern section changed significantly during the decade from 1965 to 1975. Figures 1 and 2 illustrate fairly well that the northeastern section had a very dominant suburbanization for that period compared with other sections. The central density in this section has decreased tremendously over time, whereas the density between 7 and 10 kilometers has notably increased, particularly in the 1970s. The highest density appears at 7 kilometers unlike other sections which show it in the more central area. The establishment of large apartment groups in Jangan Field, located around 8 lilometers, resulted in a high density in that area. In addition, this section has one dominant subcenter, Chongryangri situated in the middle of the section. This subcenter is notable for its high density and has a very strong pull factor which has induced the population to move in to that area based on convenient transportation networks such as bus, subway, and train lines, and various market roles including agricultural products, herb remedies, and miscellaneous commodities.

Compared with other sections, the northeastern section had a very dominant suburbanization for the decade from 1965 to 1975. Transportation networks in this section have encouraged suburbanization. One highway running through this quadrant connecting Seoul with Ujongbu, which is located in the outside of the Seoul's northeastern boundary, was expanded, and another highway connecting the northern part of Seoul with Ujongbu was constructed. Furthermore, a subway line and a railroad connecting Seoul with Ujongbu have contributed significantly to the suburbanizing in the section. In particular, the subway line provides convenient facilities for residents commuting between suburban areas and the hub of Seoul.

Another reason for the distinct suburbanization in this section could be the urban growth of the new city of Guri, which is just outside of Seoul's northeastern boundary. It has been expected that as the population of Guri increases, the interactions of population and commodities between Seoul and Guri will increase. These interactions could be a source of suburbanization in the section.

(3) Southwestern Section (SW)

The density within 1 kilometer of the center of the southwestern section largely has decreased with the passing of time. Although the density between 1 and 5 kilometers has fluctuated over time, the central density has been dominant. The low density around 6 kilometers has not changed over time because the Han river runs through this section. The density of a subcenters, subcenter, Youngdungpo, which is located between 8 and 12 Kilometers, has dramatically changed. The highest desnity of the subcenter was originally at the 8-kilometer area, but it has slightly moved out to the 9-kilometer area, where the Juro Industrial Complex and many other industrial and educational facilities are located in the suburban area of this section.

Thus, the population in the outskirt of the southwestern section has increased remarkably like the southeastern section (Fig 2). This trend reflects the fact that the new urban development in the southern areas of the Han river is distinct from those of the northern areas.

(4) Southeastern Section (SE)

Although this section is similar to the other sections in illustrating the same pattern of Western cities, it has a suburban dominance in population distribution unlike the other sections. This area has been popular for residential, commercial, and recreational sites. The city government has invested in particular urban facilities including sports facilities and water recreation facilities on the Han river around that area.

Suburbanization in this area has been notable since the middle of the 1970s. The rapid suburbanization has produced two new subcenters of Seoul: Yongdong, and Jamsil. Yongdong has luxurious hotels, inns, restaurants, and saloons in the commercial sectors, and expensive new houses and apartments in the residential sectors. Yongdong is not only a newly built-up area but also the most prosperous urban subcenter because various urban facilities, including many schools, cultural and art centers, trade centers, hospitals, and government agencies, have moved into this area.

On the other hand, Jamsil is a typical new town in-town which has been built since the end of the 1970s. The primary rationale for the new town in-town is an urgent need for an effective solution to the urban problems of the large metropolis.[10] The dominant function of the new town in-town is to induce the processes of central city revitalization or to develop lagged areas. The latter can be applicable to the development of the new town in-town. Jamsil was a large vacant and undeveloped area before the 1970s. The new town in-town was built at jamsil because of the availability of this large vacant area, with cheaper land prices. Jamsil opened an apartment era in Korea through the first establishment of large groups of apartments. Recently, this area became famous as a recreation center with sports facilities and boat cruising lines on the Han river. A huge sports

10) Siverman, J.A., 1978, "New towns in-town, again?", Urban Design, Vol. 9, pp. 21-23 and 48.

complex includes an olympic village, and several stadiums for the 1988 Seoul Olympics.

