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Possible Revitalization of the Central Part of the Tokyo Metropolitan Area: ROXY-index Analysis of Spatial Cycles*

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Contents

Abstract

The major four stages of the spatial-cycles are quantitatively examined, by use of the data extending over the past fifty years (for the period 1947-2000), for the two kinds of urban systems in Japan. The one is the spatial system of primary core cities, and the other is that of the Tokyo Metropolitan Area. The spatial-cycle hypothesis constructed by Klaassen and the method of the Roxy-index analysis developed by the author are applied to our investigation. The results obtained illuminate rather clearly the recent trend of the revived agglomeration of the population in the core cities of large metropolitan areas, especially that towards the central part of the Tokyo Metropolitan Area. This would imply that the core city of the Tokyo Metropolitan Area will play an increasingly critical role in the urban policies of Japan, as compared with either its suburban area or the core cities of other metropolitan areas.

Keywords

Centralization, Concentration, Core City, Functional Urban Region (FUR), Functional Urban Core (FUC), Klaassen, Metropolitan Area, Revived Concentration and Centralization, Roxy Index, Spatial Cycles, and Urban Changes

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1. Introduction

The four stages of the spatial cycles are quantitatively examined for the two kinds of urban systems in Japan. They are; ① the spatial system of 87 core cities (Functional Urban Cores: FUCs) for each 87 metropolitan areas (Functional Urban Region: FURs), and ② the spatial system of the Tokyo Metropolitan Area (Tokyo FUR) which consists of 160 localities.[1] To this empirical study, the Klaassen's spatial-cycle hypothesis and Kawashima's ROXY-index method are mainly applied. Our data for the population for the above-mentioned two urban systems cover the period of the fifty-four years from 1947 through 2000.

In the following, the basic scheme for the Klaassen's spatial-cycle hypothesis is explained in Section 2, and that for the method of the Roxy-index analysis in Section 3. In Section 4, the empirical analysis is carried out for the two urban systems. The obtained results are examined in the same section to gain a better insight into the characteristics of urban dynamism in agglomeration and deglomeration tendencies in association with the spatial-cycle process of the redistribution of population. In the concluding remarks in Section 5, some policy implications of our results are briefly discussed to emphasize the increasing importance of the central part of the Tokyo Metropolitan Area in future urban policies in Japan.

2. Spatial Cycles : Klaassen's Hypothesis

The inter-metropolitan and intra-metropolitan spatial redistribution patterns of the population are summarized with respect to analytical terminologies in Table 1. As can be seen from this table, the spatial

Table 1 Spatial Agglomeration and Deglomeration: Terminologies for Inter-metropolitan and Intra-metropolitan Spatial Redistribution Phenomena of Population

Type of Spatial Redistribution / Type of Phenomena	Agglomeration	Deglomeration
Inter-MET Phenomena	Concentration	Deconcentration
Intra-MET Phenomena	Centralization (Urbanization)	Decentralization (Suburbanization)

[Note] MET: Metropolitan Area

agglomeration and deglomeration processes are referred to as concentration and deconcentration respectively for the inter-metropolitan or inter-core-city phenomena, and centralization and decentralization respectively for the intra-metropolitan phenomena. Figure 1 illustrates the concepts of these terminologies by a diagram.

The revised version of the Klaassen's spatial-cycle paradigm[2] argues the existence of the four major recursively transmuting stages along the spatial-cycle path as given by Tables 2, 3 and 4 for the inter-FUR

Figure 1 Metropolitan Area, System of Metropolitan Areas and System of Core Cities

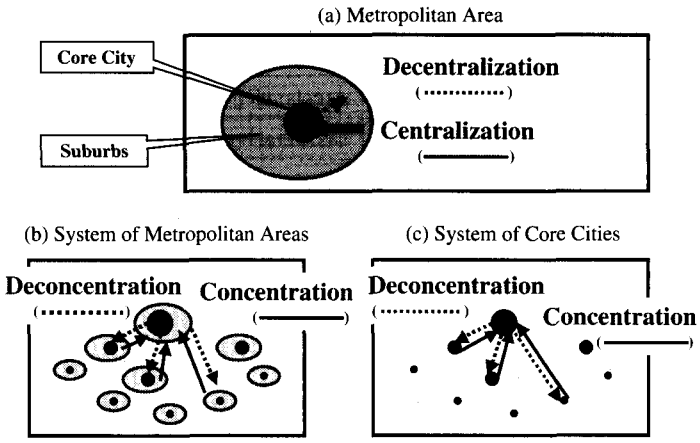


Table 2 Four Major Stages of Spatial Cycles: For Inter-MET Phenomena of Concentration and Deconcentration

Changes in Inter-MET Phenomena	Four Stages of Spatial Cycles	
Concentration	Stage−1	Accelerating Concentration
	Stage−2	Decelerating Concentration
Deconcentration	Stage−3	Accelerating Deconcentration
	Stage−4	Decelerating Deconcentration

[Note] MET: Metropolitan Area

Table 3 Four Major Stages of Spatial Cycles: For Inter-FUC Phenomena of Concentration and Deconcentration

Changes in Inter-FUC Phenomena	Four Stages of Spatial Cycles	
Concentration	Stage−1	Accelerating Concentration
	Stage−2	Decelerating Concentration
Deconcentration	Stage−3	Accelerating Deconcentration
	Stage−4	Decelerating Deconcentration

[Note] FUC: Core-city of Functional Urban Region (*i.e.*, Core-city of Metropolitan Area)

Table 4 Four Major Stages of Spatial Cycles: For Intra-MET Phenomena of Centralization and Decentralization

Changes in Intra-Met Phenomena	Four Stages of Spatial Cycles	
Centralization	Stage−1	Accelerating Centrarlzation
	Stage−2	Decelerating Centralization
Decentralization	Stage−3	Accelerating Decentralization
	Stage−4	Decelerating Decentralization

[Note] MET: Metropolitan Area

(*i.e.*, inter-metropolitan) phenomena, inter-FUC(*i.e.*, inter-core-city) phenomena and intra-FUR phenomena respectively.[3] For example, the four major stages for the inter-FUR phenomena are; ① accelerating concentration, ② decelerating concentration, ③ accelerating deconcentration, and ④ decelerating deconcentration. We use, in what is discussed below, the term 'revived accelerating concentration' (or 'revived concentration') to indicate clearly the phenomena of the re-entry steps of the spatial-cycle path from the deconcentration stage into the concentration stage, or the term revived accelerating centralization (or 'revived centralization') for the re-entry steps of the spatial-cycle path from the decentralization stage into the centralization stage.

3. Roxy Index : Analytical Methodology

The Roxy index[4] is an indicative instrument to identify quantitatively the major stages of spatial cycles. This index can be used in conducting both the inter- metropolitan (or inter-core-city) and intra-metropolitan analyses on the spatial agglomeration and deglomeration processes of the system of spatial units.

The mathematical formulation to define the value of the Roxy index is given in Table 5. This definition enables us to construct Tables 6 and 7 which state the implication of the Roxy-index value as to its sign and direction of changes in relation to the direction and speed of the spatial redistribution process of the population. As can be seen from these two tables, depending upon the stages of the spatial cycles, the value of the Roxy index turns out to be;

(1) Positive and increasing, for the stage of accelerating concentration (or centralization),
(2) Positive and decreasing, for the stage of decelerating concentration (or centralization),
(3) Negative and decreasing, for the stage of accelerating deconcentration (or decentralization),
(4) Negative and increasing, for the stage of decelerating deconcentration (or decentralization), and
(5) At or in the vicinity of the value zero, for the stage at which the spatial redistribution process is neutral[5].

Table 5 Definition of ROXY Index (Standard Definition)

$$R^t \equiv \left(WAGR^t / SAGR^t - 1.0 \right) \times S_c$$

$$= \left\{ \frac{\sum_{i=1}^{n} \left(w_i^t \times r_i^t \right)}{\sum_{i=1}^{n} w_i^t} \times \frac{n}{\sum_{i=1}^{n} r_i^t} - 1.0 \right\} \times S_c$$

where

- R^t : Value of ROXY Index for Period between Years t and $t+1$
- $WAGR^t$: Weighted Average of Annual Growth Ratios of Population of Each Spatial Unit for Period between Years t and $t+1$
- $SAGR^t$: Simple Average of Annual Growth Ratios of Population of Each Spatial Unit for Period between Years t and $t+1$
- S_c : Scaling Factor $(= 10^4)$
- r_i^t : Annual Growth Ratio of Spatial Unit i for Period between Years t and $t+1$
- w_i^t : Weighting Factor for Spatial Unit i for r_i^t
- n : Number of Spatial Units

Table 6 Implications of ROXY-index Values: For the State of Spatial Redistribution Process of Population among Metropolitan Areas or among Their Core Cities

A	B	C	D
Sign of ROXY-index Value	Changes in Spatial Redistribution Process of Population	Direction of Changes in ROXY-index Value	Speed of Spatial Redistribution Process of Population
Positive	Concentration (or Revived concentration)	Increasing	Accelerating
		Levelling-off	Stationary
		Decreasing	Decelerating
Zero	Neutrality from both concentration and deconcentration (*viz.* Symmetric growth and decline)	Levelling-off	Continuation of neutrality
Negative	Deconcentrationn	Decreasing	Accelerating
		Levelling-off	Stationary
		Increasing	Decelerating

[Notes]

(1) The weighting factor appropriate for this table would be population of each metropolitan area or that of each core city of metropolitan areas.

