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ROXY INDEX ANALYSIS OF POPULATION CHANGES IN JAPAN FOR 1960–85: SPATIAL (DE)CENTRALIZATION AND (DE)CONCENTRATION

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ABSTRACT

The spatial cycles hypothesis is investigated through the analytical method of ROXY index. Consideration is given to both "spatial centralization and decentralization phenomena" and "spatial concentration and deconcentration phenomena" of population in Japan; the former phenomena correspond to the intra-metropolitan redistribution processes of population, while the latter correspond to the inter-metropolitan redistribution processes of population. It may be laid down as a general rule that the empirical results of the study would reasonably support the basic conceptual framework of the spatial cycles hypothesis.

KEY WORDS

Urban Systems, Centralization, Concentration, Metropolitan Analysis, ROXY Index, and Spatial Cycles.

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1. INTRODUCTION

The characteristic of a nation's specific urban change has, in general, twin facets: (1) spatial centralization of population; and (2) spatial concentration of population. The former phenomena correspond to the agglomeration of population into centers, rather than into suburbs, of each metropolitan areas. The latter phenomena correspond to the agglomeration of population toward larger metropolitan areas from both smaller- and non-metropolitan areas. The spatial cycles hypothesis[1], however, implies that the characteristic of urban change in a nation also possesses another pair of facets: (1) decentralization of population within each metropolitan areas; and (2) deconcentration of population in a system of metropolitan areas. In the above context, the phenomena of the spatial centralization and decentralization of population should be recognized as the intra-metropolitan redistribution processes of population, while the phenomena of the spatial concentration and deconcentration of population should be recognized as the inter-metropolitan redistribution processes of population.

The primary objective of this paper is to investigate, based on the spatial cycles hypothesis and the ROXY index method[2], the staging of intra- and inter-metropolitan redistribution processes of population in Japan during the period of 1960 through 1985. For this purpose, we start with a discussion of the basic concepts of ROXY index in the next Section. In Section 3, the values of ROXY index for five consecutive five-year periods between 1960 and 1985, are calculated for four urbanized units. These four spatial units are Tokyo metropolitan area and its three major railway-line regions. Tokyo metropolitan area is the largest among the eighty-six metropolitan areas (FUCs)[3] in Japan, and has its 143 component localities (*i.e.*, subareas). The first of the three major railway-line regions, on the other hand, is the Chuo Line region stretching westwards from the central business district (CBD) of Tokyo city. It consists of fifteen localities situated along the Chuo Line which is the busiest commuting railway line in Tokyo metropolitan area. The second one is the Takasaki Line region. It consists of eighteen localities situated along the Takasaki Line which is among the extremely busy major commuting railway lines in Tokyo metropolitan area. This region extends northwestwards from the CBD of Tokyo city. The third one is the Joban Line region stretching northeastwards from the CBD of Tokyo city along the Joban Line which is also quite a busy major commuting railway line in Tokyo metropolitan area. This region has fourteen component localities. In the same Section, we examine, based on the calculated values of ROXY index, the staging of intra-metropolitan urban changes for the four urbanized spatial units. We also try to compare the stage of spatial cycles among the three railway-line regions. In Section 4, we calculate the values of ROXY index for the Japanese urban system, and carry out an inter-metropolitan analysis on urban changes. Brief concluding remarks are pro-

vided in Section 5.

In our study we employ two sets of data. The first set is the population data for Tokyo metropolitan area (*i.e.*, Tokyo FUC) consisting of 143 component localities. The second set is the population data for the Japanese urban system composed of eighty-six metropolitan areas. Both data sets carry the information on the level of population in every five years from 1960 to 1985.

2. ROXY INDEX: DEFINITIONS AND IMPLICATIONS

The ROXY index for the period between year t and year $t+1$ is generally defined as;

$$\left(\frac{\text{weighted average annual growth ratio}}{\text{simple average annual growth ratio}} - 1.0\right) \times 10^4$$

Since we are interested in the spatial changes of population, the annual growth ratio appearing in this definitional formulation should be the population level in year $t+1$ divided by the population level in year t.

Table 1 ROXY Index for the Period between Year t and Year $t+1$ (Weighting Factor: Reversed Distance from Subarea to CBD, *i.e.*, $d_{max}+d_{min}-d_i$)

$$\text{ROXY Index} = \left(\frac{\text{weighted average growth ratio}}{\text{simple average growth ratio}} - 1.0\right) \times 10^4$$

$$= \left[\frac{\sum_{i=1}^{n} RD_i r_i^{t,t+1}}{\sum_{i=1}^{n} RD_i} \times \frac{n}{\sum_{i=1}^{n} r_i^{t,t+1}} - 1.0\right] \times 10^4$$

$$= \frac{n\sum_{i=1}^{n} RD_i r_i^{t,t+1} - \sum_{i=1}^{n} RD_i \times \sum_{i=1}^{n} r_i^{t,t+1}}{\sum_{i=1}^{n} RD_i \times \sum_{i=1}^{n} r_i^{t,t+1}} \times 10^4$$

where

RD_i : Reversed distance from subarea i in a metropolitan area to its CBD which is defined as "$d_{max}+d_{min}-d_i$"

d_i : Distance from subarea i in a metropolitan area to the CBD of the central city of the metropolitan area to which that subarea belongs

d_{max} : Maximum value of d_i $(i=1, 2, 3, \ldots, n)$

d_{min} : Minimum value of d_i $(i=1, 2, 3, \ldots, n)$

$r_i^{t,t+1}$: Population growth ratio of subarea i for the period between year t and year $t+1$, growth ratio being defined as the population level in year $t+1$ divided by the population level in year t

n : Number of subareas

The weighting factor which we use to calculate the value of ROXY index for our intra-metropolitan analysis is the "reversed distance." For subarea i in the metropolitan area under investigation, the reversed distance is defined as;

> the sum of "distance to the center of the metropolitan area from the subarea which is nearest to the center" and "distance to the metropolitan center from the subarea which is farthest from the center" subtracted by "distance to the metropolitan center from subarea i."[4]

The ROXY index with the reversed distance as weighting factor, is mathematically presented in Table 1. Implications of the value of this kind of ROXY index are summarized in Table 2. As shown by this table, positive value of ROXY index for a specific period of time would imply that the centralization (or intra-metropolitan urbanization) of population is taking place during that period in the metropolitan area under investigation. If the positive value of ROXY index is increasing, unchanged, or decreasing over two adjacent periods, then the speed of population centralization is accelerating, stabilizing or decelerating respectively during those two periods. In case the value of ROXY index remains around zero during a specific period of time, the symmetric growth or decline of population[5] is taking place in the metropolitan area during that period. In case the value of ROXY index for a specific period of time is negative, it would be implied that the decentralization (or suburbanization) of population is going on in the metropolitan area during that period. If the negative value of ROXY index is increasing, unchanged or decreasing over two adjacent periods, then the speed of suburbanization is decelerating, stabilizing or accelerating respectively.

For our inter-metropolitan analysis, meanwhile, we use the ROXY index for which the weighting factor is the population of each metropolitan area. Table 3 shows the mathematical formulation of this ROXY index, while Table 4 summarizes the implications of the value of this kind of ROXY index. As indicated by Table 4, positive value of ROXY index for a specific period of time would imply the concentration (or inter-metropolitan urbanization) of population during that period from smaller- and non-metropolitan areas to larger metropolitan areas. If the positive value of ROXY index is increasing, unchanged or decreasing over two adjacent periods, then the speed of population concentration in the system of metropolitan areas under investigation is accelerating, stabilizing or decelerating respectively. In case the value of ROXY index remains around zero during a specific period of time, the symmetric growth or decline of population[6] in the system of metropolitan areas is taking place during that period. In case the value of ROXY index for a specific period of time is negative, then this would tell us that the deconcentration of population is taking place in the system of metropolitan

Table 2 Implications of ROXY Index for Intra-metropolitan Spatial Redistribution Processes of Population (Weighting Factor: Reversed Distance from Subarea to CBD, *i.e.*, $d_{max}+d_{min}-d_i$)

(i)	(ii)	(iii)	(iv)
Value of ROXY Index	Intra-metropolitan Spatial Redistribution Pattern of Population Shares	Direction of Changes in Value of ROXY Index	Speed of Spatial Redistribution of Population
ROXY > 0	Centralization of Population (Agglomeration of Population)	→ (1) → (2) → (3)	(1) Accelerating (2) Stabilizing (3) Decelerating
ROXY = 0	Symmetric Growth or Decline of Population (viz. BGD, BSGD or CSGD of Population)	0.0 ⟶ 0.0	Can not be specified
ROXY < 0	Decentralization of Population (Dispersion or Suburbanization of Population)	→ (1) → (2) → (3)	(1) Decelerating (2) Stabilizing (3) Accelerating

(Note)

1. d_i : Distance from subarea i in a metropolitan area to the CBD of its central city to which that subarea belongs
2. d_{max} : Maximum value of d_i for the metropolitan area
3. d_{min} : Minimum value of d_i for the metropolitan area
4. BGD : Balanced Growth or Decline (Namely, the growth rate curve is nearly flat, reflecting the constant share of population over different distance-zone groups of subareas in a metropolitan area.)
5. BSGD : Bell-Shaped Growth or Decline (Namely, the growth rate curve is bell-shaped, reflecting the "medianization" of population over distance-zone groups of subareas. This "medianization" means increase in population share by middle distance-zone group of subareas and, at the same time, decrease in population share by near and far distance-zone groups of subareas.)
6. CSGD : Cup-Shaped Growth or Decline (Namely, the growth rate curve is cup-shaped, reflecting the "bipolarization" of population over distance-zone groups of subareas. This "bipolarization" means increase in population share by near and far distance-zone groups of subareas and, at the same time, decrease in population share by middle distance-zone group of subareas.)
7. In this table, special attention should be paid to that, if we use d_i (the distance from subarea i in a metropolitan area to the CBD of its central city to which that subarea belongs) as weighting factor, then positive value of ROXY index would imply the intra-metropolitan decentralization phenomena (suburbanization phenomena) of population while negative value of ROXY index would imply the intra-metropolitan centralization phenomena (*i.e.*, intra-metropolitan urbanization phenomena) of population.

