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Urbanization, Suburbanization and Revived-urbanization: ROXY-index Analysis for the Chuo-line Region of Tokyo

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CONTENTS

ABSTRACT

It is one of the most important roles for spatial economists to provide scholars and policy makers who are tackling urban and regional issues with a better insight into the basic tendency of the changes in the spatial redistribution of socio-economic activities within urban areas. Based on this standpoint, the present paper examines the urbanization and suburbanization process of the Chuo-line region of the Tokyo metropolitan area for the period 1947-95. For investigating the Chuo-line region that extends to the west from the CBD of Tokyo and that is long and narrow in shape, this paper employs the Klaassen's spatial-cycle framework as a theoretical scheme and the ROXY-index approach as an analytical instrument. Results show, for the period 1990-95, that the Chuo-line region seems to be nearly at the last phase of the decelerating-suburbanization stage and to be about to get into the first phase of the accelerating-urbanization stage (*i.e.*, the first phase of the revived-urbanization stage). One of the noteworthy policy implications derived from our results is that the magnitude of the necessity for the urban investment in the inner zone of the Tokyo metropolitan area along the Chuo-line region is increasing significantly for augmenting the positive effects stemming from the urban agglomeration economies and for reducing the negative effects caused by the urban agglomeration diseconomies, in order to prepare for the forthcoming revived-urbanization stage.

KEY WORDS

Klaassen hypothesis, Population change, Revived-urbanization
ROXY-index, Spatial cycles, Suburbanization
Tokyo metropolitan area, Urbanization

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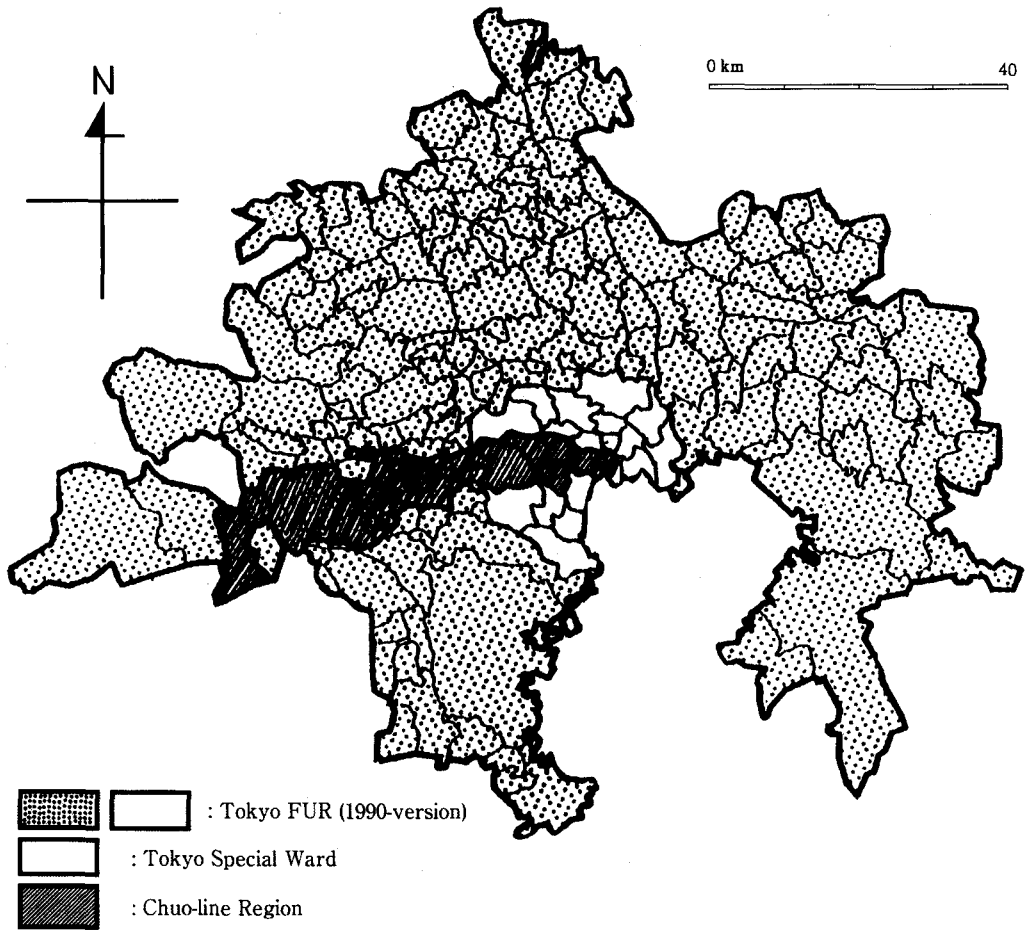
1. Introduction: Objective

This paper is a follow-up study to a part of the investigation by Kawashima and Hiraoka (1993) which analyzes, by applying the Klaassen's spatial-cycle hypothesis and the ROXY-index analytical method, the spatial-cycle phenomena of the urbanization and suburbanization process for the five major railway-line regions in the Tokyo metropolitan area for the period from 1960 through 1990. The primary purpose of the present paper is to examine, for the period from 1947 through 1995, the spatial-cycle process for the area along the Chuo Line, which is one of the major mass-rapid transit railway-lines in the Tokyo metropolitan area. We call this area the Chuo-line region, whose geographical location is presented by Figure 1.

Figure 1 Geographical Location of the Chuo-line Region



In the following, we briefly explain our analytical approach in Section 2. In Section 3 we describe the population changes in the Chuo-line region for the period from 1947 through 1995. In Section 4 we examine, in light of the ROXY-index values, the spatial-cycle stages of the urbanization and suburbanization process for the Chuo-line region and its possible future path of the spatial-cycles. In Section 5, in conclusion, we discuss some policy implications that can be derived from our examination in section 4, and application potentials of our analytical approach based on the Klaassen's hypothesis and the ROXY-index method for the study of urban dynamism.

2. Data, Spatial Units and Analytical Approach

2-1 Data and Spatial Units

We utilize the national census figures from 1947 through 1995 for our analysis. From these figures, we pick up population data as shown in Table A-2 in the Appendix for the spatial units described below for the calculation of the ROXY-index values.

For spatial units, as listed in Table A-1 in the Appendix, we use sixteen localities which compose the Chuo-line region. Each of the member localities of the Chuo-line region satisfies the following two conditions.

(1) The locality is situated within the boundary of the 1990-version of the Tokyo functional urban region (Tokyo FUR[1]) which is conceptually considered as the Tokyo metropolitan area.

(2) The locality is passed through, even in part, by the Chuo Line.

2-2 Analytical Approach

We employ in our investigation, as a theoretical framework, the spatial-cycle hypothesis originally conceived and constructed by Klaassen[2] in the 1970's. As an analytical instrument, we employ the ROXY-index method originally conceived and applied in an empirical study by Kawashima[3] also in the 1970's.

2-2-1 Spatial-cycle Paradigm: Klaassen's Hypothesis

The essence of the Klaassen's spatial-cycle hypothesis argues that the process of the intra-metropolitan spatial redistribution of different socio-economic activities tends to follow the recurrently transmuting successive stages along the spatial-cycle path.

One of the generalized versions[4] of the Klaassen's original spatial-cycle hypothesis is the spatial-cycle paradigm with four major stages: ① accelerating urbanization, ② decelerating urban-

ization, ③ accelerating suburbanization, and ④ decelerating suburbanization. This paradigm is shown in column B of Table 1. Two other kinds of spatial-cycle paradigms, one with two major stages and the other with eight major stages, are shown in columns A and C of the same table.