(2) The state of the "symmetric growth and 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 population of each metropolitan area's core city," is nearly flat regardless of their population size to reflect their constant sharing of population over time.

(ii) Bell-shaped growth or decline (BSGD) : The fitted growth-rate curve is bell-shaped, reflecting the "medianization" of population over metropolitan areas or core cities. The phenomena of "medianization" means:① the increase in population (as compared with other metropolitan areas or core cities) shared by metropolitan areas or core cities with the medium population size, or ② the decrease in population shared by metropolitan areas or core cities with the larger or smaller popoulation size (but not by those with the medium population size)

(iii) Cup-shaped growth or decline (CSGD) : The fitted growth-rate curve is cup-shaped, reflecting the "bipolarization" of population over metropolitan areas or core cities. The phenomena of "bipolarization" means: ① the increase in population shared by metropolitan areas or core cities with the larger or smaller population size, or ② the decrease in population shared by metropolitan areas or core cities with the minimum population size.

(3) It should be kept in mind that this table shows only the necessary condition of the ROXY-index value for the state of spatial redistribution process of population.

[Source] Constructed from Kawashima and Hiraoka (2001)

Table 7 Implications of ROXY-index Values: For the States of Spatial Redistribution Process of Population within a Metropolitan Area

A	B	C	D
Sign of ROXY-index Value	Changes in Spatial Redistribution Process of Population	Direction of Changes in ROXY-index Value	Speed of Spatial Redistribution Process of Ppopulation
Positive	Centralization (or Revived Centralization)	Increasing	Accelerating
		Levelling-off	Stationary
		Decreasing	Decelerating
Zero	Neutrality from both centralization and decentralization (*viz.* Symmetric growth and decline)	Levelling-off	Continuation of neutrality
Negative	Decentralization	Decreasing	Accelerating
		Levelling-off	Stationary
		Increasing	Decelerating

[Notes]

(1) The weighting factor appropriate for this table would be: ① the reversed CBD distance (*i.e.*, "the maximum value over subarea's distance from the CBD" minus "each subarea's CBD distance") of each subarea consisting the metropolitan area under our investigation, or ② value one assigned for the core-city area and value zero assigned for the subrban area.

(2) The state of the "symmetric growth and 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 in population (as compared with other subareas) 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 diatence (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) The concept of centralization and decentralization in this table can be used interchangeably with those of urbanization and suburbanization. Therefore, the "revived centralization" may be referred to as "revived urbanization" or "reurbanization."

(4) It should be kept in mind that this table shows only the necessary condition of the ROXY-index value for the state of spatial redistribution process of population.

[Source] Constructed from Kawashima and Hiraoka (2001)

Based on Tables 6 and 7, we can draw Figures 2 and 3 which display the general spatial-cycle path in the form of a wave-like cyclic form and a circular-cyclic form respectively. As to the latter, the axis of abscissas indicates the value of the Roxy index (ROXY), while the axis of ordinate indicates the marginal value of the Roxy index with respect to time ($\Delta ROXY/\Delta T$). It is also to be noted for Figure 3 that, in order to have the circular-cyclic curve moving in an anticlockwise direction, the negative value is set toward the right-hand side of the abscissas.

Figure 2 Wavelike - cyclic Curve: Path of Spatial Cycles by ROXY
(Presented by "ROXY- index Value" and "Time")

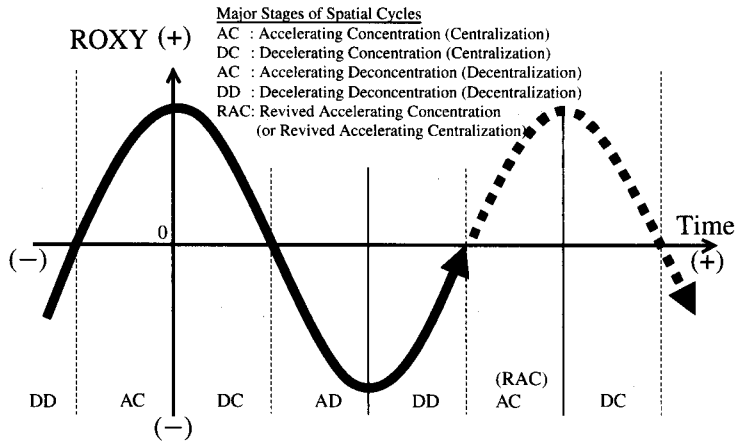
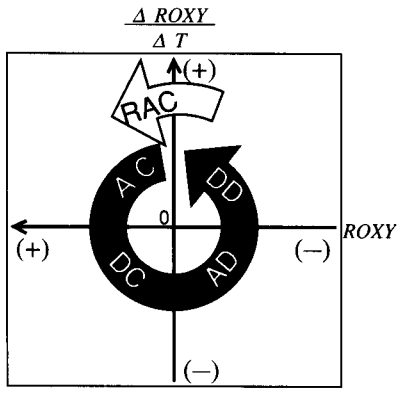


Figure 3 Circular-cyclic Curve: Path of Spatial Cycles by ROXY
(Presented by "ROXY-index Value"and "Marginal
ROXY-Index Value")



ROXY : ROXY-index Value
Δ ROXY/ΔT : Marginal Value of ROXY-index Value with Respect to Time (T)

Major Stages of Spatial Cycles
AC : Stages of Accelerating Concentration (or Accelerating Centralization)
DC : Stages of Decelerating Concentration (or Decelerating Centralization)
AD : Stages of Accelerating Deconcentration (or Accelerating Decentralization)
DD : Stages of Decelerating Deconcentration (or Decelerating Decentralization)
RAC: Stage of Revived Accelerating Concentration (or Revived Accelerating Centralization)

[Note] In this graph, the axis of abscissas has the positive sign towards the left side so that the stages of spatial cycles would follow the anticlockwise path.

4. Empirical Analysis : For The Period 1947-2000

The values of the Roxy index, if we use them with a careful knowledge of their limitations, provide useful quantitative information on the dynamic changes in the process of the spatial redistribution of various socio-economic activities. With this understanding, we apply in this section the Roxy-index method to our data to meet our research purpose.

4.1. System of Eighty-seven Core Cities

4.1.1. Population Data for The FUCs

For our study, we use the FUC data constructed from the national-census population data given in Table A-1 in Appendix A which cover the period from 1947 through 2000.[6] From this table, we obtain Tables A-2 through A-5 which respectively provide us with ① the gross population growth ratio, ② annual population growth ratio, ③ expected population in the middle year between the two neighbouring census years and ④ weighted annual population growth ratio, where the figures for ①, ② and ④ are set as those for the two neighbouring census years.

4.1.2. Obtained Results : Value of Roxy Index and Its Marginal Value

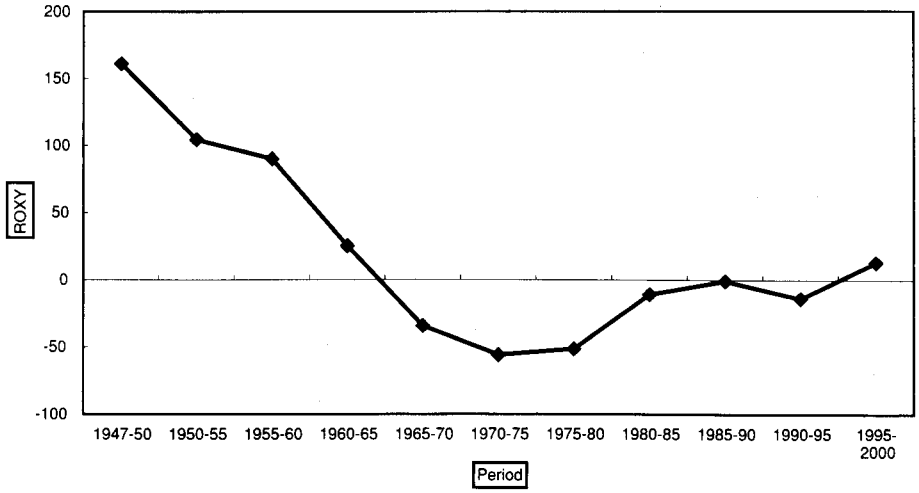
On the basis of Tables A-3 and A-5, we can calculate the value of the Roxy index (ROXY) and its marginal value with respect to time (ΔROXY/ΔT) for the FUC system in Japan. The obtained results are given by Table 8 from which we can draw in Figure 4 the wavelike-cyclic curve of the spatial cycles, and in Figure 5 the circular-cyclic curve.