Table 3 ROXY Index for the Period between Year t and Year $t+1$ (Weighting Factor: Population of Metropolitan Area)

$$\text{ROXY Index} = \left(\frac{\text{weighted average growth ratio}}{\text{simple average growth ratio}} - 1.0\right) \times 10^4$$

where

Weighted average growth ratio:

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

Simple average growth ratio:

$$\sum_{i=1}^{n} (X_{i,\,t+1}/X_{i,\,t}) \times \frac{1}{n}$$

$X_{i,\,t}$: Population level of metropolitan area i in year t

n : Number of metropolitan areas

Table 4 Implications of ROXY Index for Inter-metropolitan Spatial Redistribution Processes of Population (Weighting Factor: Population of Metropolitan Area)

(i)	(ii)	(iii)	(iv)
Value of ROXY Index	Inter-metropolitan Spatial Redistribution Pattern of Population Shares	Direction of Changes in Value of ROXY Index	Speed of Spatial Redistribution of Population
ROXY > 0	Concentration of Population (Agglomeration of Population)	→ (1) → (2) → (3)	(1) Accelerating (2) Stabilizing (3) Decelerating
ROXY = 0	Symmetric Growth or Decline of Population (viz. BGD, BSGD or CSGD of Population)	0.0 → 0.0	Can not be specified
ROXY < 0	Deconcentration of Population (Dispersion of Population)	→ (1) → (2) → (3)	(1) Decelererating (2) Stabilizing (3) Accelerating

(Note)

1. BGD : Balanced Growth or Decline (Namely, the growth rate curve is nearly flat, reflecting the constant share of population over different population-size groups of metropolitan areas.)
2. BSGD : Bell-Shaped Growth or Decline (Namely, the growth rate curve is bell-shaped, reflecting the "medianization" of population over population-size groups. This "medianization" means increase in population share by medium population-size group of metropolitan areas and, at the same time, decrease in population share by small and large popuation-size groups of metropolitan areas.)
3. CSGD : Cup-Shaped Growth or Decline (Namely, the growth rate curve is cup-shaped, reflecting the "bipolarization" of population over population-size groups. This "bipolarization" means increase in population share by small and large population-size groups of metropolitan areas and, at the same time, decrease in population share by medium population-size group of metropolitan areas.)

areas during that period. If the negative value of ROXY index is increasing, unchanged or decreasing over two adjacent periods, then the speed of inter-metropolitan deconcentration of population is decelerating, stabilizing or accelerating respectively.

3. CHANGE IN VALUES OF ROXY INDEX: INTRA-METROPOLITAN ANALYSIS

Table 5 furnishes the value of ROXY index for Tokyo FUC and its three major railway-line regions[7]. From this table, we can draw Figure 1 diagrammatically showing the change in the value of ROXY index. Table 5 shows that the ROXY index for Tokyo FUC decreased continuously from 44.00 for the 1960–65 period to −35.80 for 1975–80, with the positive sign turning negative towards the end of the 1960s. It then began to increase to −24.61 for the 1980–85 period. This would imply, according to Table 2, that the phenomena of the centralization of population were observed in Tokyo FUC until the end of the 1960s, with the speed of centralization decelerating. After that Tokyo FUC entered the suburbanization stage, with the speed of suburbanization accelerating until the end of the 1970s. In the early 1980s, however, the speed of suburbanization began to decelerate.

For the Chuo Line region, the ROXY index remained negative throughout the whole twenty-five year period of 1960 through 1985, but it increased continuously from −193.09 for the 1960–65 period to −43.59 for 1980–85. This would imply that the Chuo Line region was being deceleratingly suburbanized in the past quarter century.

For the Takasaki Line region, the ROXY index decreased from −46.98 for the 1960–65 period to −101.98 for 1965–70. It then began to increase to have the value of −44.38 for 1980–85. This would imply that the Takasaki Line region was being acceleratingly suburbanized until the late 1960s. After that, the speed of suburbanization was being decelerated continuously in this region.

For the Joban Line region, the ROXY index decreased from −51.12 for the 1960–65 period to −143.50 for 1970–75. It then began to increase to −124.60 for 1975–80 and to −77.24 for 1980–85. It would imply that the accelerating suburbanization was taking place until the middle of the 1970s. After that, the speed of suburbanization process started decelerating in this region.

From Table 5, we now construct Table 6 which shows the marginal values of ROXY index for each five-year period. Based on Table 6, we can produce Figure 2. This figure transforms the aforementioned "spatial cycles implications" into a scheme of "visual paradigm of spatial cycles" which is conceived in terms of the two-dimensional plane with the value of ROXY index along the horizontal axis and marginal value of ROXY index along the vertical axis[8]. The essence of what this

Table 5 ROXY Index for Tokyo FUC and Its Three Railway-line Regions
(Weighting Factor: Reversed Distance to CBD, *i.e.*, $d_{max}+d_{min}-d$)

Spatial Unit	Number of Localities	Period				
		1960-65	1965-70	1970-75	1975-80	1980-85
Tokyo FUC	143	44.00	−4.66	−33.25	−35.80	−24.61
Chuo Line Region	15	−193.09	−163.64	−120.79	−77.51	−43.59
Takasaki Line Region	18	−46.98	−101.98	−86.44	−65.67	−44.38
Joban Line Region	14	−51.12	−121.21	−143.50	−124.60	−77.24

Table 6 Value of ROXY Index and Its Marginal Change for Tokyo FUC and Three Railway-line Regions
(Weighting Factor: Reversed Distance to CBD, *i.e.*, $d_{max}+d_{min}-d$)

Spatial Unit	1960-65		1965-70		1970-75		1975-80		1980-85	
	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$
Tokyo FUC	44.00	−48.66	−4.66	−38.63	−33.52	−15.57	−35.80	4.32	−24.61	11.19
Chuo Line Region	−193.09	29.45	−163.64	36.15	−120.79	43.07	−77.51	38.60	−43.59	33.92
Takasaki Line Region	−46.98	−55.00	−101.98	−19.73	−86.44	18.16	−65.67	21.03	−44.38	21.29
Joban Line Region	−51.12	−70.00	−121.21	−46.19	−143.50	−1.74	−124.60	33.13	−77.24	47.36

(Note) 1. ΔT: Five Years
2. $\Delta ROXY/\Delta T$: Marginal Change in the Value of ROXY Index
3. Calculation of the Marginal Change in the Value of ROXY Index:
For the period 1960-65;
ROXY(1965-70) − ROXY(1960-65)
For the periods 1965-70, 1970-75, and 1975-80 respectively;
{ROXY(1970-75) − ROXY(1960-65)}/2
{ROXY(1975-80) − ROXY(1965-70)}/2
{ROXY(1980-85) − ROXY(1970-75)}/2
For the period 1980-85;
ROXY(1980-85) − ROXY(1975-80)

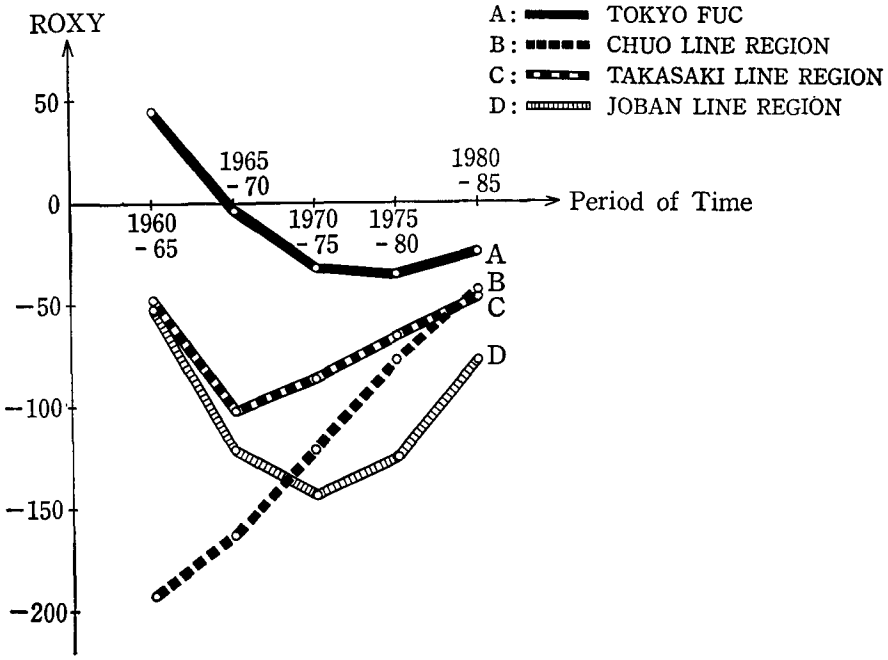


Figure 1 ROXY Index (Weighting Factor: Reversed Distance to CBD)