Table 1 Three Kinds of Spatial-cycle Paradigms for Recurrently Transmuting Stages: For Study of Intra-metropolitan Analysis

A		B		C	
Two major stages		Four major stages		Eight major stages	
T-1	Urbanization	F-1	Accelerating urbanization	E-1	First half of accelerating urbanization
				E-2	Second half of accelerating urbanization
		F-2	Decelerating urbanization	E-3	First half of decelerating urbanization
				E-4	Second half of decelerating urbanization
T-2	Suburbanization	F-3	Accelerating subrbanization	E-5	First half of accelerating suburbanization
				E-6	Second half of accelerating suburbanization
		F-4	Decelerating subrbanization	E-7	First half of decelerating suburbanization
				E-8	Second half of decelerating suburbanization

[Notes]

(1) In case we use the terms of centralization (instead of urbanization) and decentralization (instead of suburbanization), the above-mentioned stages are referred to as following: centralization (for T-1) and decentralization (for T-2); accelerating centralization (for F-1), decelerating centralization (for F-2), accelerating decentralization (for F-3) and decelerating decentralization (for F-4); first half of accelerating centralization (for E-1), second half of accelerating centralization (for E-2), first half of decelerating centralization (for E-3), second half of decelerating centralization (for E-4), first half of accelerating decentralization (for E-5), second half of accelerating decentralization (for E-6), first half of decelerating decentralization (for E-7) and second half of decelerating decentralization (for E-8).

(2) For the two-stage paradigm represented in column A, the spatial-cycle path follows the recurrently transmuting stages of T-1, T-2, T-1, T-2, ···.

(3) For the four-stage paradigm represented in column B, the spatial-cycle path follows the recurrently transmuting stages of F-1, F-2, F-3, F-4, F-1, F-2, F-3, F-4, ···.

(4) For the eight-stage paradigm represented in column C, the spatial-cycle path follows the recurrently transmuting stages of E-1, E-2, E-3, E-4, E-5, E-6, E-7, E-8, E-1, E-2, E-3, E-4, E-5, E-6, E-7, E-8, ···.

(5) The stage of urbanization is called the stage of revived-urbanization when the spatial-cycle path arrives at the stage of urbanization on its second or further round, in order to highlight the phenomena of the re-entry of the spatial-cycle path into the stage of urbanization.

(6) In the Klaassen's original framework, the following terms are used to describe the four major stages represented in column B: reurbanization (for F-1), urbanization (for F-2), suburbanization (for F-3), and counter-urbanization (for F-4).

Table 2 Definition of ROXY Index for Intra-metropolitan Analysis of Spatial Redistribution Process of Population

$$RI(t,t+1) \equiv \Phi(t,t+1) = (WAGR_{t,t+1} / SAGR_{t,t+1} - 1.0) \times 10^4 \quad \cdots\cdots (1)$$

where

$RI(t,t+1)$: Value of ROXY index for the period between years t and $t+1$ (calculated on the annual growth-ratio basis)

$\Phi(t,t+1)$: Abbreviation of $RI(t,t+1)$

$WAGR_{t,t+1}$: Weighted average of the annual growth ratios of population, for the period between years t and $t+1$ over n subareas composing the metropolitan area being investigated, which is equal to

$$\sum_{i=1}^{n} \left(w_i^t \times r_i^{t,t+1} \right) / \sum_{i=1}^{n} w_i^t$$

$SAGR_{t,t+1}$: Simple average of the annual growth ratios of population, for the period between years t and $t+1$ over n subareas composing the metropolitan area being investigated, which is equal to

$$\sum_{i=1}^{n} r_i^{t,t+1} / n$$

x_i^τ : Population of subarea i of the metropolitan area in year τ

n : Number of subareas composing the metropolitan area

$r_i^{t,t+1}$: Annual growth ratio of population of subarea i for the period between years t and $t+1$, which is defined as the k-th root of $x_i^{t+k} / x_i^t = r_i^{t,t+k}$

w_i^t : Weighting factor for subarea i in year t

[Note]

In case the quantitative characteristics of the weighting factor positively correspond to the concept of urbanization (or centralization), we utilize the definition given by Equation (1). One example of such weighting factors is "a reversed CBD-distance of subarea i" (δ_i) which is defined as

$$\delta_i = \left(\underset{j}{Max} \quad d_j \right) - d_i$$

where d_i is a CBD distance of subarea i. In case the quantitative characteristics of the weighting factor adversely correspond to the concept of urbanization (or centralization), we utilize the definition given by Equation (2) which has the negative sign added:

$$RI(t,t+1) \equiv \Phi(t,t+1) = -(WAGR_{t,t+1} / SAGR_{t,t+1} - 1.0) \times 10^4 \quad \cdots\cdots (2)$$

One example of such weighting factors is a CBD distance of subarea i (d_i).

Table 3 Calculation Formula of ROXY Index for the Analysis of the Chuo-line Region

$$RI(t,t+1) \equiv \Phi(t,t+1)$$
$$= -(WAGR_{t,t+1} / SAGR_{t,t+1} - 1.0) \times 10^{d}$$

where

$RI(t,t+1)$: Value of ROXY index for the period between years t and $t+1$ (calculated on the annual growth-ratio basis)

$\Phi(t,t+1)$: Abbreviation of $RI(t,t+1)$

$WAGR_{t,t+1}$: Weighted average of the annual growth ratios of population, for the period between years t and $t+1$ over n subareas composing the metropolitan area being investigated, which is equal to

$$\sum_{i=1}^{n}\left(w_i^t \times r_i^{t,t+1}\right) / \sum_{i=1}^{n} w_i^t = \sum_{i=1}^{n}\left(d_i \times r_i^{t,t+1}\right) / \sum_{i=1}^{n} d_i$$
$$= \sum_{i=1}^{n}\left\{d_i \times \left(r^{t,t+k}\right)^{1/k}\right\} / \sum_{i=1}^{n} d_i$$

$SAGR_{t,t+1}$: Simple average of the annual growth ratios of population, for the period between years t and $t+1$ over n subareas composing the metropolitan area being investigated, which is equal to

$$\sum_{i=1}^{n} r_i^{t,t+1} / n = \sum\left(r_i^{t,t+1}\right) / n$$

x_i^{τ} : Population of subarea i of the metropolitan area in year τ

n : Number of subareas composing the metropolitan area

$r_i^{t,t+1}$: Annual growth ratio of population of subarea i for the period between years t and $t+1$, which is defined as the k-th root of

$$x_i^{t+k} / x_i^{t} = r_i^{t,t+k}$$

w_i^t : Weighting factor for subarea i in year t

d_i : CBD distance of subarea i

[Note]
In our analysis, the weighting factor w_i^t which is used for the calculation of $WAGR_{t,t+1}$ for subarea i in year t, is the CBD distance of subarea i (d_i).

In an intra-metropolitan analysis like the study in this paper, the phenomena of urbanization and suburbanization are often referred to as those of centralization and decentralization respectively. If we are interested in using those terms, the spatial-cycle stages of each paradigm are called as stated in the note (1) of Table 1.

It should be also kept in mind that, as mentioned in the note (6) of Table 1, we call the stage of urbanization the stage of revived-urbanization when the spatial-cycle path arrives at that stage of urbanization on its second or further round, in order to emphasize the re-entry phenomena of the spatial-cycle path into the stage of urbanization.

We mainly apply in the following the spatial-cycle paradigm with four major stages to our investigation of the population changes in the Chuo-line region.

2-2-2 ROXY-index Method

The ROXY index[5] is an indicative instrument to quantitatively identify, for a given system of spatial units[6], the stages of the spatial-cycle path for various types of socio-economic activities.

For the present study which conducts an intra-metropolitan analysis of the spatial redistribution process of population, the ROXY index is defined as shown by Table 2. As can be easily seen from this table, "the proportion of the weighted average of the growth ratio to the simple average of the growth ratio" plays a fundamental role in the definition of the ROXY index. From Table 2, we can construct the calculation formula for the ROXY-index value for the Chuo-line region as given by Table 3.

Based on Tables 2 and 3, we obtain Table 4[7] which indicates the following five relationships among ① the sign of the ROXY-index value, ② the direction of the changes in the ROXY-index value, ③ the pattern of the spatial redistribution process of population, and ④ the speed of the spatial redistribution process of population.

(1) The ROXY-index value is positive and increasing for the stage of accelerating urbanization.
(2) The ROXY-index value is positive and decreasing for the stage of decelerating urbanization.
(3) The ROXY-index value is negative and decreasing for the stage of accelerating suburbanization.
(4) The ROXY-index value is negative and increasing for the stage of decelerating suburbanization.
(5) The ROXY-index value is zero (or in the vicinity of zero) for the stage at which the spatial redistribution process is neutral (that is, the stage which corresponds to neither the phenomena of urbanization nor the phenomena of suburbanization).