Several circumstances have supported the development in this southeastern section. First, urban development policies of the city government are closely related to the impact on urbanization in this area. In the 1970s, the government emphasized urban development in the section by providing incentives such as tax exemption for five years and opportunities to get loans easily from financial agencies. Second, the urbanization of this section has significantly depended on the establishment of transportation networks including the circular subway, a circular highway, five newly built bridges which are across the Han river, and riverside highways. Furthermore, the section has well-planned grid pattern streets. These wide streets more or less contribute to solving a traffic jam problem. Third, a psychological aspect is one factor for developing the area. This section has some advantages for the socioeconomic status of residents. Because large groups of middle and high income residents are concentrated in this area, many distinctive elementary and secondary schools, religious facilities, and other urban facilities are scattered throughout the section. For these reasons, residents in Seoul generally want to live there to upgrading their socioeconomic status based on the neighborhood. At the same time, the good neighborhood has induced the public and the private sectors to invest in various urban facilities in the section.

## 3. APPLICATION OF THREE MODELS TO POPULATION DISTRIBUTION

### 1) Clark Model

Using data on population and area, the following regression equations were estimated:

$$\text{Log } D_{65} = 10.137 - \underset{(-20.727)}{0.239} \text{ Dis}_{65} \qquad (7)$$

$$\text{Log } D_{75} = 10.095 - \underset{(-12.331)}{0.141} \text{ Dis}_{75} \qquad (8)$$

$$\text{Log } D_{85} = 9.862 - \underset{(-8.202)}{0.079} \text{ Dis}_{85} \qquad (9)$$

The figures in parentheses are t-values, and all equations in this study are significant at the 0.05 significance level. The intercept, a(Log $D_0$) implies the values of magnitude of densities of the central city. The actual central densities are as follows: 24,765 in 1965, 13,091 in 1975, and 7,203 in 1985.[11] The central density has decreased over time. In the equations, the values of the intercept have also decreased as time passes. In order to compare estimated densities by the Clark model with observed densities, central densities are produced applying the natural anti-logarithm to the values of the intercept in the equations: 25,234 (persons per square kilometer) in 1965, 24,196 in 1975, and 19,108 in 1985. Considering the values of the actual densities, the model almost correctly produces the central density in 1965, but it cannot significantly produce the densities in 1975

Table 1. Intercepts (a) and parameters (b) in the Clark model

| Section | Component | 1965 | 1975 | 1985 |
|---|---|---|---|---|
| Northwest | a | 9.884 | 10.350 | 10.150 |
| | b | −0.217 | −0.220 | −0.185 |
| | | (−11.599) | (−14.898) | (−9.664) |
| | $R^2$ | 0.771 | 0.857 | 0.705 |
| Northeast | a | 10.780 | 10.206 | 9.570 |
| | b | −0.297 | −0.109 | −0.057 |
| | | (−22.049) | (−7.387) | (−3.921) |
| | $R^2$ | 0.928 | 0.596 | 0.283 |
| Southwest | a | 10.561 | 11.001 | 10.456 |
| | b | −0.251 | −0.204 | −0.119 |
| | | (18.360) | (−14.343) | (−5.624) |
| | $R^2$ | 0.894 | 0.841 | 0.448 |
| Southeast | a | 9.697 | 9.741 | 9.802 |
| | b | −0.229 | −0.141 | −0.067 |
| | | (−8.899) | (−11.146) | (−5.112) |
| | $R^2$ | 0.670 | 0.761 | 0.401 |

11) Seoul Metropolitan Government, 1966, 1976, and 1986, Seoul Statistical Yearbook, Seoul Metropolitan Government, Seoul.