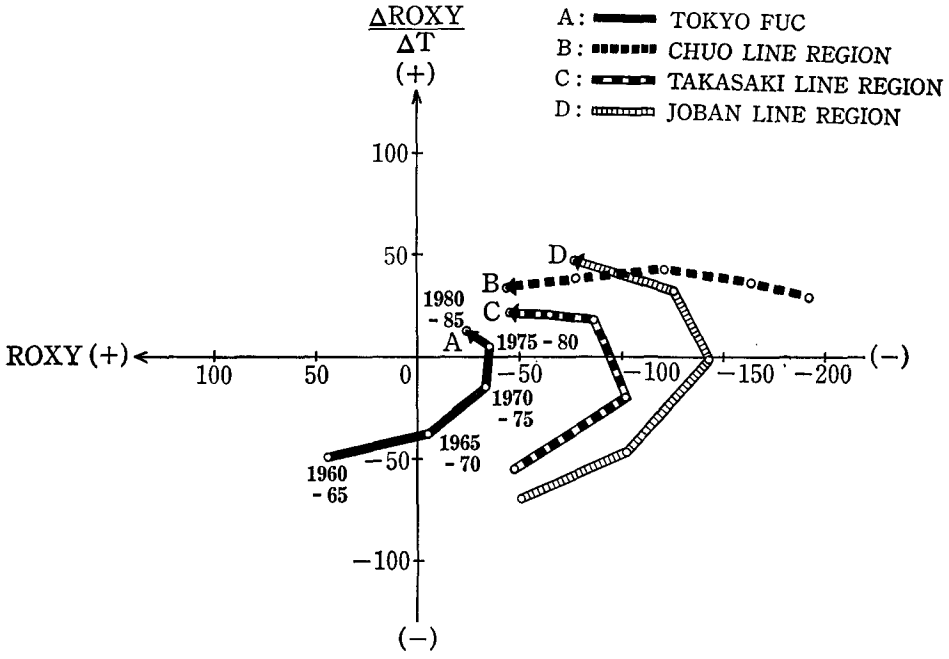
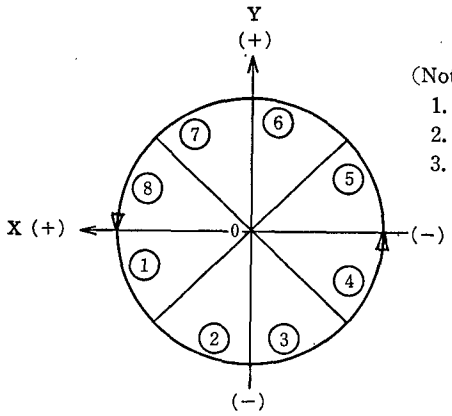


Figure 2 ROXY Index and Its Marginal Change
(Weighting Factor: Reversed Distance to CBD)



(Note)
1. X : Value of ROXY Index
2. Y : Marginal Change in Value of ROXY Index
3. Number Enclosed with a Circle: Substage Number
   Decelerating Centralization Stage;
   Substages ① and ②
   Accelerating Suburbanization Stage;
   Substages ③ and ④
   Decelerating Suburbanization Stage;
   Substages ⑤ and ⑥
   Accelerating Centralization Stage;
   Substages ⑦ and ⑧

Figure 3 Implications of Circular Diagram for Spatial Cycles

visual paradigm of spatial cycles would tell us, can be presented through the circular diagram shown in Figure 3[9]. Referring to Figure 3, Figure 2 enables us to perceive visually that among the three major railway-line regions in Tokyo FUC the Chuo Line region had been always at the most advanced stage along the circular path in the spatial cycles scheme since 1960, followed by the Takasaki Line region, and then by the Joban Line region. Figure 2 would also draw us to perceive casually that the Chuo Line region will perhaps be the first one among the three major railway-line regions to enter the accelerating centralization stage (*i.e.*, recentralization stage) in the foreseeable future, from the present decelerating suburbanization stage.

4. CHANGE IN VALUES OF ROXY INDEX: INTER-METROPOLITAN ANALYSIS

Table 7 furnishes the value of ROXY index for the Japanese metropolitan system of eighty-six FUCs. From this table, we can draw Figure 4 which diagrammatically shows the change in the value of ROXY index. Table 7 indicates that the ROXY index for the Japanese metropolitan system remained positive throughout the twenty five years since 1960, but that it decreased continuously from 118.05 for the 1960–65 period to 0.74 for 1975–80. It then increased to 17.57 for the 1980–85. This would imply, according to Table 4, that before 1980 the population had been always agglomerating to larger metropolitan areas, with the speed of concentration decelerating. However, during the 1980–85 period, the population concentration became somewhat reaccelerated.

In the same way as we have done for four urbanized spatial units, from Table 7 we can construct Table 8 showing the marginal values of ROXY index. Based on

Table 7 ROXY Index for Japanese Metropolitan System of 86 FUCs
(Weighting Factor: Population of Metropolitan Area)

Number of FUCs	Poriod				
	1960-65	1965-70	1970-75	1975-80	1980-85
86	118.05	85.71	40.06	0.74	17.57

Table 8 Value of ROXY Index and Its Marginal Change for Japanese Metropolitan System of 86 FUCs
(Weighting Factor: Population of Metropolitan Area)

Urban System	1960-65		1965-70		1970-75		1975-80		1980-85	
	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$
Japanese Metropolitan System	118.05	−32.34	85.71	−39.00	40.06	−42.49	0.74	−11.25	17.57	16.83

(Note) 1. ΔT: Five Years
2. $\Delta ROXY/\Delta T$: Marginal Change in the Value of ROXY Index
3. Calculation of the Marginal Change in the Value of ROXY Index:
For the period 1960-65;
ROXY(1965-70) − ROXY(1960-65)
For the periods 1965-70, 1970-75, and 1975-80 respectively;
{ROXY(1970-75) − ROXY(1960-65)}/2
{ROXY(1975-80) − ROXY(1965-70)}/2
{ROXY(1980-85) − ROXY(1970-75)}/2
For the period 1980-85;
ROXY(1980-85) − ROXY(1975-80)

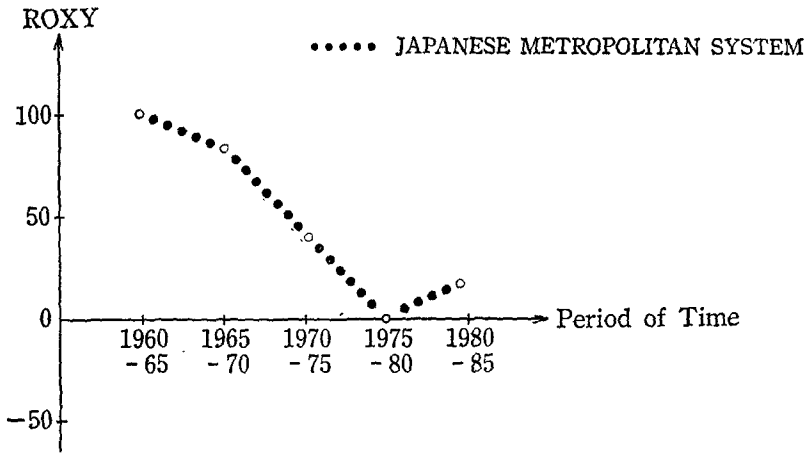


Figure 4 ROXY Index (Weighting Factor: Population of Metropolitan Area)

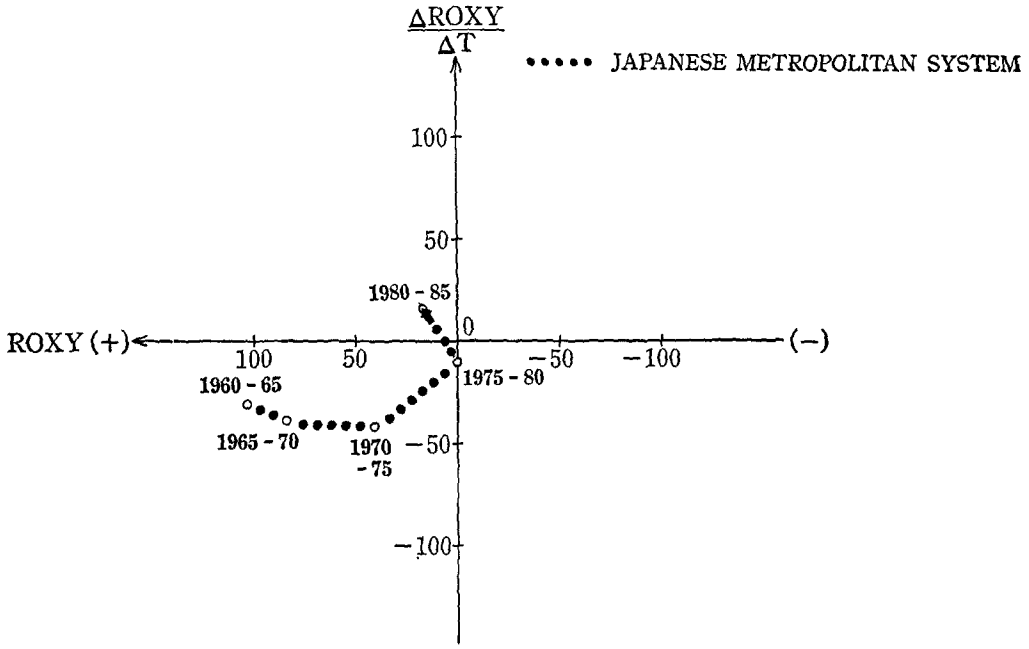


Figure 5 ROXY Index and Its Marginal Change
(Weighting Factor: Population of Metropolitan Area)

this table, we can produce Figure 5 which transforms the spatial cycles implications discussed above for the Japanese metropolitan system, into a visual paradigm of spatial cycles. Referring to interpretations analogous to those provided by Figure 3 for the visual paradigm of spatial cycles, Figure 5 addresses us at least three possibilities. One is that the Japanese metropolitan system already got into the reconcentration stage for the 1980–85 period and would remain in that stage for a while, skipping both accelerating and decelerating deconcentration stages. The second possibility is that the abrupt sharp reverse turn of the curve for the 1980–85 period would not necessarily indicate the actual basic trend of spatial cycle movement of the Japanese metropolitan system but that the abrupt turn had better be considered as showing merely a short-term tendency. The third possibility is that the application of spatial cycles hypothesis to the analysis of population changes in the Japanese system of metropolitan areas would not be appropriate. The results of the next population census of Japan which will take place in 1990 will possibly provide us with some answers to this argument.