Table 4 Implications of ROXY-index Values for Intra-metropolitan Analysis of Spatial Redistribution Process of Population: For Terms of Urbanization and Suburbanization

A	B	C	D
Sign of ROXY-index value	Pattern of spatial redistribution process of population within a metropolitan area	Direction of changes in ROXY-index values	Speed of spatial redistribution process of population within a metropolitan area
Positive	Urbanization (or Revived-Urbanization)	Increasing	Accelerating
		Levelling-off	Stationary
		Decreasing	Decelerating
Zero	Neutrality from both urbanization and suburbanization (*viz.* Symmetric growth or symmetric decline[1])	Levelling-off	Continuation of neutrality
Negative	Suburbanization	Decreasing	Accelerating
		Levelling-off	Stationary
		Increasing	Decelerating

[Source] Reconstructed from Kawashima and Hiraoka (1998)

[Note]

The spatial redistribution pattern of the "symmetric growth or symmetric decline" comprises the following three sub-patterns of BLGD, BSGD and CSGD.

(i) Balanced growth or decline (BLGD): The fitted growth-rate curve which is a function of "the distance from the center of the metropolitan area under our investigation to each of its subareas" (*i.e.*, the subarea's CBD distance), is nearly flat regardless of their CBD distance to reflect the constant sharing of population by subareas over time.

(ii) Bell-shaped growth or decline (BSGD): The fitted growth-rate curve is bell-shaped, reflecting the "medianization" of population over subareas in the metropolitan area.
The phenomena of "medianization" means: ① the increase (as compared with other subareas) in population shared by subareas with the medium CBD distance, or ② the decrease in population shared by subareas with either relatively longer or relatively shorter CBD distance (but not by subareas with the medium CBD distance).

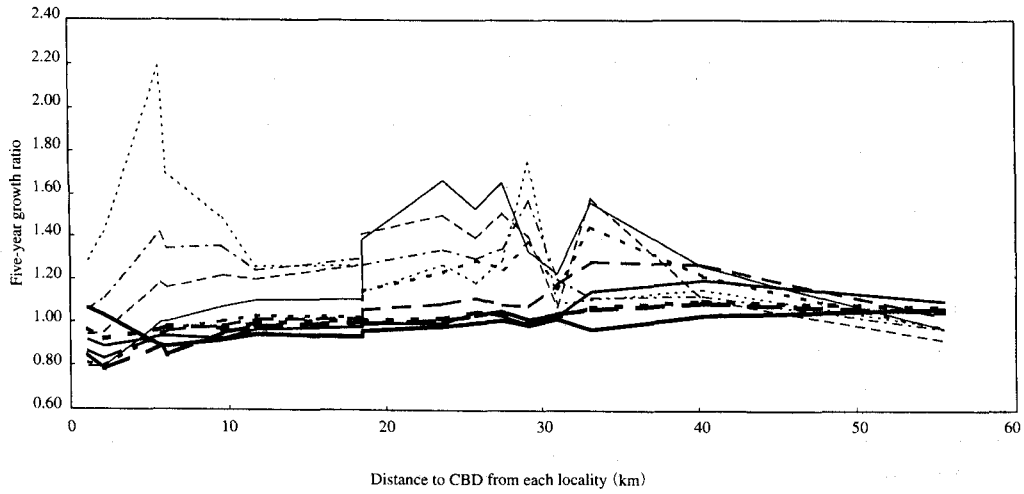
(iii) Cup-shaped growth or decline (CSGD): The fitted growth-rate curve is cup-shaped, reflecting the "bipolarization" of population over subareas in the metropolitan area.
The phenomena of "bipolarization" means: ① the increase in population shared by subareas with either relatively shorter or relatively longer CBD distance, or ② the decrease in population shared by subareas with the medium CBD distance.

3. Population Changes

3-1 Five-year Growth Ratios for Localities of the Chuo-line Region

We have in Japan eleven national population censuses after the World War II: for years of 1947, 1950, 1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990 and 1995. By use of these censuses we construct Table A-2 in the Appendix showing the population level for each of the localities composing the Chuo-line region. In this table, the distance to the CBD from each locality is also shown. From Table A-2, we calculate the gross growth ratio[8] for the population of each locality, for one three-year period and nine five-year periods as given by Table A-3. This table also gives the estimated gross growth ratio for the hypothetical five-year period 1947-52. From Table A-3, we obtain Table A-4 showing the annual growth ratio by locality for each period. Also from Table A-3, we can construct Figure 2 which shows the five-year growth-ratio curves for each of ten periods. Based on Figure 2, we can draw Figure 3, which shows "the gross growth-ratio curve of each period" together with "the gross growth-ratio curve of the previous period," if any. These two figures help us observe visually how the levels of the growth ratios of the population have changed for localities composing the Chuo-line region in both temporal and spatial context. The following six messages can be derived from these two figures, concerning the urbanization and suburbanization process of the Chuo-line region for the period from 1947 through 1995.

Figure 2 Five-year Growth-ratio Curves for the Chuo-line Region



[Note] The five-year growth ratio for the period 1947-52 is an estimated value calculated on the basis of the three-year growth ratio for the period 1947-50

Figure 3 Five-year Growth-ratio Curves for the Chuo-line Region: For Each Period together with the Five-year Growth-ratio Curve for Previous Period