Table 8 ROXY-index Value and Its Marginal Value for the System of FUCs: 1947-2000

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
ROXY	160.95	104.27	90.05	25.27	-34.36	-55.94	-51.44	-10.81	-0.79	-13.79	13.03
ΔROXY/ΔT	-14.17	-7.88	-7.90	-12.44	-8.12	-1.71	4.51	5.07	-0.30	1.38	5.36

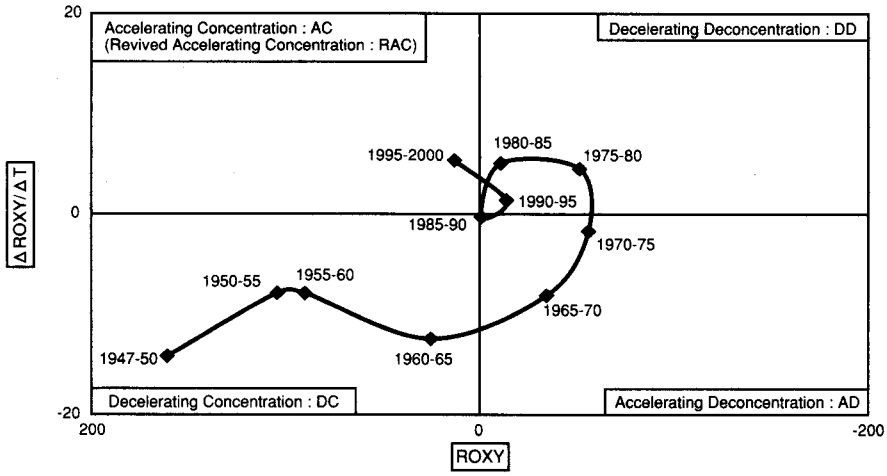
[Notes] (1) ROXY: ROXY-index value
(2) ΔROXY/ΔT: Marginal value of the ROXY-index value with respect to time
(3) FUC: Functional Urban Core (*i.e.*, Core City)
(4) The Tokyo FUC for this table comprises the twenty-three (23) Tokyo special wards.

Figure 4 Spatial Cycles for the System of FUCs (*i.e.*, Core Cities): 1947-2000 (Wavelike-cyclic Form)



[Note] The Functional Urban Core (FUC) of the Tokyo Functional Urban Region (FUR) comprises the 23 Tokyo special wards.

Figure 5 Spatial Cycles for the System of FUCs (*i.e.*, Core Cities): 1947-2000 (Circular-cyclic Form)



[Note] The Functional Urban Core (FUC) of the Tokyo Functional Urban Region (FUR) comprises the 23 Tokyo special wards.

Judging from these Table and Figures, the followings can be pointed out concerning the spatial-cycle stage of the system of the eighty-seven core cities (*i.e.*, the FUC system);

(1) The FUC system abided at the stage of decelerating concentration until the middle of the 1960s after the World War II.

(2) The FUC system stayed at the stage of accelerating deconcentration from the late 1960s to the early 1970s.

(3) The FUC system came in the stage of decelerating deconcentration in the middle of the 1970s.

(4) The FUC system seems to have recently finished the last phase of the deconcentration[7] stage.

(5) The FUC system seems to have entered into the revived concentration[8] stage, upon the arrival of the twenty-first century, *for the first time* after the World War II.

4.2. System of Core and Suburban Areas of the Tokyo Metropolitan Area

4.2.1. Population Data for The Tokyo FUR

We use a series of the national census population data from 1947 through 2000, for each of the 160 localities composing the Tokyo metropolitan area (*i.e.*, the Tokyo FUR). The processed data are given in Table 9(a) in which the original census data are aggregated into the population of the core area (or core-city area)[9] and that of the suburban area. The processed data are given in Tables 9(b)~(f) which show five types of information for our empirical study: ① gross growth ratio of population between the two neighbouring census years, ② annual growth ratio of population between the two neighbouring census years, ③ estimated population in the middle year between the two neighbouring census years[10] , ④ weighted average of the annual growth ratio of population, and ⑤ simple average of the annual growth ratio of population.

Table 9 ROXY-index Analysis for the Tokyo FUR (*i.e.*, Tokyo Metropolitan Area) with the Core City of the 23 Tokyo Special Wards: 1947-2000

(a) Population (Unit: Person)

Year	1947	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Core	4177837	5385071	6969104	8310027	8893094	8840942	8646520	8351893	8354615	8163573	7967614	8134688
Suburbs	5463126	5861621	6639717	7763851	10288186	13334917	16253613	18115215	19592659	21243881	22176431	22871313
Total	9640963	11246692	13608821	16073878	19181280	22175859	24900133	26467108	27947274	29407454	30144045	31006001

(b) Gross Population Growth Ratio between the Two Neighbouring Census Years

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
Core	1.28896149	1.29415267	1.19240967	1.07016427	0.99413567	0.9780089	0.96592537	1.00032591	0.97713336	0.97599593	1.02096914
Suburbs	1.07294267	1.13274417	1.1693045	1.32513955	1.29613879	1.2188762	1.11453466	1.08155818	1.08427759	1.04389735	1.03133426
Total	1.16655276	1.21002878	1.18113671	1.19331999	1.15611987	1.12284863	1.06293039	1.05592473	1.05224767	1.02504777	1.02859457

(c) Annual Population Growth Ratio between the Two Neighbouring Census Years

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
Core	1.08829503	1.05292419	1.03582192	1.01365482	0.99882437	0.99556257	0.99309024	1.00006517	0.99538426	0.99515241	1.00415909
Suburbs	1.02374589	1.02524195	1.03177624	1.05791877	1.05324717	1.04037982	1.02192427	1.01580414	1.01631444	1.00862925	1.00618975
Total	1.05269234	1.03886506	1.03385595	1.03598003	1.0294389	1.02344437	1.01228072	1.01094282	1.01023775	1.0049601	1.0056546

(d) Estimated Population in the Middle Year between the Two Neighbouring Census Years (Unit: Person)

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
Core	4743200.28	6126101.52	7610088.2	8596618.59	8866979.66	8743190.6	8497929.74	8353253.89	8258541.6	8064998.36	8050717.61
Suburbs	5658866.86	6238549.88	7179817.09	8937334.23	11712903.4	14722112	17159186.9	18839459.4	20401571.4	21705148.3	22521192.1
Total	10412921.8	12371508.3	14790082.1	17558973.6	20624290.6	23498549.7	25671667.4	27197123.4	28668068.9	29773471.7	30571985.4

(e) Weighted Average of Annual Growth Ratio (WAGR) (Weighting Factors : One for Core City and Zero for Suburbs)

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
WAGR	1.08829503	1.05292419	1.03582192	1.01365482	0.99882437	0.99556257	0.99309024	1.00006517	0.99538426	0.99515241	1.00415909

(f) Simple Average of Annual Growth Ratio (SAGR)

Period	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
SAGR	1.05602046	1.03908307	1.03379908	1.0357868	1.02603577	1.0179712	1.00750726	1.00793466	1.00584935	1.00189083	1.00517442

(g) ROXY-index Value (ROXY) and Its Marginal Value with Respect to Time ($\Delta R/\Delta T$)

Year	1948.5	1952.5	1957.5	1962.5	1967.5	1972.5	1977.5	1982.5	1987.5	1992.5	1997.5
ROXY	305.624479	133.205135	19.5670355	-213.67308	-265.20907	-220.13023	-143.09591	-78.075315	-104.04233	-67.257009	-10.101044
$\Delta R/\Delta T$	-43.104836	-31.78416	-34.687822	-28.477611	-0.6457144	12.211316	14.2054912	3.9053579	1.08183063	9.3941287	11.4311928

[Note]
The 1995-version of the Tokyo Functional Urban Region (*i.e.*,Tokyo Metropolitan Area) consists of 156 localities. It is divided into two areas; ① Functional Urban Core <FUC> (*i.e.*,Core or Core-city) area and ② Suburban area. The Core area comprises the 23 Tokyo special wards.