5. CONCLUSION

This paper has tried to investigate how the spatial cycles hypothesis and the method of ROXY index can work together for getting a better insight into the dynamic characteristics of urban changes: urban changes in terms of both intra- and inter-metropolitan redistribution processes of population. It seems to have been demonstrated that the analytical approach employed in this paper would be useful to a reasonable extent for the study of spatial redistribution processes though it should be clearly kept in mind that our approach still has to be further improved in many aspects.

NOTES

1) The spatial cycles hypothesis argues that the life-cycle of metropolitan areas recurrently follows four successive metamorphous stages; (1) urbanization stage, (2) suburbanization stage, (3) disurbanization stage, and (4) reurbanization stage. The basic framework of the spatial cycles hypothesis was originally conceived by Klaassen and Paelinck (1979), and was well discussed, for example, by Klaassen et al. (1981).

2) See Kawashima (1982) for the initial application of ROXY index, and Kawashima (1985) for a detailed discussion on the definitional aspects of ROXY index. See also Kawashima (1986a, b and c) for the application of ROXY index method to the analyses of intra-metropolitan redistribution processes of population in Japan, and Kawashima (1987) for the application of ROXY index method to the analysis of inter-metropolitan redistribution processes of population in Japan as compared with those in the U.S.

3) These eighty-six metropolitan areas are called Functional Urban Cores (FUCs), and are the Japanese version of Standard Metropolitan Statistical Areas (SMSAs) in the

Table N-1 ROXY Index for Tokyo FUC and Its Three Railway-line Regions
(Weighting Factor: Distance to CBD)

Spatial Unit	Number of Localities	Period				
		1960-65	1965-70	1970-75	1975-80	1980-85
Tokyo FUC	143	−58.03	6.15	43.85	47.21	32.46
Chuo Line Region	15	229.12	194.18	143.33	91.98	51.72
Takasaki Line Region	18	75.66	164.24	139.21	105.76	71.48
Joban Line Region	14	74.11	175.73	208.04	180.64	111.98

Table N-2 Value of ROXY Index and Its Marginal Change for Tokyo FUC and Three Railway-line Regions
(Weighting Factor: Distance to CBD)

Spatial Unit	1960-65		1965-70		1970-75		1975-80		1980-85	
	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$
Tokyo FUC	−58.03	64.18	6.15	50.95	43.85	20.53	47.21	−5.70	32.46	−14.75
Chuo Line Region	229.12	−34.94	194.18	−42.90	143.33	−51.10	91.98	−45.81	51.72	−40.26
Takasaki Line Region	75.66	88.58	164.24	31.78	139.21	−29.24	105.76	−33.87	71.48	−34.28
Joban Line Region	74.11	101.62	175.73	66.97	208.04	2.46	180.64	−48.03	111.98	−68.66

(Note) 1. ΔT: Five Years
2. $\Delta ROXY/\Delta T$: Marginal Change in the Value of ROXY Index
3. Calculation of the Marginal Change in the Value of ROXY Index:
For the period 1960-65;
ROXY(1965-70) − ROXY(1960-65)
For the periods 1965-70, 1970-75, and 1975-80 respectively;
{ROXY(1970-75) − ROXY(1960-65)}/2
{ROXY(1975-80) − ROXY(1965-70)}/2
{ROXY(1980-85) − ROXY(1970-75)}/2
For the period 1980-85;
ROXY(1980-85) − ROXY(1975-80)

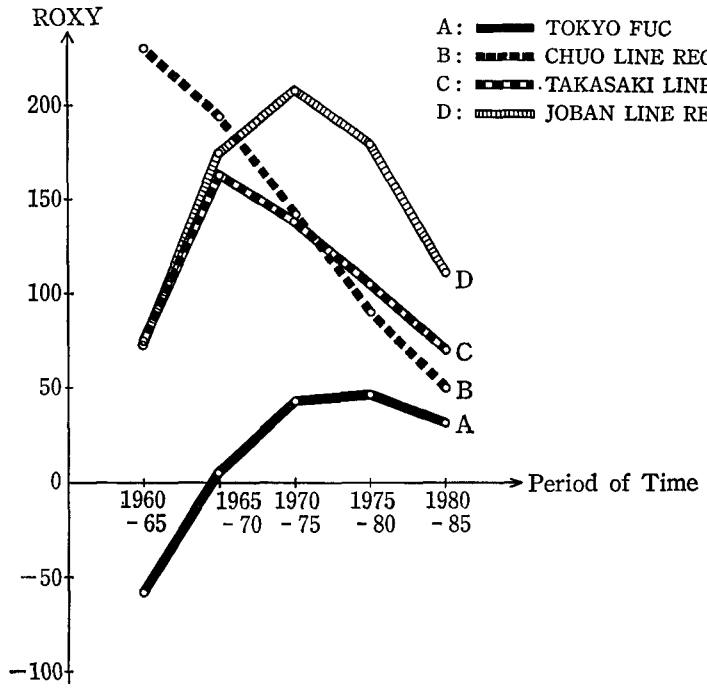


Figure N-1 Value of ROXY Index (Weighting Factor: Distance to CBD)

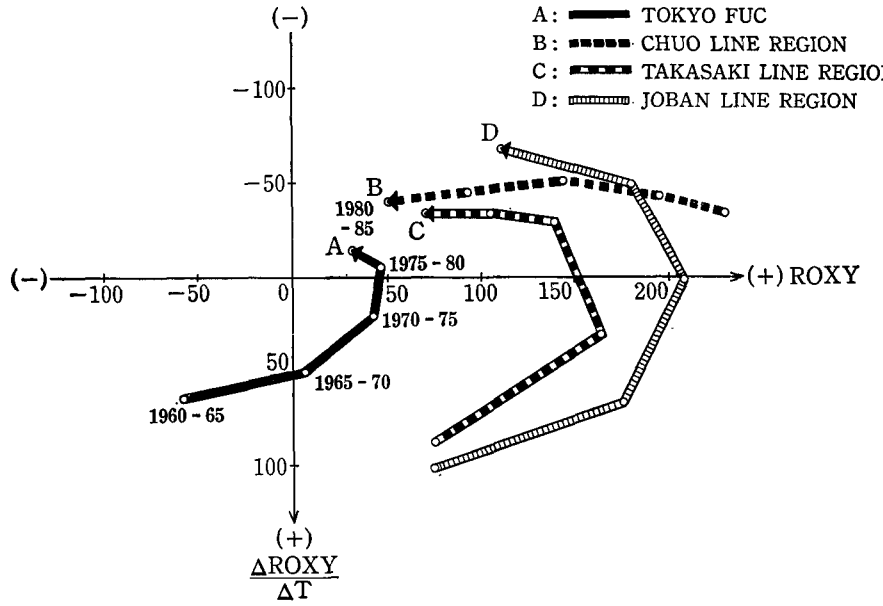


Figure N-2 ROXY Index and Its Marginal Change
(Weighting Factor: Distance to CBD)

Table N-3 ROXY Index for Tokyo FUC and Its Three Railway-line Regions
(Weighting Factor: Inverse of Distance to CBD)

Spatial Unit	Number of Localities	Period				
		1960-65	1965-70	1970-75	1975-80	1980-85
Tokyo FUC	143	−213.31	−263.45	−237.20	−157.36	−93.63
Chuo Line Region	15	−524.46	−397.43	−262.43	−133.54	−82.90
Takasaki Line Region	18	−478.59	−482.87	−339.66	−187.79	−116.80
Joban Line Region	14	−421.70	−452.21	−395.12	−289.10	−162.79

Table N-4 Value of ROXY Index and Its Marginal Change for Tokyo FUC and Three Railway-line Regions
(Weighting Factor: Inverse of Distance to CBD)

Spatial Unit	1960-65		1965-70		1970-75		1975-80		1980-85	
	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$
Tokyo FUC	−213.31	−50.14	−263.45	−11.95	−237.20	53.05	−157.36	71.79	−93.63	63.73
Chuo Line Region	−524.46	127.03	−397.43	131.02	−262.43	131.95	−133.54	89.77	−82.90	50.64
Takasaki Line Region	−478.59	−4.28	−482.87	69.47	−339.66	147.49	−187.79	111.43	−116.80	71.09
Joban Line Region	−421.70	−30.51	−452.21	13.29	−395.12	81.56	−289.10	116.17	−162.79	126.31

(Note) 1. ΔT: Five Years
2. $\Delta ROXY/\Delta T$: Marginal Change in the Value of ROXY Index
3. Calculation of the Marginal Change in the Value of ROXY Index:
For the period 1960-65;
ROXY(1965-70) − ROXY(1960-65)
For the periods 1965-70, 1970-75, and 1975-80 respectively;
{ROXY(1970-75) − ROXY(1960-65)}/2
{ROXY(1975-80) − ROXY(1965-70)}/2
{ROXY(1980-85) − ROXY(1970-75)}/2
For the period 1980-85;
ROXY(1980-85) − ROXY(1975-80)