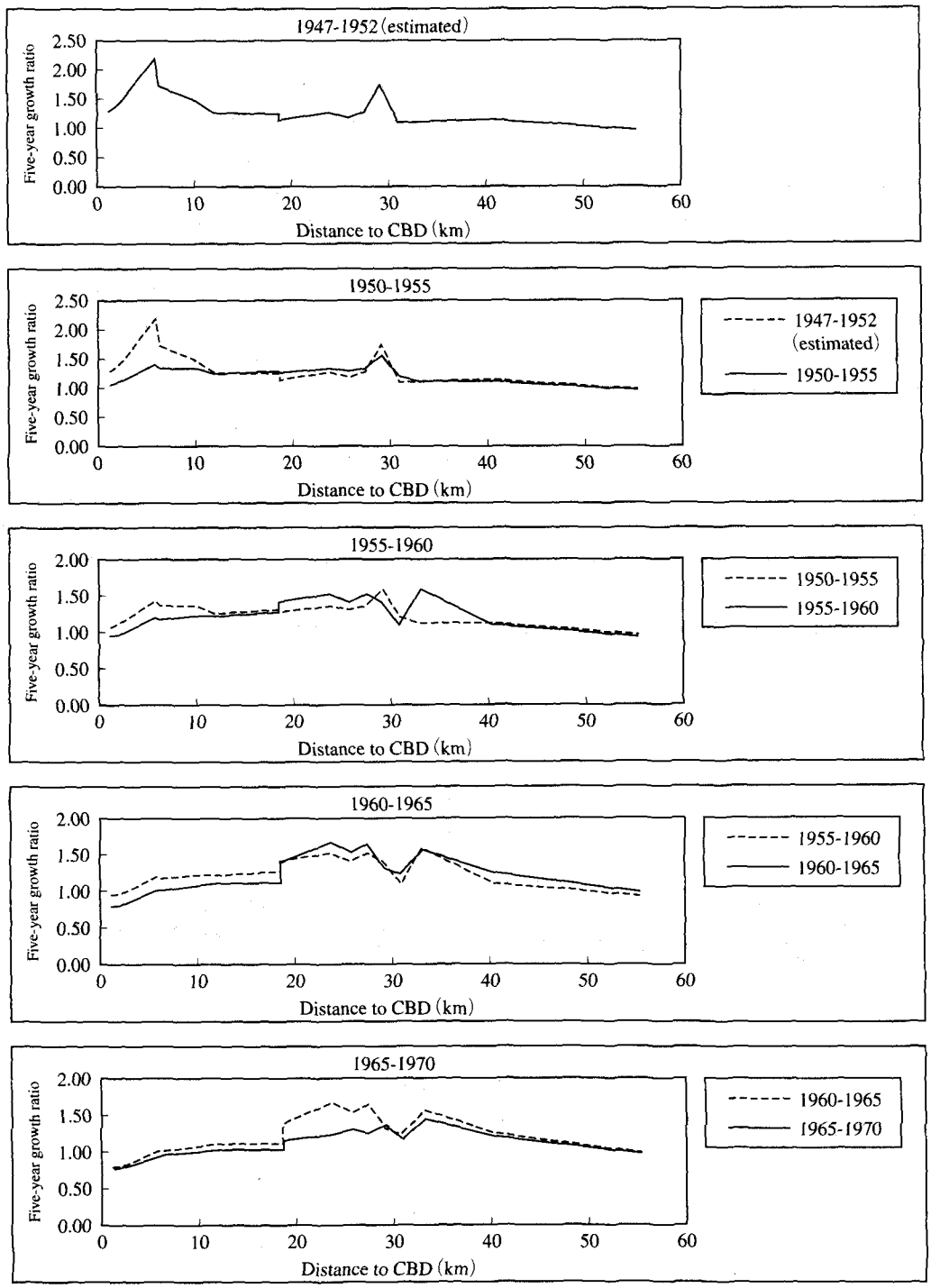
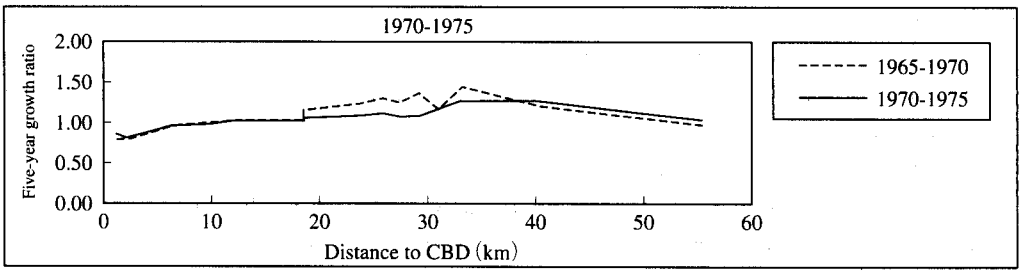
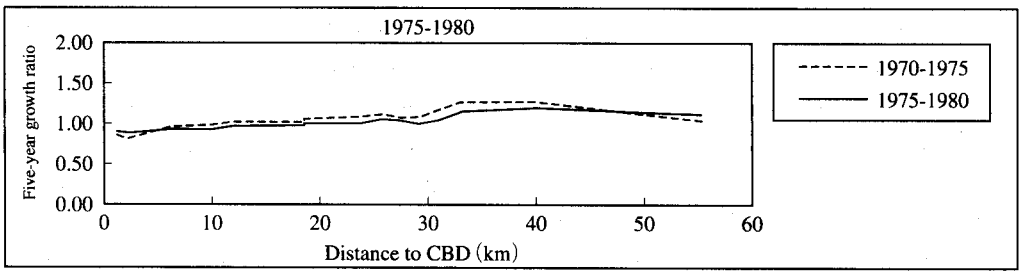
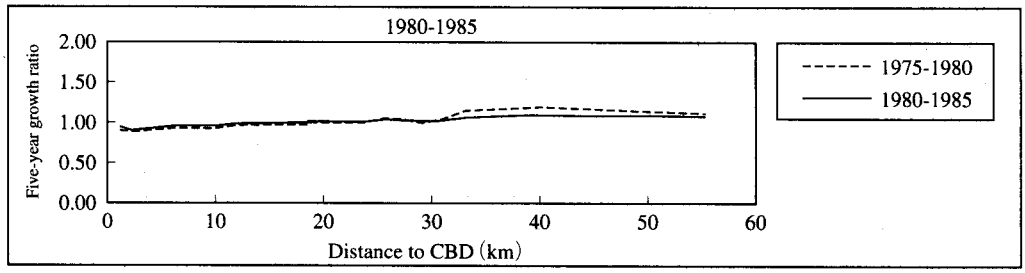
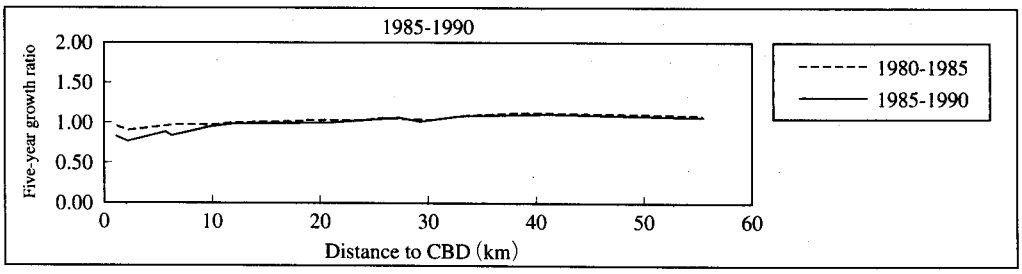


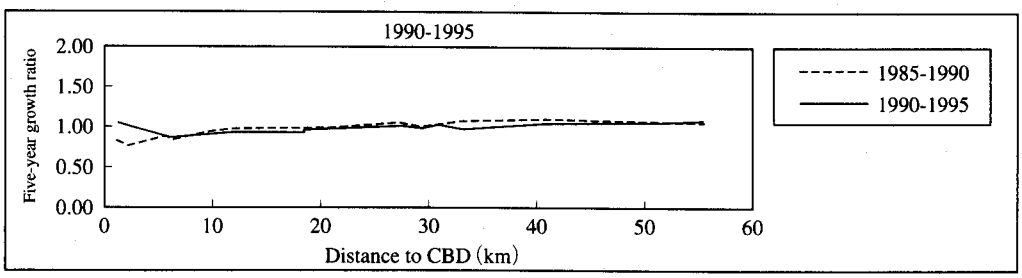
Figure 3 (Continued)











(1) (i) For the periods 1947-50 and 1950-55, the growth-ratio curve for each period is characterized by the two distinctly high peaks: one existing towards its left-hand side and the other at its center. The left-hand side peak corresponds to Shinjuku-ku (5.7km for the CBD distance, with a three-year growth rate of 60.06% for the period 1947-50[9] and with a five-year growth rate of 41.52% for the period 1950-55). The central peak corresponds to Kunitachi-shi (29.2km, 40.11%[10], 57.40%).

(ii) The left-hand side peak (corresponding to Shinjuku-ku) is clearly higher than the central peak (corresponding to Kunitachi-shi) for the period 1947-50, but becomes evidently lower than the central peak for the period 1950-55. This perhaps may reflect the start of the suburbanization process of the population in the Chuo-line region in the 1950's.

(2) (i) For the periods 1955-60, 60-65 and 65-70, the growth-ratio curve for each period is characterized by a relatively deep valley existing at its center, and a high peak existing next to this deep valley towards its right-hand side direction. The valley corresponds to Tachikawa-shi (31.0km for the CBD distance, with five-year growth rates of 7.39% for the period 1955-60, 22.88% for the period 1960-65, and 16.24% for the period 1965-70). The peak corresponds to Hino-shi (33.2km, 58.92%, 56.66%, 44.98%).

(ii) The emergence of the central valley (corresponding to Tachikawa-shi) for the 1955-60 period is not caused by a drastic decrease in the population of Tachikawa-shi, but by a sudden increase in the population of Hino-shi.

(3) For the period from 1950 through 1970, the left-hand side portion of the growth-ratio curve which corresponds to localities with the CBD distance less than 18km, gradually lowers as time proceeds. Meanwhile, the right-hand side portion of the growth-ratio curve which corresponds to localities with the CBD distance more than 40km, either gradually heightens as time goes on, or remains at the previous level even though time goes on.

(4) For the periods 1965-70 and 1970-75, the growth-ratio curve for each period is characterized by the downward levelling-off motions of localities situated at a CBD distance of approximately 20km to 30km. They are Koganei-shi (23.7km for the CBD distance, with a five-year growth rate of 23.70% for the period 1965-70 and that of 8.74% for the period 1970-75), Fuchu-shi (25.8km, 29.26%, 11.77%), Kokubunji-shi (27.5km, 25.19%, 8.49%), Kunitachi-shi (29.2km, 37.33%, 7.86%) and Hino-shi (33.2km, 44.98%, 28.61%). The only exception for this case is Tachikawa-shi (31.0km, 16.24%, 17.97%) whose growth ratio went up.