4.2.2. Obtained Results: Value of Roxy Index and Its Marginal Value

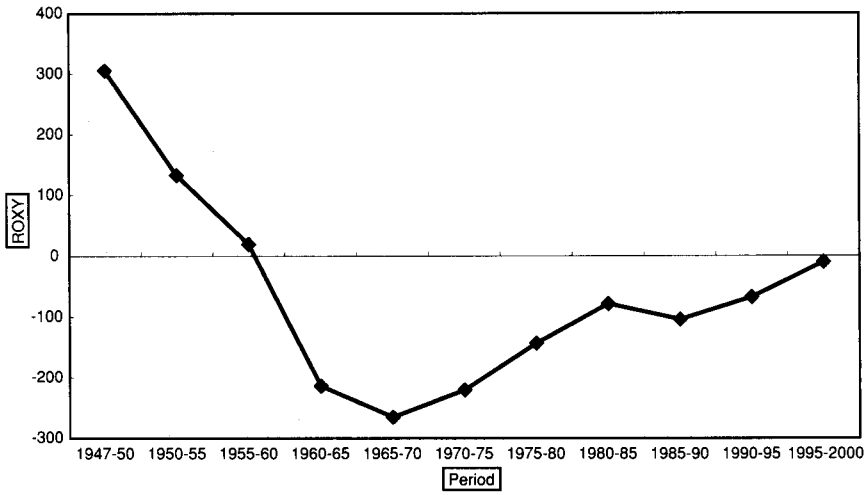
Table 9(g) shows the Roxy-index value (ROXY) and its marginal value with respect to time ($\Delta R/\Delta T$)[11] calculated based on Tables 9(e) and (f). From Table 9(g), we can draw Figures 6 and 7 demonstrating the wavelike-cyclic curve and circular-cyclic curve respectively to show diagrammatically spatial-cycle path which the Tokyo FUR has followed since 1947 until 2000.

These Figures together with Table 9(g) describe the following five points concerning the spatial-cycle stage of the Tokyo FUR:

1) The Tokyo FUR system abided at the stage of decelerating decentralization until the late 1950s after the World War II.
2) The Tokyo FUR stayed at the stage of accelerating decentralization from the end of the late 1950s to the late 1960s.

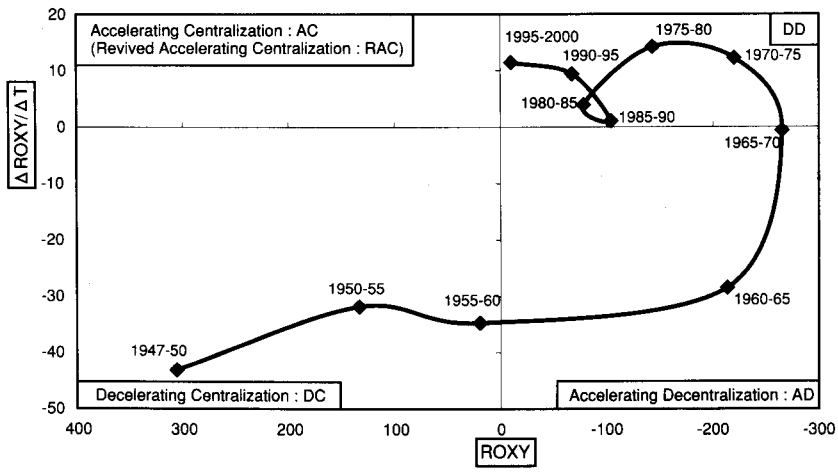
3) The Tokyo FUR came in the stage of decelerating decentralization towards the end of the 1960s.
4) The Tokyo FUR is presently approaching the end of the stage of decelerating decentralization.
5) The Tokyo FUR is likely to get out of the decentralization [12] and to go into the stage of revived centralization [13] before it takes too long.

Figure 6 Spatial Cycles for the Tokyo FUR (*i.e.*,Tokyo Metropolitan Area): 1947-2000 (Wavelike-cyclic Form)



[Note] The Functinal Urban Core (FUC) of the Tokyo Functional Urban Region (FUR) comprises the 23 Tokyo special wards.

Figure 7 Spatial Cycles for the Tokyo FUR (*i.e.*,Tokyo Metropolitan Area): 1947-2000 (Circular-cyclic Form)



[Notes]
(1) The Functional Urban Core (FUC) of the Tokyo Functional Urban Region (FUR) comprises the 23 Tokyo special wards.
(2) DD: Decelerating Decentralization

5. Conclusion

In the previous section, we obtained the following information on the recent state of the spatial cycles from the results of our Roxy-index analysis:

(1) The core-city system (the FUC system) of Japan seems to have reached the stage of revived concentration towards the end of the last century for the first time after the World War II.
(2) The Tokyo Metropolitan Area (the Tokyo FUR) seems to be completing the stage of decentralization ready to move into the stage of revived centralization in the rather near future.

This information can be restated as follows:

(1) The core cities (core areas) of the larger population metropolitan areas will have increasingly stronger dynamic forces to draw people into them than those of the medium or smaller metropolitan areas.
(2) The core area of the Tokyo Metropolitan Area will have a stronger dynamic force to draw people into itself than its suburban area in drawing people into the suburban area.
(3) The core area of the Tokyo Metropolitan Area will therefore play an increasingly critical role in the domain of the "urban investment" policy-making and programmes synergistically effected by the common-direction vectors of both revived concentration and revived centralization[14].

In conclusion, taking a middle or long-term view in the light of the aforementioned, it will be necessary for significant investment to be made in the core area of the Tokyo Metropolitan Area in order (1) to accommodate satisfactorily the demand for urban services which is expected to increase in the core area in due course, and (2) to enable society to benefit effectively from the urban agglomeration economies stemming from the process of the (a) revived concentration of population and (b) revived centralization of population in the core area both of which will take place driven by the spatial-cycle dynamism.

The results of the present empirical study and the conclusion drawn from it may hopefully help us (1) to get a better insight into the characteristics of urban dynamism in association with the spatial-cycle processes, and (2) to design more appropriate middle on long-term urban policies for the Tokyo Metropolitan Area.[15]

Notes

1) For the definitions of the FUC and FUR in detail, see Kawashima and Hiraoka (1995). The FURs in Japan were originelly delineated in the middle of the 1970s, with the intention of delineating the boundaries of functionally meaningful metropolitan areas corresponding to the Standard Metropolitan Statistical Areas (SMSAs) or the Metropolitan Statistical Areas (MSAs) in the U.S.A. Since then the FURs have been set up several times to get the newest version of the delineation of FUR boundaries.

See Glickman (1979) for the background to the early work on delineating Japanese FURs and data arrangements for them. This paper employs the 1995-version of the FURs in Japan the geographical boundaries of which are delineated by the Mitsubishi Research Institute (1999). The FUC is the central core city (or a set of central core cities) of the FUR.

2) The original spatial-cycle hypothesis is a conceptual framework which considers the processes of urban growth and decline as more or less self-embedded cyclical dynamic phenomena of the urban mechanism itself. For an early discussion on the spatial-cycle hypothesis, see Klaassen and Paelinck (1979), and Klaassen, Bourdrez and Volmuller (1981). This original framework tries to indicate the existence of the intra-metropolitan spatial-cycle path in terms of the absolute change in the population levels of spatial units comprising a specific metropolitan area. This framework has been revised and later extended by the author and his research collaborators, without losing its original unique and valuable conceptual essence, to the implied existence of the inter-metropolitan spatial cycles as well as to the use of the growth ratio of population instead of the absolute changes in population levels.

3) See Table A-0 for the two-stage and eight-stage schemes as well as for the four-stage scheme.

4) The basic concept of the Roxy index was initiated and applied in an empirical study by Kawashima (1978, pp.9, 13 and 14). Since then, the method of Roxy-index analysis has been furthermore developed and applied in a number of empirical studies to examine the spatial-cycle phenomena associated with the changes in the population and other social and economic variables for the various systems of spatial units. In parallel with these studies, some theoretical examinations have also been carried out on the fundamental characteristics peculiar to the Roxy index. See Kawashima (1981, pp.10-12; and 1982, pp.26-30), for example, as one of the early-stage studies of the Roxy-index. See also Appendix B for a list of publications and presentations by Kawashima (including those with collaborators) which discuss the Roxy index or apply it to empirical studies.

5) The neutrality of the pattern of the spatial redistributions means that the spatial-cycle stage corresponds to the phenomena of neither concentration (or centralization) nor deconcentration (or decentralization). That is, this concept corresponds to the phenomena of symmetric growth or decline as explained in the notes of Tables 6 and 7.