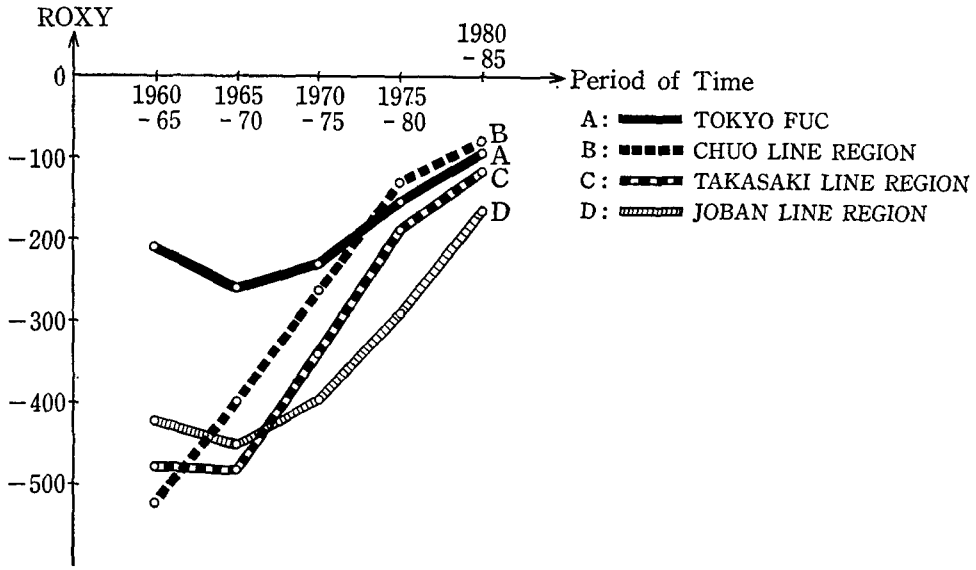


Figure N-3 ROXY Index (Weighting Factor: Inverse of Distance to CBD)

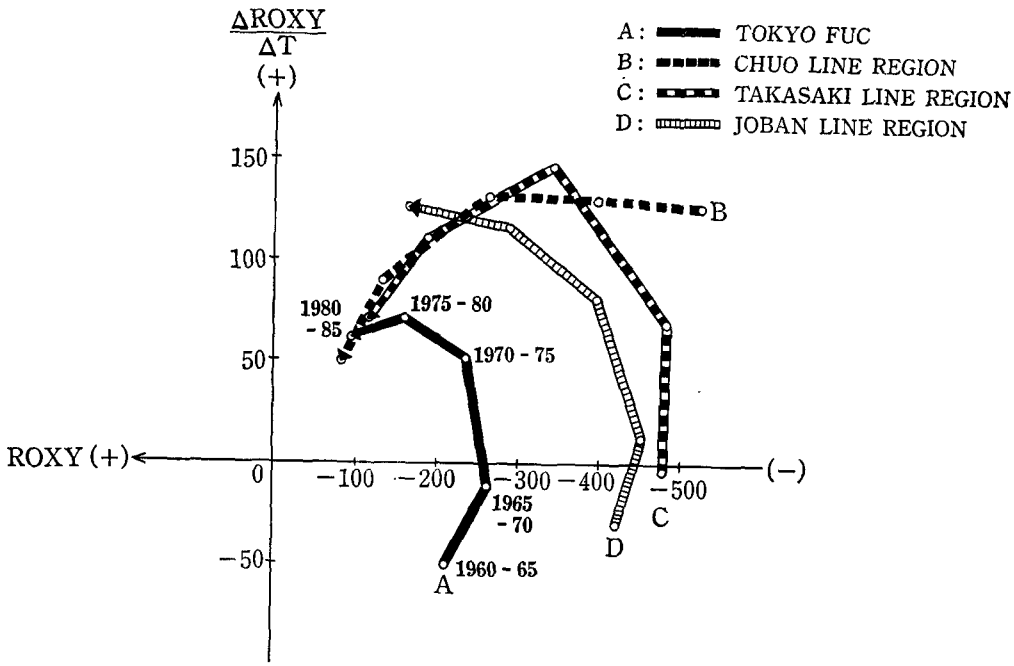


Figure N-4 ROXY Index and Its Marginal Change
(Weighting Factor: Inverse of Distance to CBD)

U.S. For the details of the delineation of FUCs, see Kawashima (1982).

4) Among other possible alternative variables to be used as weighting factor for the intra-metropolitan analysis are: (1) distance to the metropolitan center from subarea *i*, and (2) inverse of distance to the metropolitan center from subarea *i*. Though the former variable was previously used as weighting factor in Kawashima (1986a, b and c), we employ in the present study "reversed distance" as weighting factor so that the positive or negative value of ROXY index would indicate the population agglomeration or dispersion respectively. This correspondence between the sign of ROXY index and population agglomeration/dispersion phenomena can be consistent with that shown in Table 4 for the inter-metropolitan analysis. The latter variable (inverse of distance), in the meantime, can also keep the consistent with the contents of Table 4. However, the author decided not to employ it as a weighting factor since the weight will turn out to be unreasonably large if the value of the distance is extremely small.

5) Symmetric growth or decline of population would primarily represent, as described by notes 4, 5 and 6 of Table 2, (1) balanced growth or decline, (2) bell-shaped growth or decline, or (3) cup-shaped growth or decline.

6) Detailed explanations of symmetric growth or decline of population in a system of metropolitan areas, are furnished by notes 1, 2 and 3 of Table 4.

7) The values of ROXY index shown in this Table and Tables N-1 and N-2 as well, have been calculated based on Tables A-1 through A-4. Meanwhile, the values of ROXY index were previously analyzed for Tokyo FUC and its three major railway-line regions by Kawashima (1986s). In that analysis, he used the data for Tokyo FUC with 121 localities instead of 143 localities and employed distance instead of reversed distance as weighting factor. The increase in the number of component localities of Tokyo FUC in the present paper is consequent upon the disaggregation of Tokyo city, which served as one spatial entity in the author's 1986 paper, into twenty-three smaller spatial units (*i.e.*, special wards).

8) For the purpose of reference, the marginal value of ROXY index and the visual paradigm of spatial cycles are shown by Tables N-1 and N-2 and Figures N-1 and N-2 for ROXY index with the weighting factor of distance to CBD, and by Tables N-3 and N-4 and Figures N-3 and N-4 for ROXY index with the weighting factor of inverse of distance to CBD.

9) See Kawashima (1986b) for a more detailed discussion on the circular diagram framework though it should be noted that in that paper the lower portion of the vertical axis in the circular diagram presents positive values and that its upper portion presents negative values.

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APPENDIX

Table A-1 Population for 143 Localities of Tokyo FUC

Code Number	Distance (km)	Population (unit : persons)					
		1960	1965	1970	1975	1980	1985
13102	1.1	161,299	128,024	103,850	90,097	82,700	79,955
13101	2.0	116,944	93,067	74,185	61,656	54,801	50,493
13105	3.6	259,383	253,449	234,326	216,250	202,351	195,814
13107	3.8	331,607	317,630	281,237	250,714	232,796	229,978
13106	4.2	318,889	286,324	240,769	207,649	186,048	176,739
13103	4.2	267,024	241,861	223,978	209,492	201,257	194,579
13108	5.0	351,053	359,672	355,835	355,257	362,270	388,899
13104	5.8	413,690	413,910	390,657	367,218	343,928	332,700
13113	6.1	282,687	283,730	274,491	263,815	247,035	242,418
13118	6.8	285,480	278,412	247,013	217,905	198,126	190,057
13116	7.5	363,193	373,126	354,427	321,078	288,626	278,455
13109	8.1	427,859	423,278	398,027	366,390	346,247	357,682
13110	8.2	293,763	298,774	295,612	285,003	273,791	269,140
13121	8.5	408,785	514,736	571,791	609,025	619,961	622,592
13117	8.8	418,603	452,064	431,219	419,996	387,458	367,506
13119	9.4	412,605	477,007	471,777	498,286	498,266	505,455
13114	9.6	351,360	376,697	378,723	373,075	345,733	335,931
13123	10.0	316,885	405,365	446,758	473,656	495,231	514,494
13122	10.5	376,651	446,040	462,954	442,328	420,187	419,006
13112	10.6	653,210	742,880	787,338	805,787	797,292	811,294
13111	11.6	706,219	755,535	734,990	691,337	661,147	662,779
13115	11.7	487,210	536,792	553,016	560,716	542,449	539,829
13120	12.0	305,628	434,721	527,931	559,665	564,156	587,879
12301	12.9	16,847	18,463	21,880	32,250	64,673	93,756
11203	14.8	173,692	249,112	305,886	345,547	379,357	403,012
12203	16.8	157,301	207,988	261,055	319,272	364,244	397,806
11221	17.0	38,533	80,707	123,269	167,176	186,618	194,204
11226	17.2	20,711	37,403	51,377	56,693	55,952	55,424
11224	17.2	30,752	52,312	69,511	77,138	78,343	76,960
14130	17.2	632,975	854,866	973,486	1,015,020	1,040,700	1,088,610
13219	17.4	25,252	39,978	60,297	70,019	70,824	73,646
11234	17.5	13,307	21,772	37,323	56,127	62,734	67,635
12207	17.8	86,372	160,001	253,591	344,552	400,870	427,479
11307	18.0	17,242	31,034	39,512	46,504	49,718	55,212
11223	18.0	50,952	69,715	77,225	76,312	70,876	70,407
13204	18.5	98,038	135,873	155,693	164,852	164,449	166,175
13203	18.5	120,337	133,516	136,959	139,493	136,895	138,810
11237	19.5	17,738	24,207	42,753	79,354	98,222	107,963
13217	19.7	46,768	71,303	86,194	91,537	91,251	91,563
12204	20.0	135,038	223,989	325,426	423,106	479,437	506,967