(5) For the periods 1980-85 and 85-90, the growth-ratio curve for each period is characterized by a shallow valley at its left-hand side. This valley corresponds to Chuo-ku (1.1km for the CBD distance, with five-year growth rates of -3.30% for the period 1980-85, and -14.92% for the period 1985-90).

(6) (i) For the period 1990-95, the growth-ratio curve is characterized by a negative gentle slope existing toward its extremely left-hand side. This slope portion of the growth-ratio curve corresponds to Chuo-ku (2.1km for the CBD distance, with a five-year growth rate of 0.63% for the period 1990-95). They are the only two localities out of the sixteen localities composing the Tokyo FUR, whose growth rates turn positive for the period 1990-95 from the negative

growth rates for the period 1985-90.

(ii) For the 1990-95 period, there exist seven localities with positive five-year growth rates. Among them, Fujino-machi has the highest growth rate (55.5km, 6.93%), followed by Chuo-ku (1.1km, 6.47%), Hachioji-shi (40.3km, 3.59%), Chiyoda-ku (2.1km, 3.18%), Tachikawa-shi (31.0km, 2.01%), Kokubunji-shi (27.5km, 1.29%) and Fuchu-shi (25.8km, 0.27%).

3-2 Trends of Changes in the Growth-ratio Curves for the Chuo-line Region

The aforementioned can be summarized by the following three points to describe the basic trends of changes in the shape of the growth-ratio curves.

(1) Tendency for the highest part of the curve to move outwards:
As the years roll on, the peak point (or high-altitude zone) of the growth-ratio curve tends to shift from localities with a shorter CBD distance to localities with a longer CBD distance.

(2) Tendency for the general height of the curve to go down:
As the years roll on, the general altitude of the growth-ratio curve tends to gradually become lower.

(3) Possible revival of the urban center in the near future:
For the period 1990-95, which is the latest period among all the ten consecutive periods investigated in this paper, the left-hand side tail (*i.e.*, the most inward part) of the growth-ratio curve seems to start to move upward.

What has been pointed out in the above would suggest the following three prospects as to the urbanization and suburbanization process of the population in the Chuo-line region.

(1) A movement from the stage of urbanization to that of suburbanization seems to have taken place around the year 1955.

(2) A movement from the stage of accelerating suburbanization to that of decelerating suburbanization seems to have taken place around the year 1965.

(3) A movement from the stage of suburbanization to that of revived-urbanization seems not to have taken place yet, but is likely to take place before too long.

4. ROXY-index Analysis

Now we want to ascertain, through a more objective approach by use of a quantitative analytical method, whether the urban-change prospects rather subjectively described in the last part of Section 3 would be appropriate to a reasonable extent or not. For this purpose, we employ the method of ROXY-index analysis, by expecting that the ROXY-index approach would facilitate our deeper and more precise understanding about the spatial redistribution process of population in

the Chuo-line region.

4-1 Obtained Values of ROXY Index

Based on Tables 3 and A-4, we calculate the ROXY-index values for each of ten five-year periods as shown in Table 5. From this table, we can draw Figure 4 which shows the changes in the ROXY-index value for the Chuo-line region in the wavelike-cyclic form for the relatively long period of forty-eight years from 1947 through 1995. From Table 5, we can also draw Figure 5 which shows the changes in the ROXY-index value in the circular-cyclic form. In Figure 5, we have the ROXY-index value along the abscissa axis which extends its positive direction towards the left-hand side. Along the ordinate axis, we have the marginal value[11] of the ROXY index. Suppose we cut the two-dimensional space of Figure 5 in the following three different ways: ① two equal parts of left-hand side half-space and right-hand side half-space, ② four quadrants of the space, and ③ eight equal parts of the space each of which radiately revolves around the origin in the open-triangle shape. Then, the intercepted spaces in each of the above ways correspond to the following stages conceived in each of the three spatial-cycle paradigms[12] shown in Table 1.

① Two half-space
- (i) Left-hand side half-space: Urbanization stage
- (ii) Right-hand side half-space: Suburbanization stage

② Four quadrants of the space
- (i) Second quadrant: Accelerating urbanization stage (*i.e.*, first-half stage of urbanization)
- (ii) Third quadrant: Decelerating urbanization stage (*i.e.*, second-half stage of urbanization)
- (iii) Fourth quadrant: Accelerating suburbanization stage (*i.e.*, first half-stage of suburbanization)
- (iv) First quadrant: Decelerating suburbanization stage (*i.e.*, second-half stage of suburbanization)

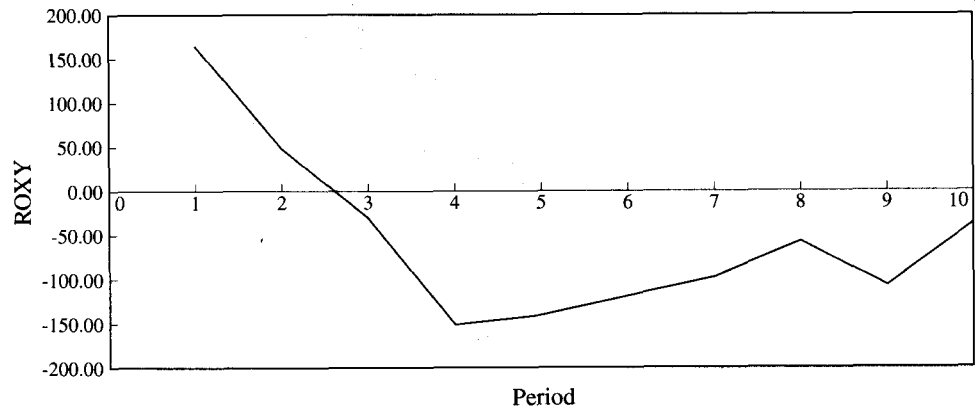
③ Eight equal parts of the space
- (i) North-northwestern segment: First-half stage of accelerating urbanization
- (ii) West-northwestern segment: Second-half stage of accelerating urbanization
- (iii) West-southwestern segment: First-half stage of decelerating urbanization
- (iv) South-southwestern segment: Second-half stage of decelerating urbanization
- (v) South-southeastern segment: First-half stage of accelerating suburbanization
- (vi) East-southeastern segment: Second-half stage of accelerating suburbanization
- (vii) East-northeastern segment: First-half stage of decelerating suburbanization
- (viii) North-northeastern segment: Second-half stage of decelerating suburbanization

Table 5 ROXY-index Value and Its Marginal Value for Each Period: For the Chuo-line Region

Period Code	1	2	3	4	5	6	7	8	9	10
Period	1947-1950	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995
ROXY	164.57	45.93	-30.98	-150.12	-139.02	-117.34	-97.51	-55.90	-107.03	-36.73
ΔROXY/ΔT	-29.66	-21.73	-19.61	-10.80	3.28	4.15	6.14	-0.95	1.92	14.06

[Note] The ROXY-index values in this table have been calculated on the basis of the annual growth ratio.

Figure 4 Wavelike-cyclic Path for the Chuo-line Region



4-2 Spatial-cycle Stages of the Chuo-line Region

Based on Table 5 and Figures 4 and 5, our empirical results can be interpreted as follows for the spatial-cycle stages of the Chuo-line region[13].

(1) For the period 1947-50, the value of the ROXY index (Φ) was 167.57 and its marginal value (MRI) was −29.66, while Φ was 45.93 and MRI is −21.75 for the period 1950-55. This implies that the spatial-cycle path of the Chuo-line region was at the stage of decelerating urbanization for the period from 1947 through 1955.