6) The data source for Tables A-1 is the Mitsubishi Research Institute (1999).

7) More precisely speaking, it means the "decelerating deconcentration."

8) More precisely speaking, it means the "revived accelerating concentration."

9) The core area comprises the twenty-three (23) Tokyo special wards.

10) This information is not employed for the present study.

11) That is, $\Delta ROXY/\Delta T$

12) More precisely speaking, it means the "decelerating decentralization."

13) More precisely speaking, it means the "revived accelerating centralization (RAC)."

14) More precisingly speaking, "possible revived centralization."

15) The scientific attitude in which we try to find *external explaining variables for a specific explained variable* is tremendously important. However, at the same time, the author wonders whether there are not a few phenomena for which we can not successfully discover any reasonable causal relations perhaps since there are no such relations exist at all. As for such phenomena, it might be appropriate

for us to tackle the basic characteristics of those phenomena by suspecting the possible existence of a self-embedded mechanism within the phenomena which are administered by various sorts of *internal genes* that we can neither easily detect nor externally manipulate. This type of approach might contribute to open newly our minds to grasp the so-far-well-hidden but important "non-causal"-relationship factors of the above-mentioned phenomena. As a matter of fact, the more the authors has investigated the behaviours of the laevorotatory spatial-cycle paths through the Roxy-index analytical methods, the more he has become inclined to think that the urban system itself may have its own powerfully built-in urban genes which fascinatingly govern the urban spatial cycles.

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Appendix A

Table A-0 Three Sets of Recurrently Transmuting Stages of Spatial Cycles: For the Scheme of Concentration and Deconcentration

T		F		E	
Two Major Stages		Four Major Stages		Eight Major Stages	
T-1	Concentration	F-1	Accelerating concentration	E-1	First half of accelerating concentration
				E-2	Second half of accelerating concentration
		F-2	Decelerating concentration	E-3	First half of decelerating concentration
				E-4	Second half of decelerating concentration
T-2	Deconcentration	F-3	Accelerating deconcentration	E-5	First half of accelerating deconcentration
				E-6	Second half of accelerating deconcentration
		F-4	Decelerating deconcentration	E-7	First half of decelerating deconcentration
				E-8	Second half of decelerating deconcentration

[Notes]

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

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

(3) For the four-stage cycle represented in the column E, the spatial-cycle path follows the resurrently 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,···.

(4) The stage of concentration is called the stage of revived accelerating concentration when the spatial-cycle path arrives at the stage of accelerating concentration 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 accelerating concentration.

(5) The table for the scheme of centralization and decentralization can be obtained by substituting in this table the term of "concentration" by "centralization" and term of "deconcentration" by "decentralization."

(6) The following terms were used in the original Klaassen framework to describe the four major stages represented in the column F; reurbanization (for F-1), urbanization (for F-2), suburbanization (for F-3) and counter-urbanization (for F-4).

[Source] Constructed from Fukatsu and Kawashima (1999)

Table A-1 Population of FUCs: 1947-2000

(unit: person)