Table A-1 (Continued)

Code Nnmber	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
11227	20.2	24,182	51,527	67,938	81,755	90,088	94,432
13208	20.3	68,621	117,995	157,488	175,858	180,535	191,076
13216	21.2	31,323	49,113	58,466	67,432	66,972	71,333
11230	22.0	14,401	36,881	77,704	108,990	119,312	129,284
11204	23.2	174,437	221,323	269,397	331,145	358,180	377,233
13222	23.5	19,637	47,239	78,075	100,821	106,521	110,079
12220	23.5	25,672	39,166	56,485	82,936	106,635	124,682
13225	23.7	11,012	19,345	30,817	43,921	48,154	50,749
13210	23.7	45,734	76,350	94,448	102,703	102,412	104,684
11222	23.8	49,585	76,571	139,368	195,915	223,243	253,483
12216	24.0	42,167	64,477	99,951	117,851	125,154	136,365
11305	24.2	12,259	20,464	31,811	43,546	50,926	58,935
12224	24.3	13,496	25,002	40,988	63,291	76,157	85,705
11466	24.5	16,300	16,761	18,524	30,786	38,895	43,616
13221	24.5	17,863	36,448	51,911	60,571	61,915	65,067
13206	25.8	82,098	126,235	163,173	182,379	191,980	201,972
11220	26.0	40,840	51,746	62,802	71,045	72,326	71,598
13211	26.2	52,923	105,365	137,373	156,182	154,610	158,673
13214	27.5	39,098	64,911	81,259	88,155	91,014	95,469
11235	27.6	12,030	23,767	52,011	70,392	79,591	85,698
11324	27.8	4,329	5,911	14,475	23,596	28,978	31,567
11465	27.8	8,844	9,308	12,207	15,806	18,463	20,340
13213	28.0	42,946	74,857	96,545	112,657	119,382	123,794
11205	28.0	169,996	215,646	268,777	327,696	354,082	373,015
12217	28.6	63,745	109,239	150,635	203,063	239,199	273,130
12305	28.7	11,849	15,262	18,480	22,148	33,706	38,027
13224	29.0	9,746	18,376	30,370	65,465	95,248	122,131
13215	29.2	32,609	43,477	59,709	64,404	64,154	64,881
11208	30.0	65,903	89,346	136,611	196,868	236,477	275,165
12326	30.2	8,217	8,305	10,509	12,968	24,975	32,214
11322	30.7	4,949	9,876	19,613	31,989	35,538	37,036
11213	30.7	35,169	41,946	56,449	83,825	94,695	100,904
12221	30.8	21,709	35,741	66,630	113,263	134,479	142,188
12208	30.8	54,150	59,799	68,641	78,194	93,958	105,937
13202	31.0	81,951	100,699	117,057	138,097	142,600	146,531
11321	31.2	16,652	34,050	51,747	58,332	57,929	57,641
13220	31.3	14,239	31,709	46,173	58,465	65,415	69,879
12222	31.7	27,063	33,216	49,240	76,218	101,061	111,661
13209	32.2	71,269	115,918	202,801	255,303	295,354	321,182
11214	32.7	34,280	42,460	84,919	121,639	155,556	171,889
13212	33.2	43,394	67,979	98,557	126,754	145,417	156,006
13342	35.0	12,065	14,049	41,275	50,842	57,194	60,930

Table A-1 (Continued)

Code Number	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
11468	35.0	15,808	16,780	18,909	25,217	32,356	35,131
11238	35.6	20,743	25,070	31,935	39,043	45,594	53,991
13207	36.3	44,805	59,655	75,662	83,856	89,343	97,544
8217	36.5	22,582	26,179	40,287	52,821	71,246	78,609
11219	36.5	38,889	54,776	110,792	146,359	166,244	178,589
11201	37.0	107,523	127,155	171,038	225,467	259,317	285,435
14209	37.2	101,655	163,381	278,326	377,341	439,257	482,778
11215	37.5	32,785	40,183	60,886	98,548	124,025	144,366
11225	37.7	36,903	51,835	65,369	83,996	104,034	118,603
11442	38.2	11,152	13,025	16,656	22,526	29,538	31,213
11464	38.5	16,457	17,634	20,244	28,074	34,549	37,006
11445	38.6	16,026	17,937	21,990	27,691	31,623	34,171
12327	38.6	17,315	16,863	16,114	16,832	17,896	23,373
14216	39.7	15,402	29,948	56,727	80,565	93,501	99,994
13218	40.0	21,985	30,790	37,938	46,456	48,710	51,481
11231	40.2	21,309	28,108	38,717	48,034	55,746	61,499
13201	40.3	164,622	207,753	253,527	322,558	387,162	426,650
8563	41.4	12,606	13,002	16,309	20,407	26,464	29,757
13302	42.0	11,003	16,027	22,783	33,124	42,018	47,202
12212	42.0	36,869	40,941	60,433	80,807	101,180	121,213
11 46	42.2	16,443	15,594	15,049	15,999	17,393	19,865
12328	42.3	5,213	5,052	4,566	4,585	4,622	4,668
13304	42.7	14,433	17,271	28,357	38,272	42,805	45,762
12325	43.0	7,912	7,639	7,331	7,444	7,452	7,704
11232	43.2	23,114	26,773	34,028	45,799	54,410	58,635
11233	44.0	15,483	20,576	31,699	46,632	50,888	58,114
11209	44.0	44,153	47,825	52,066	55,925	61,178	66,550
11463	44.2	23,378	25,169	27,923	43,083	49,704	51,462
11328	44.3	7,008	9,583	14,634	20,994	35,843	49,381
14212	44.7	46,239	61,383	82,888	108,952	145,387	175,596
11239	44.8	23,569	24,854	27,308	51,230	77,334	87,586
11446	45.0	16,054	15,500	15,238	16,166	19,462	20,946
11329	45.0	16,683	17,768	21,646	32,338	43,221	48,228
8208	45.6	33,581	34,917	37,267	40,569	43,131	48,857
12322	46.0	6,093	6,040	6,259	8,463	12,807	17,463
12329	46.5	9,732	9,333	8,825	8,952	9,553	14,208
11462	47.2	8,351	8,436	9,099	20,576	21,257	26,223
8444	48.0	16,131	17,203	19,372	27,674	40,170	51,926
11217	48.0	31,868	36,526	41,990	51,632	57,085	60,565
11347	48.8	14,915	14,229	14,072	14,724	16,108	17,043
11326	49.8	11,173	14,885	20,006	25,807	31,197	34,467
11461	49.8	12,890	14,489	16,112	18,090	19,792	20,119

Table A-1 (Continued)

Code Number	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
14214	50.8	26,984	32,013	43,751	61,621	70,052	77,765
11210	51.2	41,756	41,547	42,149	45,184	47,590	50,538
11212	51.6	38,267	42,706	50,383	57,682	63,889	70,425
11425	51.8	11,821	11,655	12,037	12,739	13,536	14,058
11304	54.5	12,095	14,482	17,247	18,775	22,606	24,990
11401	57.2	7,222	6,896	6,782	6,790	7,000	7,278
8204	58.0	42,474	50,202	54,173	55,971	56,656	57,539
8203	58.5	71,378	78,971	89,958	104,031	112,517	120,175
11216	59.0	42,900	43,884	45,001	46,506	48,488	51,505
14211	59.3	51,285	57,930	75,226	103,677	123,130	141,806
11202	61.7	98,168	109,575	120,841	131,486	136,807	143,496
11402	62.0	7,801	7,709	8,485	9,164	10,181	11,152
9364	62.5	9,974	10,339	11,983	14,015	16,453	18,983
9366	65.0	20,299	19,624	19,397	19,952	20,377	20,413
11406	67.0	9,452	9,282	9,764	10,984	11,567	11,656
11407	70.0	7,775	7,759	7,958	8,718	9,873	10,986
11408	70.5	25,478	25,298	25,137	25,846	28,466	31,720
11403	72.5	21,317	20,759	20,847	22,275	24,624	27,094
11218	72.5	60,856	62,241	69,193	75,750	82,243	89,123
Total	4,538.9	13,398,791	15,854,147	18,014,439	19,959,407	21,052,156	22,120,159

Table A-2 Population for Localities of Three Railway-line Regions in Tokyo FUC

(a) Chuo Line Region

Code Number	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
13102	1.1	161,299	128,024	103,850	90,097	82,700	79,955
13101	2.0	116,944	93,067	74,185	61,656	54,801	50,493
13104	5.8	413,690	413,910	390,657	367,218	343,928	332,700
13113	6.1	282,687	283,730	274,491	263,815	247,035	242,418
13114	9.6	351,360	376,697	378,723	373,075	345,733	335,931
13115	11.7	487,210	536,792	553,016	560,716	542,449	539,829
13204	18.5	98,038	135,873	155,693	164,852	164,449	166,175
13203	18.5	120,337	133,516	136,959	139,493	136,895	138,810
13210	23.7	45,734	76,350	94,448	102,703	102,412	104,684
13206	25.8	82,098	126,235	163,173	182,379	191,980	201,972
13214	27.5	39,098	64,911	81,259	88,155	91,014	95,469
13215	29.2	32,609	43,477	59,709	64,404	64,154	64,881
13202	31.0	81,951	100,699	117,057	138,097	142,600	164,531
13212	33.2	43,394	67,979	98,557	126,754	145,417	156,006
13201	40.3	164,622	207,753	253,527	322,558	387,162	426,650
Total	284.0	2,521,071	2,789,013	2,935,304	3,045,972	3,042,729	3,082,504

Table A-2 (Continued)