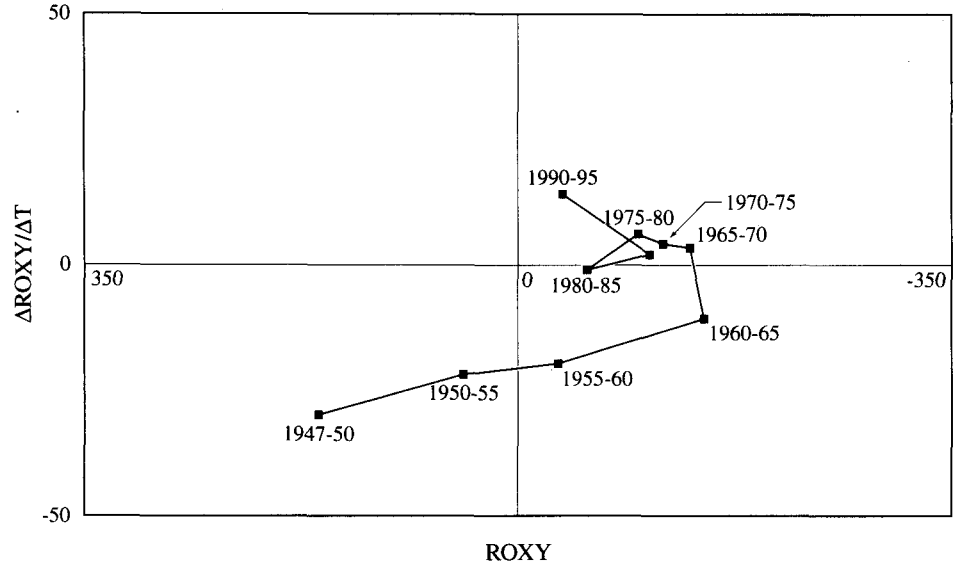
(2) Between the period 1950-55 (for which Φ is 45.93, and MRI is −21.73) and the period 1955-60 (Φ=−30.98, MRI=−19.61), the spatial-cycle path of the Chuo-line region moved from the urbanization stage to the suburbanization stage (more precisely speaking, from the stage of decelerating urbanization to the stage of accelerating suburbanization).

(3) For the period 1960-65 (Φ=−150.12, MRI=−10.80), the spatial-cycle path of the Chuo-line region remained at the stage of accelerating suburbanization.

(4) Towards the period 1965-70 (Φ=−139.02, MRI=4.15), the spatial-cycle path of the Chuo-line region arrived at the stage of decelerating suburbanization.

(5) For the period from 1965 through 1995, Φ continued to increase excepting the period 1985-90 (Φ=107.3, MRI=1.92) for which Φ decreased temporarily. This implies that the spatial-cycle path of the Chuo-line region in general remained at the stage of decelerating suburbanization

Figure 5 Circular-cyclic Path for the Chuo-line Region



during the period from 1865 through 1995.

(6) Along the basic spatial-cycle path which we may call the first-order spatial-cycle path, a small-scale spatial-cycle path emerged centering around the 1980's. This second-order spatial-cycle path[14] corresponds to the shallow valley for the ninth period appearing in the wave-like-cyclic path of the ROXY-index values in Figure 4.

(7) For the period 1990-95 ($\Phi = -36.73$, MRI=14.06), the spatial-cycle path of the Chuo-line region seems to have been approaching to the end of the suburbanization stage (in more concrete terms, to the end of the stage of decelerating suburbanization), possibly implying that the spatial-cycle path of the Chuo-line region will get into the stage of revived-urbanization in the near future.

The following three points summarize the aforementioned interpretation of the ROXY-index values on what the changes in the value of the ROXY-index would tell us about the urbanization and suburbanization process of the Chuo-line region after 1947.

(1) In the middle of the 1950's, the urbanization stage was over and the suburbanization stage began.

(2) In the middle of the 1960's, the spatial-cycle path got into the stage of the second half of suburbanization from the stage of the first half of suburbanization.

(3) In the middle of 1990's, the suburbanization stage seems to be gradually approaching to its end, and in consequence of that the revived-urbanization stage appears to arrive relatively

soon.

5. Conclusion

By adding to the study of Kawashima and Hiraoka (1993) the recently published 1995 census data and the 1947, 1950 and 1955 census data for the Chuo-line region, we have in our investigation obtained more sufficient evidence for the Klaassen's spatial-cycle hypothesis. One of the most important findings successfully obtained through our investigation is that the Chuo-line region appears to be continuously approaching the end-stage of decelerating suburbanization, and is likely to go into the first phase of the stage of accelerating urbanization sooner or later.

This finding would provide us with the policy implications that the necessity is significantly increasing for the urban investment to the inner zone of the Tokyo metropolitan area along the Chuo-line region to prepare for the forthcoming revived-urbanization stage which we will face in the near future, by augmenting the positive effects stemming from the urban agglomeration economies and by reducing the negative effects stemming from the urban agglomeration diseconomies. In conclusion, we have learned the following from the above examinations.

(1) The Klaassen's spatial-cycle hypothesis seems to be working reasonably well to describe the phenomena of urban changes along the path of urbanization, suburbanization and possibly future revived-urbanization for the Chuo-line region in the Tokyo metropolitan area.
(2) The ROXY-index method appears to be a useful analytical instrument for obtaining a deeper insight into the fundamental characteristics of the urban dynamism of the intra-metropolitan spatial redistribution process of not only population but also other various socio-economic activities. It should, though, be borne in mind that there is yet room for further improvement in the ROXY-index approach.

Notes

1) As to the work for defining the FURs of Japan, in the first half of the 1970's, Kawashima delineated with N. Glickman and A. Okabe the geographical boundaries of the FURs as Japanese metropolitan areas. They fixed the eighty-five (85) FURs based on the 1970 population census data, which would conceptually correspond to the Standard Metropolitan Statistical Areas (SMSAs) in the U.S.A. See Glickman (1979) for the outcomes of the delineation work of the 1970-version of the FURs in Japan. The set of 1970-version of the FURs comprises 1,021 administratively defined localities, and has a total population of 74,731,359 which shares 71.4% of the national population of Japan in 1970. The average population of the 85 FURs was 889,659 in 1970. Using the 1970-version of the FURs as spatial units in his

investigations, Kawashima conduced a number of studies of both inter-metropolitan and intra-metropolitan analyses of the dynamic spatial redistribution processes of the socio-economic activities. Meanwhile, based on the 1990 population census data, Kawashima *et al.* (1993) delineated the geographical boundaries of the 1990-version of the eighty-eight (88) FURs. This set of the FURs comprises 1,607 administratively defined localities, and has a total population of 103,635,477 which shares 83.8% of the national population of Japan in 1990. The average population of the 88 FURs was 1,177,676 in 1990. Among the 1990-version of the FURs, the Tokyo FUR is the largest in terms of population (30,144,045 in 1995), and consists of 152 administratively defined localities extending over six adjacent prefectures (Kanagawa, Tokyo, Saitama, Tochigi, Ibaraki and Chiba prefectures), while the 1970-version of the Tokyo FUR consists of 121 administratively defined localities.

2) See, for example, Klaassen and Paelinck (1979) and Klaassen *et al.* (1981).

3) See Kawashima (1978; pp. 9, 13 and 14).

4) Kawashima has written more than twenty-five papers on the ROXY index through which he has developed a series of generalized versions of the Klaassen's original spatial-cycle hypothesis in order to facilitate research works for both intra-metropolitan and inter-metropolitan analyses.

5) Since the original basic concept of the ROXY index was initiated and applied in an empirical study by Kawashima (1978), the methodological framework of the ROXY-index analysis has been further developed, and applied in a number of studies to empirically test both original and generalized versions of the Klaassen's spatial-cycle hypothesis. In parallel with this, Kawashima and others have made theoretical investigations into the mathematical characteristics of the ROXY index. See Kawashima (1981, 1982, 1985) as examples of the early works on the ROXY index. See also, as examples of the recent works on the ROXY-index approach, Kawashima and Hiraoka (1998, 1999) and Hirvonen, Hiraoka and Kawashima (1999).

6) Among the conceivable systems of spatial units are: ① a group of localities composing a specific metropolitan area, ② a group of all metropolitan areas in a specific country, ③ a group of larger cities in a specific country or in a specific region of the world, and ④ a group of urbanized areas in a spatially extensive region.