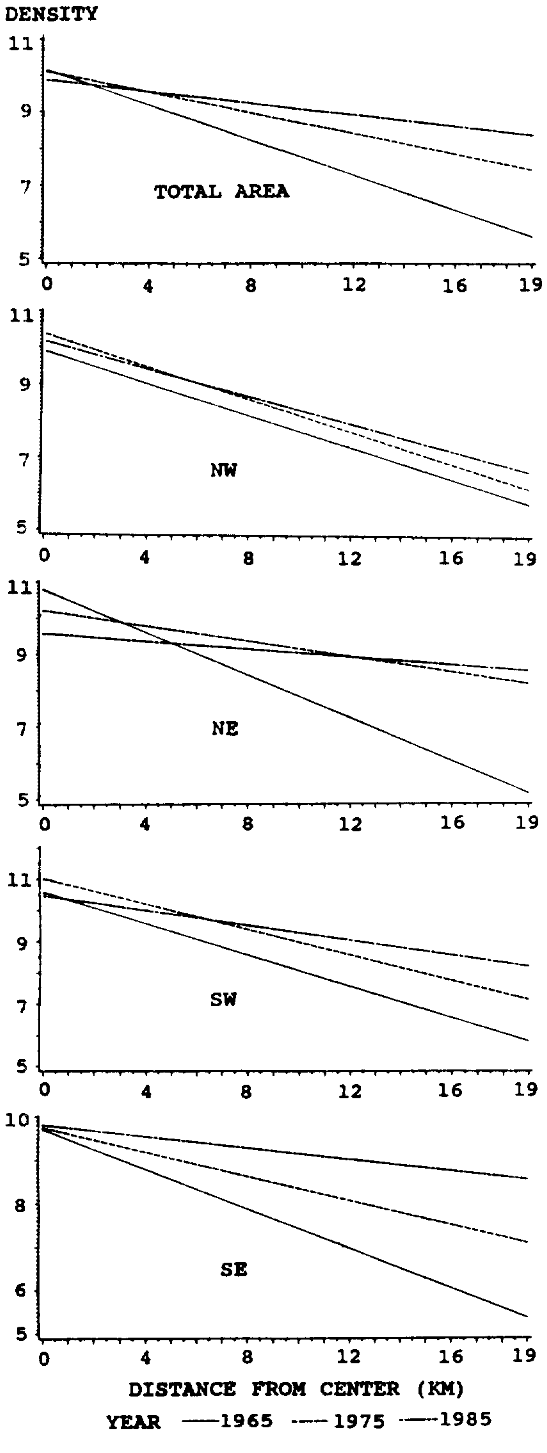


FIG. 3. POPULATION DENSITIES (CLARK)

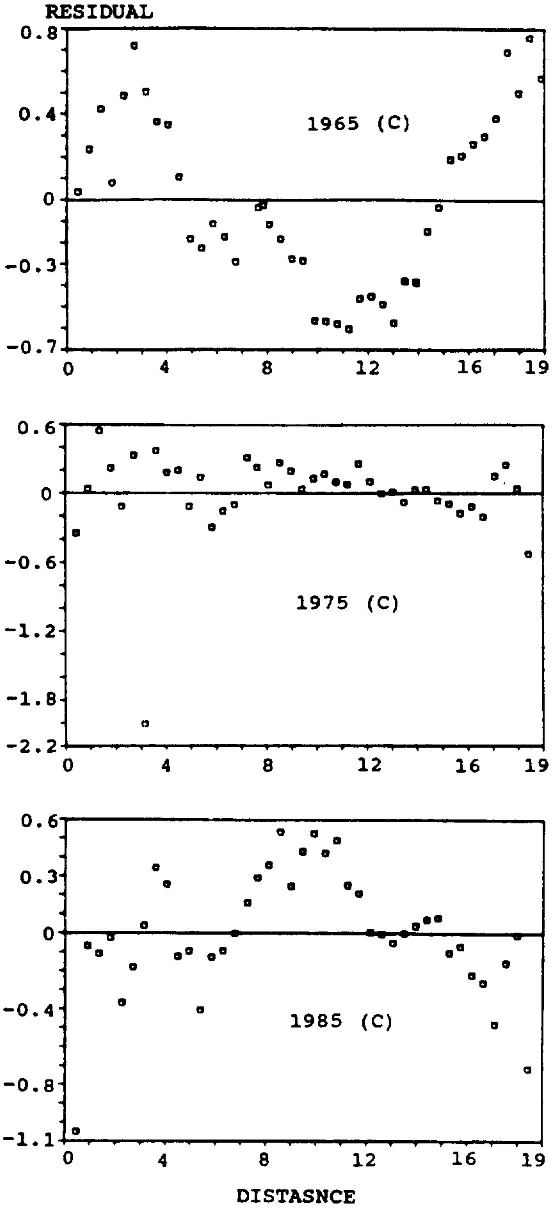


FIG. 4. RESIDUAL DISTRIBUTION (CLARK)

and in 1985. The decreasing ratios of the intercepts in the equations are much different from those of the actual decreasing ratios. The decreasing ratios according to the model are 0.04 between 1965 and 1975, and 0.21 between 1975 and 1985, whereas the actual decreasing ratios are 0.47 between 1965 and 1975, and 0.45 between 1975 and 1985.

The population density gradient, b, is very important in measuring suburbanization in an urban center. The values of the density gradient in the equations have prevalently decreased over time. The value of the gradient was the largest in 1965, and the smallest in 1985, indicating that this section has been significantly suburbanized.