Code No.	Functional Urban Core	1947	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
29	Tokyo	4,177,837	5,385,071	6,969,104	8,310,027	8,893,094	8,840,942	8,646,520	8,351,893	8,354,615	8,163,573	7,967,614	8,134,688
54	Osaka	1,900,449	2,327,286	2,909,476	3,466,087	3,833,368	3,806,167	3,625,358	3,474,270	3,459,044	3,441,789	3,417,465	3,401,814
47	Nagoya	1,008,931	1,193,780	1,457,936	1,740,563	1,996,307	2,115,659	2,177,185	2,191,135	2,229,665	2,279,234	2,289,349	2,314,679
27	Kitakanto	836,343	862,973	883,929	892,166	950,864	1,026,264	1,098,280	1,150,893	1,197,633	1,224,717	1,228,848	1,232,506
53	Kyoto	1,031,679	1,119,697	1,219,226	1,284,818	1,365,007	1,419,165	1,461,059	1,473,065	1,479,218	1,461,103	1,463,822	1,467,785
64	Shimonoseki-Kitakyushu	810,576	942,952	1,101,828	1,233,719	1,297,064	1,301,045	1,325,035	1,334,035	1,325,571	1,289,090	1,279,393	1,263,860
55	Kobe	693,971	820,956	986,311	1,113,937	1,216,614	1,288,901	1,360,565	1,367,390	1,410,834	1,477,410	1,423,792	1,493,398
75	Fukuoka	416,322	487,885	591,868	682,365	769,176	871,717	1,002,201	1,088,588	1,160,440	1,237,062	1,284,795	1,341,470
1	Sapporo	342,133	393,770	487,446	615,684	821,272	1,010,177	1,240,613	1,401,757	1,542,979	1,671,742	1,757,025	1,822,368
62	Hiroshima-Kure	555,448	616,082	696,180	768,020	882,379	981,480	1,095,266	1,133,948	1,270,606	1,302,428	1,318,373	1,329,398
13	Sendai	331,570	380,217	414,775	459,876	520,059	598,950	709,326	792,036	857,335	918,398	971,297	1,008,130
61	Okayama-Kurashiki	552,539	581,652	622,716	654,048	707,412	815,216	906,226	949,550	986,111	1,008,423	1,038,593	1,056,933
77	Kurume-Saga	261,149	278,758	303,762	311,532	320,315	337,640	356,740	380,737	391,099	398,310	405,664	404,498
43	Gifu-Ogaki	311,538	337,377	383,350	427,153	484,470	520,683	549,146	553,508	557,653	558,605	556,893	552,997
34	Toyama-Takaoka	332,418	355,189	373,921	392,674	411,040	428,940	459,764	480,110	489,907	496,720	498,982	497,884
31	Niigata	261,945	281,676	301,001	325,018	356,302	383,919	423,188	457,785	475,630	486,097	494,769	501,431
80	Kumamoto	334,817	358,548	400,240	424,580	455,249	488,051	528,086	568,820	601,367	626,707	650,341	662,012
44	Shizuoka	245,923	275,284	316,488	350,897	382,799	416,378	446,952	458,341	468,362	472,196	474,092	469,695
49	Kariya-Toyota-Anjo	197,859	205,193	214,728	230,566	282,897	379,172	455,973	511,094	553,573	594,713	615,848	641,979
56	Himeji	270,606	286,312	309,335	334,520	373,653	408,353	436,086	446,256	452,917	454,360	470,986	478,309
26	Utsunomiya	201,015	211,211	227,094	239,007	265,696	301,231	344,420	377,746	405,375	426,795	435,357	443,808
45	Hamamatsu	259,421	288,845	332,452	365,652	402,463	443,352	480,376	503,213	527,259	547,875	561,606	582,095
46	Numazu	237,994	252,695	274,001	299,803	335,816	369,677	398,520	409,446	426,180	433,222	441,428	441,745
86	Kagoshima	241,592	269,560	314,011	334,643	371,129	403,340	456,827	505,360	530,502	536,752	546,282	552,098
70	Takamatsu	189,274	211,302	229,475	243,538	257,716	274,367	298,999	316,661	326,999	329,684	331,004	332,865
50	Tsu-Ise-Matsusaka	282,388	296,394	310,807	313,988	324,723	336,260	353,388	364,093	373,031	380,066	388,237	387,118
57	Wakayama	225,081	243,520	265,244	285,155	328,657	365,267	389,717	400,802	401,352	396,553	393,885	386,551
87	Naha	—	108,673	171,694	223,060	257,190	276,394	295,006	295,778	303,674	304,836	301,890	301,032
69	Tokushima	159,298	177,363	192,642	203,326	213,328	223,451	239,281	249,343	257,884	263,356	268,706	268,218
78	Nagasaki	254,954	300,522	349,121	387,910	411,733	427,083	450,194	447,091	449,382	444,599	438,635	423,167
37	Fukui	155,730	175,109	183,275	193,858	205,501	215,137	231,364	240,962	250,261	252,743	255,604	252,274
63	Fukuyama	191,448	199,114	206,601	218,766	238,083	289,043	329,714	346,030	360,261	365,612	374,517	378,789
48	Toyohashi	169,594	185,984	202,985	215,515	238,672	258,547	284,585	304,273	322,142	337,982	352,982	364,856
82	Oita	177,389	186,136	200,204	207,151	226,417	260,584	320,237	360,478	390,096	408,501	426,979	436,470
23	Mito	108,770	117,403	128,213	139,380	154,973	173,789	197,953	215,566	228,985	234,968	246,347	246,739
35	Kanazawa	266,493	283,863	299,911	313,114	335,830	361,382	395,268	417,684	430,481	442,868	453,975	456,438
39	Nagano	243,046	248,653	253,430	257,071	269,160	285,355	306,637	324,360	336,973	347,026	358,516	360,112
38	Kofu	125,140	139,037	154,501	160,963	172,457	182,669	193,879	199,262	202,405	200,626	201,124	196,154
74	Kochi	151,923	166,531	184,728	200,817	222,791	248,121	280,962	300,822	312,241	317,069	321,999	330,654
16	Yamagata	174,595	180,579	183,763	188,560	193,737	204,127	219,773	237,041	245,158	249,487	254,488	255,369
25	Tuchiura-Tsukuba	154,661	153,395	154,002	147,463	151,544	161,607	185,229	223,063	247,672	270,867	288,255	300,680
21	Koriyama	185,924	195,798	206,049	213,825	223,236	241,726	264,628	286,451	301,673	314,642	326,833	334,824
30	Hiratsuka-Atsugi	122,535	130,176	143,762	154,522	196,319	246,565	304,590	359,685	405,590	443,233	462,449	472,002
51	Yokkaichi	156,475	167,810	179,454	195,974	218,981	229,234	247,001	255,442	263,001	274,180	285,779	291,105
71	Matsuyama	198,409	215,083	241,000	262,044	290,662	322,902	367,323	401,703	426,658	443,322	460,968	473,379
15	Akita	161,348	173,029	190,202	203,661	216,607	235,873	261,246	284,863	296,400	302,362	311,948	317,625
19	Fukushima	179,911	189,626	201,375	205,435	213,412	227,455	246,535	262,837	270,762	277,528	285,754	291,121
40	Matsumoto	148,401	150,091	155,663	158,183	164,927	175,049	185,595	192,085	197,340	200,715	205,523	208,970
32	Nagaoka	128,610	135,366	143,604	148,254	154,752	162,262	171,742	180,259	183,756	185,938	190,470	193,414
2	Hakodate	239,600	252,756	267,945	271,172	281,029	292,286	307,453	320,154	319,194	307,249	298,881	287,637
83	Miyazaki	129,700	142,137	156,886	166,360	182,869	202,861	234,346	264,855	279,114	287,352	300,068	305,755
3	Asahikawa	164,230	184,242	214,479	239,636	271,930	297,189	320,526	352,619	363,631	359,071	360,568	359,536
12	Morioka	130,158	141,805	157,254	171,838	191,901	212,690	237,705	258,740	272,776	278,497	286,478	288,843
11	Hachinohe	117,806	133,263	149,938	174,348	189,387	208,801	224,366	238,179	241,430	241,057	242,654	241,920
79	Sasebo	206,072	227,736	263,884	262,484	247,069	247,898	250,729	251,187	250,633	244,677	244,909	240,838
24	Hitachi	115,143	121,686	135,368	161,226	179,703	193,210	202,383	204,596	206,074	202,141	199,244	193,353
22	Iwaki	313,785	340,260	351,440	345,663	333,881	327,164	330,213	342,074	350,569	355,812	360,598	360,138
10	Hirosaki	131,959	139,784	147,107	150,702	151,624	157,603	164,911	175,330	176,082	174,704	177,972	177,086
60	Matsue	94,111	97,307	103,771	106,476	110,534	118,005	127,440	135,568	140,005	142,956	147,416	152,616
76	Omuta	166,438	191,978	201,737	205,766	193,875	175,143	165,969	163,000	159,424	150,453	145,085	138,629
9	Aomori	153,138	173,907	197,812	210,883	224,433	240,063	264,222	287,594	294,045	287,808	294,167	297,859
20	Aizuwakamatsu	92,262	93,687	97,885	99,546	102,239	104,065	108,650	114,528	118,140	119,080	119,640	118,118
33	Jyoetsu	115,743	113,552	117,069	116,542	119,318	120,410	123,418	127,842	130,659	130,116	132,205	134,751
28	Oyama	82,144	82,908	83,785	83,481	90,658	105,374	120,290	127,226	134,217	142,262	150,115	155,198
66	Yamaguchi	93,737	96,008	99,660	101,916	98,977	101,041	106,099	114,744	124,213	129,461	135,579	140,447
52	Hikone	76,627	77,606	75,873	72,931	74,549	78,753	85,066	83,701	94,204	99,519	103,508	107,860
67	Tokuyama	73,289	77,603	82,712	87,382	93,472	98,520	106,967	111,469	112,638	110,900	108,671	104,672
59	Yonago	87,537	91,404	97,735	99,737	103,985	109,096	118,332	127,374	131,792	131,453	134,762	138,756
4	Muroran	96,722	110,443	123,533	145,679	161,252	162,059	158,715	150,199	136,208	117,855	109,766	103,278
6	Obihiro	61,912	67,552	92,442	100,915	117,253	131,568	141,774	153,861	162,932	167,384	171,715	173,030
58	Tottori	95,168	100,222	107,483	107,350	108,823	113,151	122,312	131,060	137,060	142,467	146,330	150,439
5	Kushiro	73,521	93,357	119,536	150,624	174,105	191,948	206,840	214,694	214,541	206,639	199,323	191,739
65	Ube	126,720	146,891	160,020	166,632	158,986	152,935	161,969	168,958	174,729	175,053	175,116	174,416
84	Miyakonojo	111,539	116,487	122,708	121,497	118,582	114,799	118,289	129,009	132,098	130,153	132,714	131,922
41	Ueda	95,661	95,554	94,384	94,275	96,539	99,499	105,151	111,540	116,178	119,435	123,284	125,368
14	Ishinomaki	84,441	85,939	89,891	93,698	98,240	106,681	115,085	120,699	122,674	121,976	121,208	119,818
72	Imabari	84,467	92,587	96,654	100,082	104,470	111,125	119,726	123,234	125,115	123,114	120,214	117,930
81	Yatsushiro	85,796	91,055	99,412	103,488	102,511	101,866	103,691	108,194	108,790	108,135	107,709	106,141
73	Niihama	106,665	115,058	120,863	125,688	125,155	126,033	131,712	132,339	132,184	129,149	127,917	125,537
36	Komatsu	87,302	89,589	88,507	89,085	91,163	95,684	100,273	104,329	106,041	106,075	107,965	108,622
18	Sakata	89,752	93,724	96,740	97,675	95,986	96,072	97,723	102,600	101,392	100,811	101,230	101,311
68	Iwakuni	75,651	79,439	90,607	100,346	105,931	106,116	111,069	112,525	111,833	109,530	107,386	105,762
85	Nobeoka	88,968	103,986	116,762	122,527	124,000	128,292	134,521	136,598	136,381	130,624	126,629	124,761
17	Tsuruoka	92,644	95,968	98,589	96,312	95,615	95,136	95,932	99,751	100,200	99,889	100,538	100,628
42	Iida	95,458	95,653	93,158	89,873	88,021	87,398	89,320	91,848	106,731	106,495	106,772	107,381
8	Tomakomai	30,760	39,226	51,319	62,384	81,812	101,573	132,477	151,967	158,061	160,118	169,328	172,086
7	Kitami	47,277	52,596	59,437	66,932	74,841	82,727	91,519	102,915	107,281	107,247	110,452	112,040
	Total	24,339,975	27,788,481	32,147,268	35,862,039	38,940,571	40,935,502	42,941,741	44,074,710	45,327,321	45,852,801	46,187,597	46,751,727

[Notes] (1) FUC: Functional Urban Core (*i.e.*, Core City)
(2) FUR: Functional Urban Region (*i.e.*, Metropolitan Area)
(3) FUCs are sorted by the population size of their corresponding FURs.
(4) The Tokyo FUC in this table comprises the twenty-three (23) Tokyo special wards.