7) In case we use the terms of centralization and decentralization, Table A-5 in the Appendix should be applied as a substitute for Table 4.

8) The *gross growth ratio* means the crude growth ratio for a specific period of time before the

growth ratio is adjusted to the *annual growth ratio.*

9) For the hypothetical five-year period 1947-52, the estimated five-year growth rate of Shinjuku-ku is 119.01%.

10) For the hypothetical five-year period 1947-52, the estimated five-year growth rate of Kunitachi-shi is 75.43%.

11) The marginal value of the ROXY index is calculated as follows when we set the notations $\Phi(T)$ for the ROXY-index value for the period T, and $MRI(T)$ for the marginal value of the ROXY index for the period T:

(i) For the period 1947-50

$$MRI(1947\text{-}50) = \{\Phi(1950\text{-}55) - \Phi(1947\text{-}50)\}/4.0$$

[Cf. $(1950+1955)/2 - (1947+1950)/2 = 8/2 = 4.0$]

(ii) For the period 1950-55

$$MRI(1950\text{-}55) = \{\Phi(1955\text{-}60) - \Phi(1947\text{-}50)\}/9.0$$

[Cf. $(1955+1960)/2 - (1947+1950)/2 = 18/2 = 9.0$]

(iii) For the period 1990-95

$$MRI(1990\text{-}95) = \{\Phi(1990\text{-}95) - \Phi(1985\text{-}90)\}/5.0$$

[Cf. $(1990+1995)/2 - (1985+1990)/2 = 10/2 = 5.0$]

(iv) For other periods

$$MRI(T) = \{\Phi(T+1) - \Phi(T-1)\}/10.0$$

[Cf. The difference between the mid-point time for $\Phi(T+1)$ and the mid-point time for $\Phi(T-1)$, is ten years.]

12) The basic framework of the spatial-cycle paradigm with the four major stages has been arranged under the ideal assumption that the path of the intra-metropolitan urbanization and suburbanization of population would follow the following four stages cyclically: stages of ① accelerating urbanization, ② decelerating urbanization, ③ accelerating suburbanization, and ④ decelerating suburbanization. The actual situation of the spatial-cycle path may be more or less deviated from this basic framework. It is therefore suggested that the above framework should not be rigidly applied, but instead should be flexibly interpreted when employed in the empirical analysis of the spatial-cycle phenomena.

13) It should be noted that in this subsection we discuss, based on the ROXY-index values, the spatial processes of urbanization and suburbanization in terms of the *relative magnitude* of the growth ratio of each locality. That is, as can be seen from Tables 2, 3 and 4, the urbanization and suburbanization of the Chuo-line region is discussed in term of *relative urbanization and suburbanization* in the sense that if the growth ratio of population in each inner locality is in general higher or lower than the growth ratio of population in each outer locali-

ty, then the Chuo-line region is considered to be at the stage of urbanization or stage of sub-urbanization respectively.

14) The second-order spatial-cycle path is referred to as *spatial curlicuette* in Fukatsu (1999) to symbolize its tiny, curly shape. The phenomena of the spatial curlicuette appearing around the 1980's may perhaps require us to conceive a new type of the spatial-cycle path which moves from the stage of decelerating suburbanization directly to the stage of accelerating suburbanization. This new type of the spatial-cycle path can be in some sense justified by, for example, the plausible fact that the increasing number of SOHOs (small offices and home offices) in the modern information-oriented society would result in enriching the locational attraction of the suburbs, of which in the 1970's Klaassen was hardly aware.

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Appendix

The following are brief explanations for each of the tables in the Appendix.

Table A-1 lists the member localities and their local codes for the Chuo-line region. This table shows that the Chuo-line region comprises sixteen (16) localities in total.

Table A-2 shows the airline distance from the central business district (CBD) of the Tokyo FUR to the center of each locality in the Chuo-line region. More precisely speaking, the CBD is the location point of the former Tokyo Metropolitan Government Office, while the center of each locality is the location point of the central public office of that locality (*i.e.*, city hall, ward office, or town hall). We will call this airline distance the CBD distance for each locality. Table A-2 also shows, for the year 1947 and for every five years from 1950 through 1995, the population of each locality in the Chuo-line region having the population of 2,939,175 in 1995. From this table it can be seen that the CBD distance for the farthest constituent locality in the Chuo-line region is 55.5km for Fujino-machi.

Table A-3 shows the gross growth ratio of population for each locality in the Chuo-line region. For the period 1947-50, this table shows the three-year growth ratio for each locality in the Chuo-line region. For other periods including the hypothetical five-year period 1947-52, it shows the five-year growth ratio for each locality.

Table A-4 shows the annual growth ratio of population for each locality in the Chuo-line region.

Table A-5 shows, for the terms of centralization and decentralization, the relationships among ① the sign of the ROXY-index value, ② the direction of the changes in the ROXY-index

value, ③ the pattern of the spatial redistribution process of population, and ④ the speed of the spatial redistribution process of population

Appendix

Table A-1 Member Localities Composing the Chuo-line Region

Code	Locality
13102	Chuo-ku
13101	Chiyoda-ku
13104	Shinjuku-ku
13113	Shibuya-ku
13114	Nakano-ku
13115	Suginami-ku
13203	Musashino-shi
13204	Mitaka-shi
13210	Koganei-shi
13206	Fuchuh-shi
13214	Kokubunji-shi
13215	Kunitachi-shi
13202	Tachikawa-shi
13212	Hino-shi
13201	Hachiouji-shi
14424	Fujino-machi

Appendix

Table A–2 CBD Distance and Population for Localities of the Chuo-line Region

Code	Locality	Distance	1947	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995
13102	Chuo-ku	1.1	139,179	161,925	171,316	161,299	128,017	103,850	90,097	82,700	79,973	68,041	72,445
13101	Chiyoda-ku	2.1	89,681	110,348	122,745	116,944	93,047	74,185	61,656	54,801	50,493	39,472	40,726
13104	Shinjuku-ku	5.7	153,924	246,373	348,675	413,690	413,910	390,657	367,218	343,928	332,722	296,790	264,503
13113	Shibuya-ku	6.1	131,682	181,244	243,410	282,687	283,730	274,491	263,815	247,035	242,442	205,625	183,235
13114	Nakano-ku	9.6	168,010	213,198	288,808	351,360	376,697	378,723	373,075	345,733	335,936	319,687	294,261
13115	Suginami-ku	11.7	284,698	326,873	406,022	487,210	536,792	553,016	560,716	542,449	539,842	529,485	500,874
13203	Musashino-shi	18.5	63,479	73,149	94,948	120,337	133,516	136,959	139,493	136,895	138,783	139,077	130,289
13204	Mitaka-shi	18.5	50,699	54,820	69,466	98,038	135,873	155,693	164,852	164,449	166,252	165,564	159,315
13210	Koganei-shi	23.7	19,583	22,624	30,349	45,734	76,350	94,448	102,703	102,412	104,642	105,899	104,311
13206	Fuchuh-shi	25.8	40,828	45,240	58,804	82,098	126,235	163,173	182,379	191,980	201,972	209,396	209,964
13214	Kokubunji-shi	27.5	16,389	19,135	25,763	39,098	64,911	81,259	88,155	91,014	95,467	100,982	102,282
13215	Kunitachi-shi	29.2	10,539	14,766	23,242	32,609	43,477	59,709	64,404	64,154	64,881	65,833	65,294
13202	Tachikawa-shi	31.0	60,028	63,214	76,309	81,951	100,699	117,057	138,097	142,600	146,523	152,824	155,892
13212	Hino-shi	33.2	22,944	24,444	27,305	43,394	67,979	98,557	126,754	145,417	156,031	165,928	161,241
13201	Hachiouji-shi	40.3	120,463	131,408	148,061	164,622	207,753	253,527	322,558	387,162	426,654	466,347	483,070
14424	Fujino-machi	55.5	9,697	9,605	9,365	8,659	8,473	8,295	8,571	9,470	10,186	10,729	11,473
Total			1,381,823	1,698,366	2,144,588	2,529,730	2,797,459	2,943,599	3,054,543	3,052,199	3,092,799	3,041,679	2,939,175