(b) Takasaki Line Region

Code Number	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
13102	1.1	161,299	128,024	103,850	90,097	82,700	79,955
13101	2.0	116,944	93,067	74,185	61,656	54,801	50,493
13106	4.2	318,889	286,324	240,769	207,649	186,048	176,739
13118	6.8	285,480	278,412	247,013	217,905	198,126	190,057
13117	8.8	418,603	452,064	431,219	419,996	387,458	367,506
11203	14.8	173,692	249,112	305,886	345,547	379,357	403,012
11226	17.2	20,711	37,403	51,377	56,693	55,952	55,424
11223	18.0	50,952	69,715	77,225	76,312	70,876	70,407
11204	23.2	174,437	221,323	269,397	331,145	358,180	377,233
11220	26.0	40,840	51,746	62,802	71,045	72,326	71,598
11205	28.0	169,996	215,646	268,777	327,696	354,082	373,015
11219	36.5	38,889	54,776	110,792	146,359	166,244	178,589
11231	40.2	21,309	28,108	38,717	48,034	55,746	61,499
11233	44.0	15,483	20,576	31,699	46,632	50,888	58,114
11217	48.0	31,868	36,526	41,990	51,632	57,085	60,565
11304	54.5	12,095	14,482	17,247	18,775	22,606	24,990
11202	61.7	98,168	109,575	120,841	131,486	136,807	143,496
11218	72.5	60,856	62,241	69,193	75,750	82,243	89,132
Total	507.5	2,210,511	2,409,120	2,562,979	2,724,409	2,771,525	2,831,815

(c) Joban Line Region

Code Number	Distance (km)	Population (unit: persons)					
		1960	1965	1970	1975	1980	1985
13102	1.1	161,299	128,024	103,850	90,097	82,700	79,955
13101	2.0	116,944	93,067	74,185	61,656	54,801	50,493
13105	3.6	259,383	253,449	234,326	216,250	202,351	195,814
13118	6.8	285,480	278,412	247,013	217,905	198,126	190,057
13121	8.5	408,785	514,736	571,791	609,025	619,961	622,592
13122	10.5	376,651	446,040	462,954	442,328	420,187	419,006
12207	17.8	86,372	160,001	253,591	344,552	400,870	427,479
12217	28.6	63,745	109,239	150,635	203,063	239,199	273,130
12222	31.7	27,063	33,216	49,240	76,218	101,061	111,661
8217	36.5	22,582	26,179	40,287	52,821	71,246	78,609
8563	41.4	12,606	13,002	16,309	20,407	26,464	29,757
8208	45.6	33,581	34,917	37,267	40,569	43,131	48,857
8444	48.0	16,131	17,203	19,372	27,674	40,170	51,926
8203	58.5	71,378	78,971	89,958	104,031	112,517	120,175
Total	340.6	1,942,000	2,186,456	2,350,778	2,506,596	2,612,784	2,699,511

Table A-3 Five-year Growth Rate of Population for 143 Localities of Tokyo FUC

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13102	1.1	−20.6294	−18.8824	−12.2431	−8.2100	−3.3192
13101	2.0	−20.4175	−20.2886	−16.8889	−11.1181	−7.8612
13105	3.6	−2.2877	−7.5451	−7.7140	−6.4273	−3.2305
13107	3.8	−4.2149	−11.4577	−10.8531	−7.1468	−1.2105
13106	4.2	−10.2120	−15.9103	−13.7559	−10.4027	−5.0035
13103	4.2	−9.4235	−7.3939	−6.4676	−3.9309	−3.3181
13108	5.0	2.4552	−1.0668	−0.1624	1.9741	7.3506
13104	5.8	0.0532	−5.6179	−5.9999	−6.3423	−3.2646
13113	6.1	0.3690	−3.2563	−3.8894	−6.3605	−1.8690
13118	6.8	−2.4758	−11.2779	−11.7840	−9.0769	−4.0727
13116	7.5	2.7349	−5.0114	−9.4093	−10.1072	−3.5239
13109	8.1	−1.0707	−5.9656	−7.9485	−5.4977	3.3026
13110	8.2	1.7058	−1.0583	−3.5888	−3.9340	−1.6987
13121	8.5	25.9185	11.0843	6.5118	1.7957	0.4244
13117	8.8	7.9935	−4.6111	−2.6026	−7.7472	−5.1495
13119	9.4	15.6086	−1.0964	5.6190	−0.0040	1.4428
13114	9.6	7.2111	0.5378	−1.4913	−7.3288	−2.8351
13123	10.0	27.9218	10.2113	6.0207	4.5550	3.8897
13122	10.5	18.4226	3.7920	−4.4553	−5.0056	−0.2811
13112	10.6	13.7276	5.9845	2.3432	−1.0542	1.7562
13111	11.6	6.9831	−2.7193	−5.9393	−4.3669	0.2468
13115	11.7	10.1767	3.0224	1.3924	−3.2578	−0.4830
13120	12.0	42.2386	21.4413	6.0110	0.8024	4.2050
12301	12.9	9.5922	18.5073	47.3949	100.5364	44.9693
11203	14.8	43.4217	22.7906	12.9659	9.7845	6.2356
12203	16.8	32.2229	25.5145	22.3007	14,0858	9.2142
11221	17.0	109.4490	52.7364	35.6188	11.6297	4.0650
11226	17.2	80.5949	37.3606	10.3470	−1.3070	−0.9437
11224	17.2	70.1093	32.8777	10.9724	1.5621	−1.7653
14130	17.2	35.0553	13.8759	4.2665	2.5300	4.6036
13219	17.4	58.3162	50.8255	16.1235	1.1497	3.9845
11234	17.5	63.6131	71.4266	50.3818	11.7715	7.8124
12207	17.8	85.2464	58.4934	35.8692	16.3453	6.6378
11307	18.0	79.9907	27.3184	17.6959	6.9112	11.0503
11223	18.0	36.8249	10.7724	−1.1823	−7.1234	−0.6617
13204	18.5	38.5922	14.5872	5.8827	−0.2445	1.0496
13203	18.5	10.9517	2.5787	1.8502	−1.8625	1.3989
11237	19.5	36.4697	76.6142	85.6104	23.7770	9.9173
13217	19.7	52.4611	20.8841	6.1988	−0.3124	0.3419
12204	20.0	65.8711	45.2866	30.0160	13.3137	5.7422
11227	20.2	113.0800	31.8493	20.3377	10.1926	4.8220
13208	20.3	71.9517	33.4701	11.6644	2.6595	5.8388

Table A-3 (Continued)

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13216	21.2	56.7953	19.0438	15.3354	−0.6822	6.5117
11230	22.0	156.1003	110.6884	40.2630	9.4706	8.3579
11204	23.2	26.8785	21.7212	22.9208	8.1641	5.3194
13222	23.5	140.5612	65.2766	29.1335	5.6536	3.3402
12220	23.5	52.5631	44.2195	46.8284	28.5750	16.9241
13225	23.7	75.6720	59.3021	42.5220	9.6378	5.3890
13210	23.7	66.9436	23.7040	8.7403	−0.2833	2.2185
11222	23.8	54.4237	82.0115	40.5739	13.9489	13.5458
12216	24.0	52.9087	55.0181	17.9088	6.1968	8.9578
11305	24.2	66.9304	55.4486	36.8898	16.9476	15.7267
12224	24.3	85.2549	62,9389	54.4135	20.3283	12.5373
11466	24.5	2.8282	10.5185	66.1952	26.3399	12.1378
13221	24.5	104.0419	42.4248	16.6824	2.2189	5.0909
13206	25.8	53.7614	29.2613	11.7703	5.2643	5.2047
11220	26.0	26.7042	21.3659	13.1254	1.8031	−1.0066
13211	26.2	99.0911	30.3782	13.6919	−1.0065	2.6279
13214	27.5	66.0213	25.1853	8.4864	3.2432	4.8949
11235	27.6	97.5644	118.8370	35.3406	13.0682	7.6730
11324	27.8	36.5442	144.8824	63.0121	22.8090	8.9344
11465	27.8	5.2465	31.1453	29.4831	16.8101	10.1663
13213	28.0	74.3049	28.9726	16.6886	5.9694	3.6957
11205	28.0	26.8536	24.6381	21.9211	8.0520	5.3471
12217	28.6	71.3687	37.8949	34.8047	17.7955	14.1853
12305	28.7	28.8041	21.0850	19.8485	52.1853	12.8197
13224	29.0	88.5491	65.2699	115.5581	45.4945	28.2242
13215	29.2	33.3282	37.3347	7.8631	−0.3882	1.1332
11208	30.0	35.5720	52.9011	44.1085	20.1196	16.3602
12326	30.2	1.0710	26.5382	23.3990	92.5895	28.9850
11322	30.7	99.5555	98.5925	63.1010	11.0944	4.2152
11213	30.7	19.2698	34.5754	48.4969	12.9675	6.5568
12221	30.8	64.6368	86.4246	69.9880	18.7316	5.7325
12208	30.8	10.4321	14.7862	13.9173	20.1601	12.7493
13202	31.0	22.8771	16.2445	17.9741	3.2608	2.7567
11321	31.2	104.4799	51.9736	12.7254	−0.6909	−0.4972
13220	31.3	122.6912	45.6148	26.6216	11.8875	6.8241
12222	31.7	22.7358	48.2418	54.7888	32.5947	10.4887
13209	32.2	62.6486	74.9521	25.8884	15.6876	8.7448
11214	32.7	23.8623	99.9976	43.2412	27.8833	10.4998
13212	33.2	56.6553	44.9815	28.6098	14.7238	7.2818
13342	35.0	16.4443	193.7932	23.1787	12.4936	6.5322
11468	35.0	6.1488	12.6877	33.3598	28.3103	8.5765
11238	35.6	20.8600	27.3833	22.2577	16.7789	18.4168