Based on the graphic results from Figure 3, the pattern of Seoul's densities is similar to that of Western cities. However, the model cannot express a crater pattern in the central city or a doughnut pattern in the peripheral area of the city. Furthermore, it cannot explain the real densities in the southeastern section which has undergone rapid suburbanization. Despite the fact that the actual densities in the southeastern section can be regarded as the same pattern as that of Western cities in accordance with Figure 2, the model reveals that the densities in this section fall into the category of non-Western cities in Figure 3.

On the other hand, the values of $R^2$ in the four sections have decreased over time (Table 1). In particular, the northeastern and the southwestern sections in 1965 showed a strong association between distance and density, about 90 percent. However, the values of all four sections in 1985 are much smaller than those in 1965.

In a residual analysis, it is reasonable to assume that the distribution of residuals should be random (Cliff and Ord, 1981, PP. 14 and 200). But, the distribution of residuals in 1965 showed a particular V shape in Figure 4, which shape cannot be regarded as a random distribution. The distribution in 1975 had a wave around zero, and one value deviated substantially from zero. The shape in 1985 was an inverted V shape. This shape also cannot be considered as a random case. Therefore, the Clark model cannot explain the population density in the city on the whole. The model could be applicable to the central density at an early stage in urban development.

2) Sherratt Model

Three simple quadratic regressions are produced by the Sherratt model:

$$\text{Log } D_{65} = 9.169 - \underset{(-11.120)}{0.011} \text{ Dis}_{65}{}^2 \quad (10)$$

$$\text{Log } D_{75} = 9.607 - \underset{(-11.872)}{0.007} \text{ Dis}_{75}{}^2 \quad (11)$$

$$\text{Log } D_{85} = 9.641 - \underset{(-11.415)}{0.005} \text{ Dis}_{85}{}^2 \quad (12)$$

The values of intercepts in the equation are larger as time passes. The central densities estimated by the Sherratt model are 9,586 in 1965, 14,854 in 1975, and 15,367 in 1985. Despite the decrease of the actual central density, the model determines that the central density increases as time goes by. This result is unexpected, and different from the real phenomenon.

The values of the gradient also slightly decrease over time. This means that the model denotes only minor suburbanization of the city.

Meanwhile, this model shows that the population distribution in Seoul is similar to that of non-Western cities, indicating that the central density gradually increases at the same rate as the peripheral density increases over time (Fig. 5). To explain the actual population distribution, the model should produce the patterns of

Table 2. Intercepts and gradients from the Sherratt model

| Section | Component | 1965 | 1975 | 1985 |
|---|---|---|---|---|
| Northwest | a | 8.988 | 9.598 | 9.526 |
| | b | -0.009 | -0.012 | -0.010 |
| | | (-8.111) | (-12.521) | (-9.855) |
| | $R^2$ | 0.622 | 0.809 | 0.714 |
| Northeast | a | 9.686 | 9.881 | 9.460 |
| | b | -0.015 | -0.006 | -0.004 |
| | | (-13.193) | (-8.399) | (-5.536) |
| | $R^2$ | 0.821 | 0.656 | 0.440 |
| Southwest | a | 9.578 | 10.341 | 10.151 |
| | b | -0.012 | -0.011 | -0.007 |
| | | (-11.799) | (-18.036) | (-7.348) |
| | $R^2$ | 0.777 | 0.893 | 0.488 |
| Southeast | a | 8.702 | 9.176 | 9.614 |
| | b | -0.010 | -0.007 | -0.004 |
| | | (-5.987) | (-7.931) | (-11.415) |
| | $R^2$ | 0.479 | 0.617 | 0.488 |