Table A-2 Gross Population Growth Ratio between the Two Neighbouring Census Years for FUCs: 1947-2000

Code No	Functional Urban Core	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
29	Tokyo	1.2890	1.2942	1.1924	1.0702	0.9941	0.9780	0.9659	1.0003	0.9771	0.9760	1.0210
54	Osaka	1.2246	1.2502	1.1913	1.1060	0.9929	0.9525	0.9583	0.9956	0.9950	0.9929	0.9954
47	Nagoya	1.1832	1.2213	1.1939	1.1469	1.0598	1.0291	1.0064	1.0176	1.0222	1.0044	1.0111
27	Kitakanto	1.0318	1.0243	1.0093	1.0658	1.0793	1.0702	1.0479	1.0406	1.0226	1.0034	1.0030
53	Kyoto	1.0853	1.0889	1.0538	1.0624	1.0397	1.0295	1.0082	1.0042	0.9878	1.0019	1.0027
64	Shimonoseki-Kitakyushu	1.1633	1.1685	1.1197	1.0513	1.0031	1.0184	1.0068	0.9937	0.9725	0.9925	0.9879
55	Kobe	1.1830	1.2014	1.1294	1.0922	1.0594	1.0556	1.0050	1.0318	1.0472	0.9637	1.0489
75	Fukuoka	1.1719	1.2131	1.1529	1.1272	1.1333	1.1497	1.0862	1.0660	1.0660	1.0386	1.0441
1	Sapporo	1.1509	1.2379	1.2631	1.3339	1.2300	1.2281	1.1299	1.1007	1.0835	1.0510	1.0372
62	Hiroshima-Kure	1.1092	1.1300	1.1032	1.1489	1.1123	1.1159	1.0353	1.1205	1.0250	1.0122	1.0084
13	Sendai	1.1467	1.0909	1.1087	1.1309	1.1517	1.1843	1.1166	1.0824	1.0712	1.0576	1.0379
61	Okayama-Kurashiki	1.0527	1.0706	1.0503	1.0816	1.1524	1.1116	1.0478	1.0385	1.0226	1.0299	1.0177
77	Kurume-Saga	1.0674	1.0897	1.0256	1.0282	1.0541	1.0566	1.0673	1.0272	1.0184	1.0185	0.9971
43	Gifu-Ogaki	1.0829	1.1363	1.1143	1.1342	1.0747	1.0547	1.0079	1.0075	1.0017	0.9969	0.9930
34	Toyama-Takaoka	1.0685	1.0527	1.0502	1.0468	1.0435	1.0719	1.0443	1.0204	1.0139	1.0046	0.9978
31	Niigata	1.0753	1.0686	1.0798	1.0963	1.0775	1.1023	1.0818	1.0390	1.0220	1.0178	1.0135
80	Kumamoto	1.0709	1.1163	1.0608	1.0722	1.0721	1.0820	1.0771	1.0572	1.0421	1.0377	1.0179
44	Shizuoka	1.1194	1.1497	1.1087	1.0909	1.0877	1.0734	1.0255	1.0219	1.0082	1.0040	0.9907
49	Kariya-Toyota-Anjo	1.0371	1.0465	1.0738	1.2270	1.3403	1.2025	1.1209	1.0831	1.0743	1.0355	1.0424
56	Himeji	1.0580	1.0804	1.0814	1.1170	1.0929	1.0679	1.0233	1.0149	1.0032	1.0366	1.0155
26	Utsunomiya	1.0507	1.0752	1.0525	1.1117	1.1337	1.1434	1.0968	1.0731	1.0528	1.0201	1.0194
45	Hamamatsu	1.1134	1.1510	1.0999	1.1007	1.1016	1.0835	1.0475	1.0478	1.0391	1.0251	1.0365
46	Numazu	1.0618	1.0843	1.0942	1.1201	1.1008	1.0780	1.0274	1.0409	1.0165	1.0189	1.0007
86	Kagoshima	1.1158	1.1649	1.0657	1.1090	1.0868	1.1326	1.1062	1.0498	1.0118	1.0178	1.0106
70	Takamatsu	1.1164	1.0860	1.0613	1.0582	1.0646	1.0898	1.0591	1.0326	1.0082	1.0040	1.0056
50	Tsu-Ise-Matsusaka	1.0474	1.0486	1.0102	1.0342	1.0355	1.0509	1.0303	1.0245	1.0189	1.0215	0.9971
57	Wakayama	1.0819	1.0892	1.0751	1.1526	1.1114	1.0669	1.0284	1.0014	0.9880	0.9933	0.9814
87	Naha	—	1.5799	1.2992	1.1530	1.0747	1.0673	1.0026	1.0267	1.0038	0.9903	0.9972
69	Tokushima	1.1134	1.0861	1.0555	1.0492	1.0475	1.0708	1.0421	1.0343	1.0212	1.0203	0.9982
78	Nagasaki	1.1787	1.1617	1.1111	1.0614	1.0373	1.0541	0.9931	1.0051	0.9894	0.9866	0.9647
37	Fukui	1.1244	1.0466	1.0577	1.0601	1.0469	1.0754	1.0415	1.0386	1.0099	1.0113	0.9870
63	Fukuyama	1.0400	1.0376	1.0589	1.0883	1.2140	1.1407	1.0495	1.0411	1.0149	1.0244	1.0114
48	Toyohashi	1.0966	1.0914	1.0617	1.1074	1.0833	1.1007	1.0692	1.0587	1.0492	1.0444	1.0336
82	Oita	1.0493	1.0756	1.0347	1.0930	1.1509	1.2289	1.1257	1.0822	1.0472	1.0452	1.0222
23	Mito	1.0794	1.0921	1.0871	1.1119	1.1214	1.1390	1.0890	1.0623	1.0261	1.0484	1.0016
35	Kanazawa	1.0652	1.0565	1.0440	1.0725	1.0761	1.0938	1.0567	1.0306	1.0288	1.0251	1.0054
39	Nagano	1.0231	1.0192	1.0144	1.0470	1.0602	1.0746	1.0578	1.0389	1.0298	1.0331	1.0045
38	Kofu	1.1111	1.1112	1.0418	1.0714	1.0592	1.0614	1.0278	1.0158	0.9912	1.0025	0.9753
74	Kochi	1.0962	1.1093	1.0871	1.1094	1.1137	1.1324	1.0707	1.0380	1.0155	1.0155	1.0269
16	Yamagata	1.0343	1.0176	1.0261	1.0275	1.0536	1.0766	1.0786	1.0342	1.0177	1.0200	1.0035
25	Tuchiura-Tsukuba	0.9918	1.0040	0.9575	1.0277	1.0664	1.1462	1.2043	1.1103	1.0937	1.0642	1.0431
21	Koriyama	1.0531	1.0524	1.0377	1.0440	1.0828	1.0947	1.0825	1.0531	1.0430	1.0387	1.0244
30	Hiratsuka-Atsugi	1.0624	1.1044	1.0748	1.2705	1.2559	1.2353	1.1809	1.1276	1.0928	1.0434	1.0207
51	Yokkaichi	1.0724	1.0694	1.0921	1.1174	1.0468	1.0775	1.0342	1.0296	1.0425	1.0423	1.0186
71	Matsuyama	1.0840	1.1205	1.0873	1.1092	1.1109	1.1376	1.0936	1.0621	1.0391	1.0398	1.0269
15	Akita	1.0724	1.0992	1.0708	1.0636	1.0889	1.1076	1.0904	1.0405	1.0201	1.0317	1.0182
19	Fukushima	1.0540	1.0620	1.0202	1.0388	1.0658	1.0839	1.0661	1.0302	1.0250	1.0296	1.0188
40	Matsumoto	1.0114	1.0371	1.0162	1.0426	1.0614	1.0602	1.0350	1.0274	1.0171	1.0240	1.0168
32	Nagaoka	1.0525	1.0609	1.0324	1.0438	1.0485	1.0584	1.0496	1.0194	1.0119	1.0244	1.0155
2	Hakodate	1.0549	1.0601	1.0120	1.0363	1.0401	1.0519	1.0413	0.9970	0.9626	0.9728	0.9624
83	Miyazaki	1.0959	1.1038	1.0604	1.0992	1.1093	1.1552	1.1302	1.0538	1.0295	1.0443	1.0190
3	Asahikawa	1.1219	1.1641	1.1173	1.1348	1.0929	1.0785	1.1001	1.0312	0.9875	1.0042	0.9971
12	Morioka	1.0895	1.1089	1.0927	1.1168	1.1083	1.1176	1.0885	1.0542	1.0210	1.0287	1.0083
11	Hachinohe	1.1312	1.1251	1.1628	1.0863	1.1025	1.0745	1.0616	1.0136	0.9985	1.0066	0.9970
79	Sasebo	1.1051	1.1587	0.9947	0.9413	1.0034	1.0114	1.0018	0.9978	0.9762	1.0009	0.9834
24	Hitachi	1.0568	1.1124	1.1910	1.1146	1.0752	1.0475	1.0109	1.0072	0.9809	0.9857	0.9704
22	Iwaki	1.0844	1.0329	0.9836	0.9659	0.9799	1.0093	1.0359	1.0248	1.0150	1.0135	0.9987
10	Hirosaki	1.0593	1.0524	1.0244	1.0061	1.0394	1.0464	1.0632	1.0043	0.9922	1.0187	0.9950
60	Matsue	1.0340	1.0664	1.0261	1.0381	1.0676	1.0800	1.0638	1.0327	1.0211	1.0312	1.0353
76	Omuta	1.1535	1.0508	1.0200	0.9422	0.9034	0.9476	0.9821	0.9781	0.9437	0.9643	0.9555
9	Aomori	1.1356	1.1375	1.0661	1.0643	1.0696	1.1006	1.0885	1.0224	0.9788	1.0221	1.0126
20	Aizuwakamatsu	1.0154	1.0448	1.0170	1.0271	1.0179	1.0441	1.0541	1.0315	1.0080	1.0047	0.9873
33	Jyoetsu	0.9811	1.0310	0.9955	1.0238	1.0092	1.0250	1.0358	1.0220	0.9958	1.0161	1.0193
28	Oyama	1.0093	1.0106	0.9964	1.0860	1.1623	1.1416	1.0577	1.0549	1.0599	1.0552	1.0339
66	Yamaguchi	1.0242	1.0380	1.0226	0.9712	1.0209	1.0501	1.0815	1.0825	1.0423	1.0473	1.0359
52	Hikone	1.0128	0.9777	0.9612	1.0222	1.0564	1.0802	0.9840	1.1255	1.0564	1.0401	1.0420
67	Tokuyama	1.0589	1.0658	1.0565	1.0697	1.0540	1.0857	1.0421	1.0105	0.9846	0.9799	0.9632
59	Yonago	1.0442	1.0693	1.0205	1.0426	1.0492	1.0847	1.0764	1.0347	0.9974	1.0252	1.0296
4	Muroran	1.1419	1.1185	1.1793	1.1069	1.0050	0.9794	0.9463	0.9069	0.8653	0.9314	0.9409
6	Obihiro	1.0911	1.3685	1.0917	1.1619	1.1221	1.0776	1.0853	1.0590	1.0273	1.0259	1.0077
58	Tottori	1.0531	1.0724	0.9988	1.0137	1.0398	1.0810	1.0715	1.0458	1.0394	1.0271	1.0281
5	Kushiro	1.2698	1.2804	1.2601	1.1559	1.1025	1.0776	1.0380	0.9993	0.9632	0.9646	0.9620
65	Ube	1.1592	1.0894	1.0413	0.9541	0.9619	1.0591	1.0432	1.0342	1.0019	1.0004	0.9960
84	Miyakonojo	1.0444	1.0534	0.9901	0.9760	0.9681	1.0304	1.0906	1.0239	0.9853	1.0197	0.9940
41	Ueda	0.9989	0.9878	0.9988	1.0240	1.0307	1.0568	1.0608	1.0416	1.0280	1.0322	1.0169
14	Ishinomaki	1.0177	1.0460	1.0424	1.0485	1.0859	1.0788	1.0488	1.0164	0.9943	0.9937	0.9885
72	Imabari	1.0961	1.0439	1.0355	1.0438	1.0637	1.0774	1.0293	1.0153	0.9840	0.9764	0.9810
81	Yatsushiro	1.0613	1.0918	1.0410	0.9906	0.9937	1.0179	1.0434	1.0055	0.9940	0.9961	0.9854
73	Niihama	1.0787	1.0505	1.0399	0.9958	1.0070	1.0451	1.0048	0.9988	0.9770	0.9905	0.9814
36	Komatsu	1.0262	0.9879	1.0065	1.0233	1.0496	1.0480	1.0404	1.0164	1.0003	1.0178	1.0061
18	Sakata	1.0443	1.0322	1.0097	0.9827	1.0009	1.0172	1.0499	0.9882	0.9943	1.0042	1.0008
68	Iwakuni	1.0501	1.1406	1.1075	1.0557	1.0017	1.0467	1.0131	0.9939	0.9794	0.9804	0.9849
85	Nobeoka	1.1688	1.1229	1.0494	1.0120	1.0346	1.0486	1.0154	0.9984	0.9578	0.9694	0.9852
17	Tsuruoka	1.0359	1.0273	0.9769	0.9928	0.9950	1.0084	1.0398	1.0045	0.9969	1.0065	1.0009
42	Iida	1.0020	0.9739	0.9647	0.9794	0.9929	1.0220	1.0283	1.1620	0.9978	1.0026	1.0057
8	Tomakomai	1.2752	1.3083	1.2156	1.3114	1.2415	1.3043	1.1471	1.0401	1.0130	1.0575	1.0163
7	Kitami	1.1125	1.1301	1.1261	1.1182	1.1054	1.1063	1.1245	1.0424	0.9997	1.0299	1.0144
	Total	1.1417	1.1569	1.1156	1.0858	1.0512	1.0490	1.0264	1.0284	1.0116	1.0073	1.0122