Appendix

Table A–3 Gross Growth Ratio of Population for Localities of the Chuo-line Region

Code	Locality	Distance	1947-1950	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1947-1952 (estimated)
13102	Chuo-ku	1.1	1.1634	1.0580	0.9415	0.7937	0.8112	0.8676	0.9179	0.9670	0.8508	1.0647	1.2869
13101	Chiyoda-ku	2.1	1.2305	1.1123	0.9527	0.7957	0.7973	0.8311	0.8888	0.9214	0.7817	1.0318	1.4129
13104	Shinjuku-ku	5.7	1.6006	1.4152	1.1865	1.0005	0.9438	0.9400	0.9366	0.9674	0.8920	0.8912	2.1901
13113	Shibuya-ku	6.1	1.3764	1.3430	1.1614	1.0037	0.9674	0.9611	0.9364	0.9814	0.8481	0.8911	1.7031
13114	Nakano-ku	9.6	1.2690	1.3546	1.2166	1.0721	1.0054	0.9851	0.9267	0.9717	0.9516	0.9205	1.4874
13115	Suginami-ku	11.7	1.1481	1.2421	1.2000	1.1018	1.0302	1.0139	0.9674	0.9952	0.9808	0.9460	1.2588
13203	Musashino-shi	18.5	1.1523	1.2980	1.2674	1.1095	1.0258	1.0185	0.9814	1.0318	1.0021	0.9368	1.2665
13204	Mitaka-shi	18.5	1.0813	1.2672	1.4113	1.3859	1.1459	1.0588	0.9976	1.0110	0.9959	0.9623	1.1391
13210	Koganei-shi	23.7	1.1553	1.3415	1.5069	1.6694	1.2370	1.0874	0.9972	1.0218	1.0120	0.9850	1.2720
13206	Fuchuh-shi	25.8	1.1081	1.2998	1.3961	1.5376	1.2926	1.1177	1.0526	1.0520	1.0368	1.0027	1.1865
13214	Kokubunji-shi	27.5	1.1676	1.3464	1.5176	1.6602	1.2519	1.0849	1.0324	1.0489	1.0578	1.0129	1.2946
13215	Kunitachi-shi	29.2	1.4011	1.5740	1.4030	1.3333	1.3733	1.0786	0.9961	1.0113	1.0147	0.9918	1.7543
13202	Tachikawa-shi	31.0	1.0531	1.2072	1.0739	1.2288	1.1624	1.1797	1.0326	1.0275	1.0430	1.0201	1.0900
13212	Hino-shi	33.2	1.0654	1.1170	1.5892	1.5666	1.4498	1.2861	1.1472	1.0730	1.0634	0.9718	1.1113
13201	Hachiouji-shi	40.3	1.0909	1.1267	1.1119	1.2620	1.2203	1.2723	1.2003	1.1020	1.0930	1.0359	1.1560
14424	Fujino-machi	55.5	0.9905	0.9750	0.9246	0.9785	0.9790	1.0333	1.1049	1.0756	1.0533	1.0693	0.9842
Simple Average			1.1908	1.2549	1.2413	1.2187	1.1058	1.0510	1.0073	1.0151	0.9798	0.9834	1.3496

Appendix

Table A–4 Annual Growth Ratio of Population for Localities of the Chuo-line Region

Code	Locality	Distance	1947-1950	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995
13102	Chuo-ku	1.1	1.0517	1.0113	0.9880	0.9548	0.9590	0.9720	0.9830	0.9933	0.9682	1.0126
13101	Chiyoda-ku	2.1	1.0716	1.0215	0.9904	0.9553	0.9557	0.9637	0.9767	0.9838	0.9519	1.0063
13104	Shinjuku-ku	5.7	1.1698	1.0719	1.0348	1.0001	0.9885	0.9877	0.9870	0.9934	0.9774	0.9772
13113	Shibuya-ku	6.1	1.1124	1.0608	1.0304	1.0007	0.9934	0.9921	0.9869	0.9963	0.9676	0.9772
13114	Nakano-ku	9.6	1.0826	1.0626	1.0400	1.0140	1.0011	0.9970	0.9849	0.9943	0.9901	0.9836
13115	Suginami-ku	11.7	1.0471	1.0443	1.0371	1.0196	1.0060	1.0028	0.9934	0.9990	0.9961	0.9890
13203	Musashino-shi	18.5	1.0484	1.0536	1.0485	1.0210	1.0051	1.0037	0.9962	1.0027	1.0004	0.9870
13204	Mitaka-shi	18.5	1.0264	1.0485	1.0713	1.0675	1.0276	1.0115	0.9995	1.0022	0.9992	0.9923
13210	Koganei-shi	23.7	1.0493	1.0605	1.0855	1.1079	1.0435	1.0169	0.9994	1.0043	1.0024	0.9970
13206	Fuchuh-shi	25.8	1.0348	1.0538	1.0690	1.0899	1.0527	1.0225	1.0103	1.0102	1.0072	1.0005
13214	Kokubunji-shi	27.5	1.0530	1.0613	1.0870	1.1067	1.0459	1.0164	1.0064	1.0096	1.0113	1.0026
13215	Kunitachi-shi	29.2	1.1190	1.0950	1.0701	1.0592	1.0655	1.0153	0.9992	1.0023	1.0029	0.9984
13202	Tachikawa-shi	31.0	1.0174	1.0384	1.0144	1.0421	1.0306	1.0336	1.0064	1.0054	1.0085	1.0040
13212	Hino-shi	33.2	1.0213	1.0224	1.0971	1.0939	1.0771	1.0516	1.0279	1.0142	1.0124	0.9943
13201	Hachiouji-shi	40.3	1.0294	1.0242	1.0214	1.0476	1.0406	1.0493	1.0372	1.0196	1.0180	1.0071
14424	Fujino-machi	55.5	0.9968	0.9950	0.9844	0.9957	0.9958	1.0066	1.0201	1.0147	1.0104	1.0135
Simple Average			1.0582	1.0453	1.0418	1.0360	1.0180	1.0089	1.0009	1.0028	0.9953	0.9964

Appendix

Table A-5 Implications of ROXY-index Values for Intra-metropolitan Analysis of Spatial Redistribution Process of Population: For Terms of Centralization and Decentralization

A	B	C	D
Sign of ROXY-index value	Pattern of spatial redistribution process of population within a metropolitan area	Direction of changes in ROXY-index values	Speed of spatial redistribution process of population within a metropolitan area
Positive	centralization (or Revived-centralization)	Increasing	Accelerating
		Levelling-off	Stationary
		Decreasing	Decelerating
Zero	Neutrality from both centralization and decentralization (*viz.* Symmetric growth or symmetric decline[1])	Levelling-off	Continuation of neutrality
Negative	Decentralization	Decreasing	Accelerating
		Levelling-off	Stationary
		Increasing	Decelerating

[Source] Reconstructed from Kawashima and Hiraoka (1998)

[Note]

The spatial redistribution pattern of the "symmetric growth or symmetric decline" comprises the following three sub-patterns of BLGD, BSGD and CSGD.

(i) Balanced growth or decline (BLGD): The fitted growth-rate curve which is a function of "the distance from the center of the metropolitan area under our investigation to each of its subareas" (*i.e.*, the subarea's CBD distance), is nearly flat regardless of their CBD distance to reflect the constant sharing of population by subareas over time.

(ii) Bell-shaped growth or decline (BSGD): The fitted growth-rate curve is bell-shaped, reflecting the "medianization" of population over subareas in the metropolitan area.
The phenomena of "medianization" means: ① the increase (as compared with other subareas) in population shared by subareas with the medium CBD distance, or ② the decrease in population shared by subareas with either relatively longer or relatively shorter CBD distance (but not by subareas with the medium CBD distance).

(iii) Cup-shaped growth or decline (CSGD): The fitted growth-rate curve is cup-shaped, reflecting the "bipolarization" of population over subareas in the metropolitan area.
The phenomena of "bipolarization" means: ① the increase in population shared by subareas with either relatively shorter or relatively longer CBD distance, or ② the decrease in population shared by subareas with the medium CBD distance.