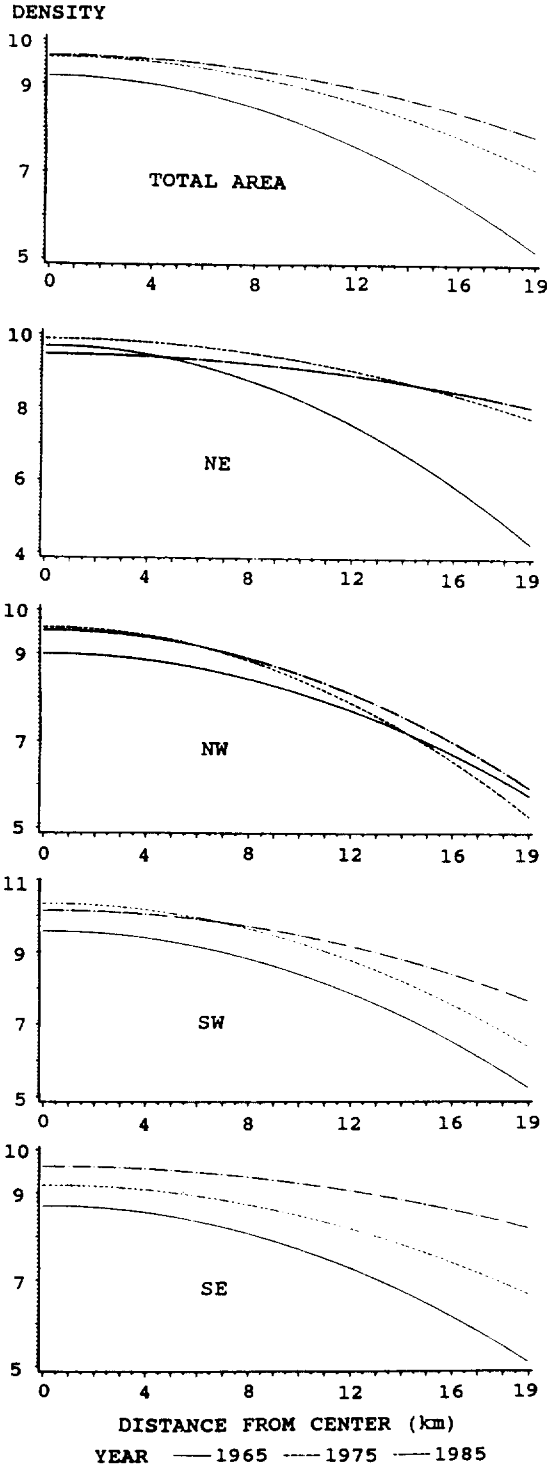


FIG. 5. POPULATION DENSITIES (SHERRATT)

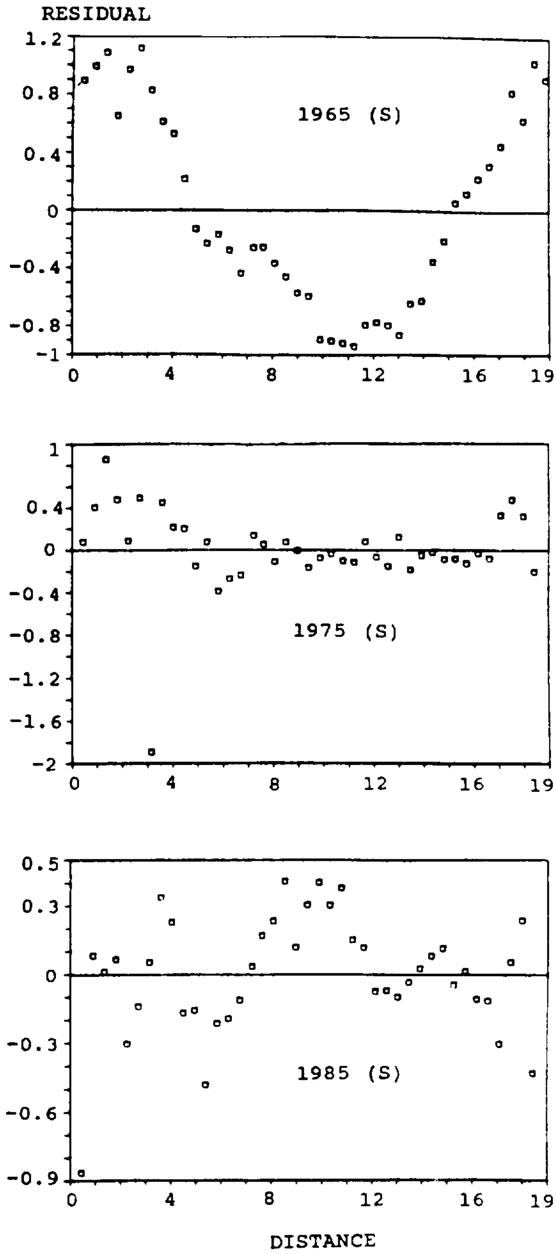


FIG. 6. RESIDUAL DISTRIBUTION (SHERRATT)

Western cities.