ROXY INDEX ANALYSIS OF POPULATION CHANGES IN JAPAN FOR 1960-85 (Kawashima)

Table A-3 (Continued)

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13207	36.3	33.1436	26.8326	10.8297	6.5434	9.1792
8217	36.5	15.9286	53.8905	31.1118	34.8820	10.3346
11219	36.5	40.8522	102.2638	32.1025	13.5865	7.4258
11201	37.0	18.2584	34.5114	31.8228	15.0133	10.0718
14209	37.2	60.7211	70.3540	35.5752	16.4085	9.9079
11215	37.5	22.5652	51.5218	61.8566	25.8524	16.4007
11225	37.7	40.4628	26.1098	28.4952	23.8559	14.0041
11442	38.2	16.7952	27.8772	35.2426	31.1285	5.6707
11464	38.5	7.1520	14.8010	38.6781	23.0640	7.1116
11445	38.6	11.9244	22.5958	25.9254	14.1996	8.0574
12327	38.6	−2.6105	−4.4417	4.4558	6.3213	30.6046
14216	39.7	94.4423	89.4183	42.0223	16.0566	6.9443
13218	40.0	40.0500	23.2153	22.4524	4.8519	5.6888
11231	40.2	31.9067	37.7437	24.0644	16.0553	10.3200
13201	40.3	26.2000	22.0329	27.2283	20.0286	10.1993
8563	41.4	3.1414	25.4345	25.1272	29.6810	12.4433
13302	42.0	45.6603	42.1539	45.3891	26.8506	12.3376
12212	42.0	11.0445	47.6100	33.7134	25.2119	19.7994
11346	42.2	−5.1633	−3.4949	6.3127	8.7130	14.2126
12328	42.3	−3.0884	−9.6200	0.4161	0.8070	0.9952
13304	42.7	19.6633	64.1885	34.9649	11.8442	6.9081
12325	43.0	−3.4505	−4.0319	1.5414	0.1075	3.3816
11232	43.2	15.8302	27.0982	34.5921	18.8017	7.7651
11233	44.0	32.8941	54.0581	47.1087	9.1268	14.1998
11209	44.0	8.3165	8.8677	7.4117	9.3929	8.7809
11463	44.2	7.6610	10.9420	54.2922	15.3680	3.5369
11328	44.3	36.7437	52.7079	43.4604	70.7297	37.7703
14212	44.7	32.7516	35.0341	31.4448	33.4413	20.7783
11239	44.8	5.4521	9.8737	87.6007	50.9545	13.2568
11446	45.0	−3.4509	−1.6903	6.0900	20.3885	7.6251
11329	45.0	6.5036	21.8258	49.3948	33.6539	11.5846
8208	45.6	3.9784	6.7302	8.8604	6.3152	13.2758
12322	46.0	−0.8699	3.6258	35.2133	51.3293	36.3551
12329	46.5	−4.0999	−5.4431	1.4391	6.7136	48.7281
11462	47.2	1.0178	7.8592	126.1347	3.3097	23.3617
8444	48.0	6.6456	12.6083	42.8557	45.1543	29.2656
11217	48.0	14.6165	14.9592	22.9626	10.5613	6.0962
11347	48.8	−4.5994	−1.1034	4.6333	9.3996	5.8046
11326	49.8	33.2229	34.4038	28.9963	20.8858	10.4818
11461	49.8	12.4050	11.2016	12.2766	9.4085	1.6522
14214	50.8	18.6370	36.6664	40.8448	13.6820	11.0104
11210	51.2	−0.5005	1.4490	7.2006	5.3249	6.1946

Table A-3 (Continued)

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
11212	51.6	11.6001	17.9764	14.4870	10.7607	10.2302
11425	51.8	−1.4043	3.2776	5.8320	6.2564	3.8564
11304	54.5	19.7354	19.0927	8.8595	20.4048	10.5459
11401	57.2	−4.5140	−1.6531	0.1180	3.0928	3.9714
8204	58.0	18.1947	7.9100	3.3190	1.2238	1.5585
8203	58.5	10,6377	13.9127	15.6440	8.1572	6.8061
11216	59.0	2.2937	2.5453	3.3444	4.2618	6.2222
14211	59.3	12.9570	29.8567	37.8207	18.7631	15.1677
11202	61.7	11.6199	10.2815	8.8091	4.0468	4.8894
11402	62.0	−1.1793	10.0662	8.0024	11.0978	9.5374
9364	62.5	3.6595	15.9010	16.9574	17.3956	15.3771
9366	65.0	−3.3253	−1.1567	2.8613	2.1301	0.1767
11406	67.0	−1.7986	5.1928	12.4949	5.3077	0.7694
11407	70.0	−0.2058	2.5648	9.5501	13.2485	11.2732
11408	70.5	−0.7065	−0.6364	2.8205	10.1370	11.4312
11403	72.5	−2.6176	0.4239	6.8499	10.5455	10.0309
11218	72.5	2.2759	11.1695	9.4764	8.5716	8.3655
Total	4,538.9	18.3252	13.6260	10.7967	5.4749	5.0731

Table A-4 Five-year Growth Rate of Population for Localities of Three Railway-line Regions in Tokyo FUC

(a) Chuo Line Region

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13102	1.1	−20.6294	−18.8824	−13.2431	−8.2100	−3.3192
13101	2.0	−20.4175	−20.2886	−16.8889	−11.1181	−7.8612
13104	5.8	0.0532	−5.6179	−5.9999	−6.3423	−3.2646
13113	6.1	0.3690	−3.2563	−3.8894	−6.3605	−1.8690
13114	9.6	7.2111	0.5378	−1.4913	−7.3288	−2.8351
13115	11.7	10.1767	3.0224	1.3924	−3.2578	−0.4830
13204	18.5	38.5922	14.5872	5.8827	−0.2445	1.0496
13203	18.5	10.9517	2.5787	1.8502	−1.8625	1.3989
13210	23.7	66.9436	23.7040	8.7403	−0.2833	2.2185
13206	25.8	53.7614	29.2613	11.7703	5.2643	5.2047
13214	27.5	66.0213	25.1853	8.4864	3.2432	4.8949
13215	29.2	33.3282	37.3347	7.8631	−0.3882	1.1332
13202	31.0	22.8771	16.2445	17.9741	3.2608	2.7567
13212	33.2	56.6553	44.9815	28.6098	14.7238	7.2818
13201	40.3	26.2000	22.0329	27.2283	20.0286	10.1993
Total	284.0	10.6281	5.2453	3.7702	−0.1065	1.3072

Table A-4 (Continued)

(b) Takasaki Line Region

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13102	1.1	−20.6294	−18.8824	−13.2431	−8.2100	−3.3192
13101	2.0	−20.4175	−20.2886	−16.8889	−11.1181	−7.8612
13106	4.2	−10.2120	−15.9103	−13.7559	−10.4027	−5.0035
13118	6.8	−2.4758	−11.2779	−11.7840	−9.0769	−4.0727
13117	8.8	7.9935	−4.6111	−2.6026	−7.7472	−5.1495
11203	14.8	43.4217	22.7906	12.9659	9.7845	6.2356
11226	17.2	80.5949	37.3606	10.3470	−1.3070	−0.9437
11223	18.0	36.8249	10.7724	−1.1823	−7.1234	−0.6617
11204	23.2	26.8785	21.7212	22.9208	8.1641	5.3194
11220	26.0	26.7042	21.3656	13.1254	1.8031	−1.0066
11205	28.0	26.8536	24.6381	21.9211	8.0520	5.3471
11219	36.5	40.8522	102.2638	32.1025	13.5865	7.4258
11231	40.2	31.9067	37.7437	24.0644	16.0553	10.3200
11233	44.0	32.8941	54.0581	47.1087	9.1268	14.1998
11217	48.0	14.6165	14.9592	22.9626	10.5613	6.0962
11304	54.5	19.7354	19.0927	8.8595	20.4048	10.5459
11202	61.7	11.6199	10.2815	8.8091	4.0468	4.8894
11218	72.5	2.2759	11.1695	9.4764	8.5716	8.3655
Total	507.5	8.9848	6.3865	6.2985	1.7294	2.1753

(c) Joban Line Region

Code Number	Distance (km)	Five-year Growth Rate (%)				
		1960-65	1965-70	1970-75	1975-80	1980-85
13102	1.1	−20.6294	−18.8824	−13.2431	−8.2100	−3.3192
13101	2.0	−20.4175	−20.2886	−16.8889	−11.1181	−7.8612
13105	3.6	−2.2877	−7.5451	−7.7140	−6.4273	−3.2305
13118	6.8	−2.4758	−11.2779	−11.7840	−9.0769	−4.0727
13121	8.5	25.9185	11.0843	6.5118	1.7957	0.4244
13122	10.5	18.4226	3.7920	−4.4553	−5.0056	−0.2811
12207	17.8	85.2464	58.4934	55.8692	16.3453	9.6378
12217	28.6	71.3687	37.8949	34.8047	17.7955	14.1853
12222	31.7	22.7358	48.2418	54.7888	32.5947	10.4887
8217	36.5	15.9286	53.8905	31.1118	34.8820	10.3346
8563	41.4	3.1414	25.4345	25.1272	29.6810	12.4433
8208	45.6	3,9784	6.7302	8.8604	6.3152	13.2758
8444	48.0	6.6456	12.6083	42.8556	45.1543	29.2656
8203	58.5	10.6377	13.9127	15.6440	8.1572	6.8061
Total	340.6	12.5878	7.5154	6.6284	4.2363	3.3193