The model cannot determine the central densities in all four quadrants. In particular, the central density in the southeastern section produced by the model is completely different from the actual densities. The model indicates an increase of the central density for each section as time passes, in spite of the actual decrease of the density (Table 2). The distribution of residuals reveals similar patterns to Clark's, indicating that its distribution is far from a random case (Fig. 6). Therefore, although the equations are significant, the Sherratt model could not be considered as a good one.

3) Newling Model

The Newling model produces the following multiple equations:

$$\text{Ln } D_{65} = 10.906 - \underset{(-16.960)}{0.473\,X} + \underset{(8.650)}{0.012\,X^2} \quad (13)$$

$$\text{Ln } D_{75} = 9.928 - \underset{(-1.931)}{0.090\,X} - \underset{(-1.147)}{0.003\,X^2} \quad (14)$$

$$\text{Ln } D_{85} = 9.318 + \underset{(3.231)}{0.090\,X} - \underset{(-6.259)}{0.009\,X^2} \quad (15)$$

The values of the intercept decrease over time. According to the equations, the central population decreased from 54,441 in 1965 to 20,475 in 1975 and to 11,126 in 1985. The decreasing ratios are 0.47 between 1965 and 1975, and 0.45 between 1975 and 1985. Although the size of the decreasing central population in the equations is different from that of the actual decreasing central population, the ratios produced by the equations are equivalent to the actual decreasing ratios. The Newling model shows the trend of changes in the central density of the city over time fairly well.

On the other hand, the values of the parameters decreased substantially between 1965 and 1975, and decreased slightly between 1975 and 1985, indicating that suburbanization was different in 1965 and 1975, but was similar in 1975 and 1985 (Fig. 7). Based on the t-values, relationships between distance and log population density, and between distance square and log population density appeared insignificant in 1975.

Values of the association between distance and density by section have also decreased as time goes by (Table 3). The model shows a strong association in the northeastern and the southwestern section in 1965, whereas it reflects the weakest association in the northeastern and the southeastern sections in 1985. The distribution of residuals by the Newling model can be regarded as a normal case (Fig. 8).

Table 3. Sectional Changes in intercepts and gradsents in the Newling Model

| Section | Component | 1965 | 1975 | 1985 |
|---|---|---|---|---|
| Northwest | a | 10.701 | 10.326 | 9.802 |
| | $b_1$ | −0.465 | −0.212 | −0.077 |
| | | (−7.109) | (−3.483) | (−1.003) |
| | $b_2$ | 0.013 | +0.001 | −0.006 |
| | | (3.908) | (−0.130) | (−1.450) |
| | F-value | 98.903 | 108.040 | 49.074 |
| | $R^2$ | 0.835 | 0.857 | 0.721 |
| Northeast | a | 11.210 | 9.775 | 8.749 |
| | $b_1$ | −0.434 | 0.031 | 0.198 |
| | | (−8.583) | (0.550) | (4.685) |
| | $b_2$ | 0.007 | −0.008 | −0.014 |
| | | (2.788) | (−2.577) | (−6.228) |
| | F-value | 290.903 | 34.762 | 34.532 |
| | $R^2$ | 0.940 | 0.659 | 0.645 |
| Southwest | a | 11.053 | 10.352 | 9.418 |
| | $b_1$ | −0.400 | −0.003 | 0.204 |
| | | (−7.909) | (−0.068) | (2.989) |
| | $b_2$ | 0.008 | −0.011 | −0.017 |
| | | (3.044) | (−4.310) | (−4.879) |
| | F-value | 207.991 | 158.507 | 36.956 |
| | $R^2$ | 0.914 | 0.893 | 0.693 |
| Southeast | a | 11.163 | 10.241 | 9.338 |
| | $b_1$ | −0.683 | −0.296 | 0.076 |
| | | (−9.270) | (−6.559) | (1.569) |
| | $b_2$ | 0.024 | 0.008 | −0.008 |
| | | (6.363) | (3.548) | (−3.045) |
| | F-value | 99.930 | 86.865 | 20.476 |
| | $R_2$ | 0.840 | 0.821 | 0.621 |

Some features are found from the examination of the intercepts and the gradient of the equations. First, based on the changes in the values of a, b, and c, there has been a crater of population distribution in the central city. The crater has become deeper and larger over time in terms of decreasing rates of population densities for the last two decades. Second, the decreasing number of residents in the central city and the increasing population in the suburban areas

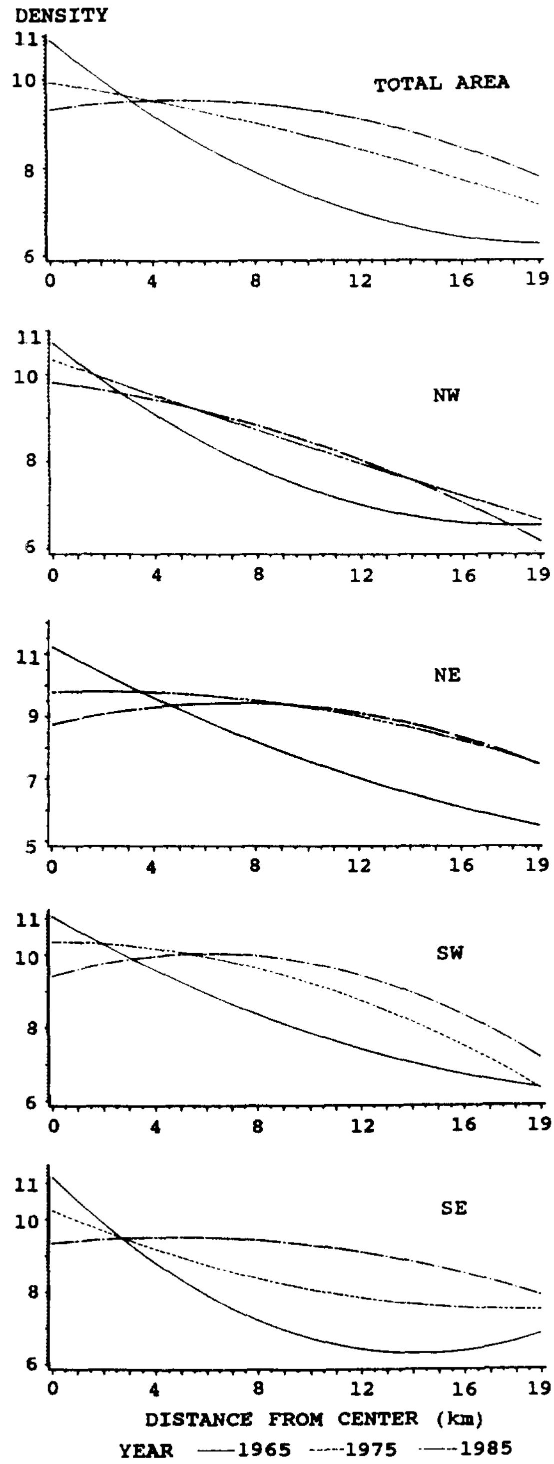


FIG. 7. POPULATION DENSITIES (NEWLING)

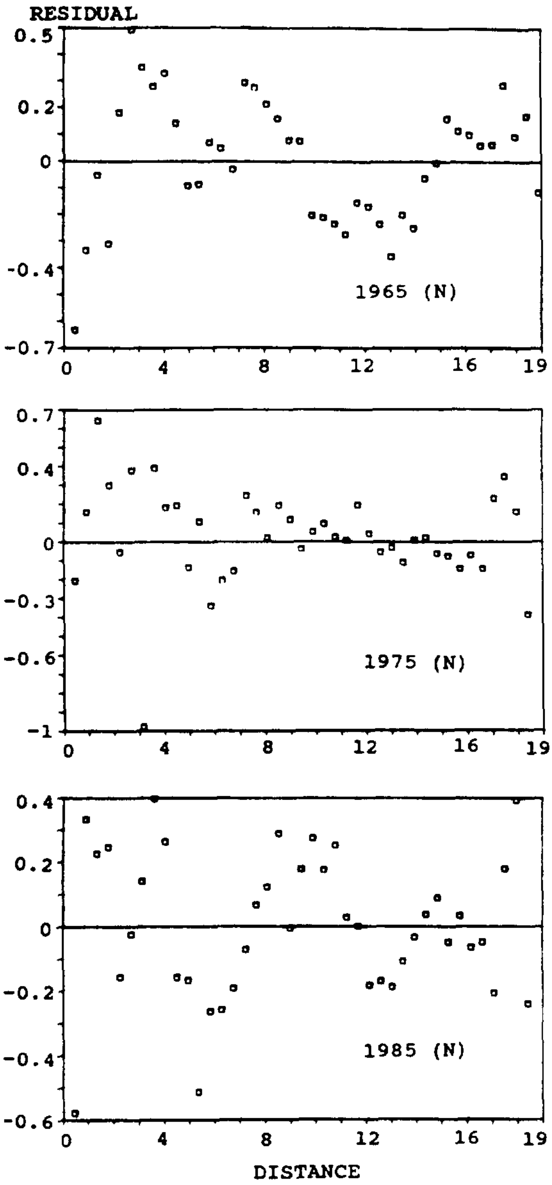


FIG. 8. RESIDUAL DISTRIBUTION (NEWLING)

determine the patterns of population distribution in the city. That is, Seoul has been tranformed to a doughnut model city which implies peripheral dominance in population distribution. Third, this model shows that the changing pattern of population densities in the city is similar to that of Western cities. The model expresses the Western patterns of population distribution in the four sections fairly well.

## 4. CONCLUSION

Seoul's pattern of urban development fits the pattern of population distribution of Western cities. That is, the central density of the city first increases and later decreases, and the density gradient steadily drops. Population distribution in the city is affected by socioeconomic situations, residents' perceptions, and government development policies. In particular, government intervention is a primary determinant of population distribution. The subway system has also significantly influenced the population distribution. These cheap and faster transportation facilities could be a factor that has made the population density gradient smaller.

The graphs and the regression equations in this study show the changes in central density as well as suburbanization. In particular, the graphic analysis is a convenient tool for explaining the changes in densities easily with the passing of time.

No model can exactly illustrate the actual densities of the city. Only some of the models can explain partially the correct distribution. For example, the Clark model shows central density at an early stage, but does not reveal it at the most developed stage. In contrast with the Clark model, the Newling model is appropriate to explain it in both less urbanized and more urbanized cities. The Newling model best represents the population density in Seoul, whereas the Sherratt model is not fit for showing the population density of the city. Based on the results of this study, it is clear that one model cannot easily represent all of these phenomena because every urban center has its own unique urban characteristics.

# 人口密度의 變化로 본 都市內部의 成長과 空間패턴

## — 서울의 例 —

李 鎭 煥 *

「國文要約」

都市內部에서 人口密度 變化패턴은 西歐地域의 여러 國家들과 非西歐地域의 國家들 사이에 많은 차이가 있다. 서울의 경우, 그 위치는 非西歐地域에 속하나 人口密度 패턴은 西歐 여러나라 都市人口密度 패턴의 범주에 들어간다. 몇 종류의 人口密度에 관한 모델을 통해 조사해 본 결과 어떠한 모델도 서울의 人口分布를 全時代를 通해서 설명하지 못한다는 것이 밝혀졌다.

都市內의 人口分布는 社會·經濟的인 環境과 住民의 認知 및 政府의 開發政策에 의해 영향을 받는다. 特히 정부의 간섭은 人口分布의 一次的 決定因子로 작용한다. 또 지하철망 역시 都市의 人口分布에 큰 영향을 미친다. 지하철과 같이 값싸고 신속한 교통수단은 都市內 人口密度의 gradient를 감소시킨다.

그래프와 회귀분석을 실시한 결과 本 硏究는 郊外化와 더불어 中心密度의 變化가 發生한 것을 확인하였다. 특히 그래프 分析은 時間의 흐름에 따른 인구밀도의 變化를 설명하는데 있어 매우 편리한 기법이다.

어떠한 모델도 都市人口密度의 실제적인 변화를 정확히 나타낼 수는 없다. 가령 Clark 모델의 경우 이는 도시발달 초기단계에서의 中心密度를 잘 나타내어 준다. 그러나 이 모델은 도시발달이 대부분 완료된 경우에는 큰 가치가 없다. 이에 반해 Newling모델은 도시화의 정도가 미약하거나 도시화가 잘 진행된 경우 모두에 적당하다. 서울의 人口密度를 설명함에 있어서는 Newling모델이 가장 적당한 것으로 생각되며 Sherratt모델은 부적절한 기법이라고 생각한다.

本 硏究에서 밝혀진 바에 의하면 都市의 人口密度를 설명하는데 있어서 모든 都市中心部는 그들 고유의 都市的 特性을 지니고 있기 때문에 어떤 하나의 모델만을 가지고는 모든 것을 설명할 수는 없다고 생각한다.

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