[Note] See the notes of the table for the population of FUCs.

Table A-3 Annual Population Growth Ratio between the Two Neighbouring Census Years for FUCs: 1947-2000

Code No	Functional Urban Core	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
29	Tokyo	1.0883	1.0529	1.0358	1.0137	0.9988	0.9956	0.9931	1.0001	0.9954	0.9952	1.0042
54	Osaka	1.0699	1.0457	1.0356	1.0203	0.9986	0.9903	0.9915	0.9991	0.9990	0.9986	0.9991
47	Nagoya	1.0577	1.0408	1.0361	1.0278	1.0117	1.0057	1.0013	1.0035	1.0044	1.0009	1.0022
27	Kitakanto	1.0105	1.0048	1.0019	1.0128	1.0154	1.0137	1.0094	1.0080	1.0045	1.0007	1.0006
53	Kyoto	1.0277	1.0172	1.0105	1.0122	1.0078	1.0058	1.0016	1.0008	0.9975	1.0004	1.0005
64	Shimonoseki-Kitakyushu	1.0517	1.0316	1.0229	1.0101	1.0006	1.0037	1.0014	0.9987	0.9944	0.9965	0.9976
55	Kobe	1.0576	1.0374	1.0246	1.0178	1.0116	1.0109	1.0010	1.0063	1.0093	0.9926	1.0096
75	Fukuoka	1.0543	1.0394	1.0289	1.0242	1.0253	1.0283	1.0167	1.0129	1.0129	1.0076	1.0087
1	Sapporo	1.0480	1.0436	1.0478	1.0593	1.0423	1.0420	1.0247	1.0194	1.0162	1.0100	1.0073
62	Hiroshima-Kure	1.0351	1.0247	1.0198	1.0282	1.0215	1.0222	1.0070	1.0230	1.0050	1.0024	1.0017
13	Sendai	1.0467	1.0176	1.0209	1.0249	1.0286	1.0344	1.0223	1.0160	1.0139	1.0113	1.0075
61	Okayama-Kurashiki	1.0173	1.0137	1.0099	1.0158	1.0288	1.0214	1.0094	1.0076	1.0045	1.0059	1.0035
77	Kurume-Saga	1.0220	1.0173	1.0051	1.0056	1.0106	1.0111	1.0131	1.0054	1.0037	1.0037	0.9994
43	Gifu-Ogaki	1.0269	1.0259	1.0219	1.0255	1.0145	1.0107	1.0016	1.0015	1.0003	0.9994	0.9986
34	Toyama-Takaoka	1.0223	1.0103	1.0098	1.0092	1.0086	1.0140	1.0087	1.0040	1.0028	1.0009	0.9996
31	Niigata	1.0245	1.0134	1.0155	1.0185	1.0150	1.0197	1.0158	1.0077	1.0044	1.0035	1.0027
80	Kumamoto	1.0231	1.0222	1.0119	1.0140	1.0140	1.0159	1.0150	1.0112	1.0083	1.0074	1.0036
44	Shizuoka	1.0383	1.0283	1.0209	1.0176	1.0170	1.0143	1.0050	1.0043	1.0016	1.0008	0.9981
49	Kariya-Toyota-Anjo	1.0122	1.0091	1.0143	1.0418	1.0603	1.0376	1.0231	1.0161	1.0144	1.0070	1.0083
56	Himeji	1.0190	1.0156	1.0158	1.0224	1.0179	1.0132	1.0046	1.0030	1.0006	1.0072	1.0031
26	Utsunomiya	1.0166	1.0146	1.0103	1.0214	1.0254	1.0272	1.0186	1.0142	1.0104	1.0040	1.0039
45	Hamamatsu	1.0365	1.0285	1.0192	1.0194	1.0195	1.0162	1.0093	1.0094	1.0077	1.0050	1.0072
46	Numazu	1.0202	1.0163	1.0182	1.0229	1.0194	1.0151	1.0054	1.0080	1.0033	1.0038	1.0001
86	Kagoshima	1.0372	1.0310	1.0128	1.0209	1.0168	1.0252	1.0204	1.0098	1.0023	1.0035	1.0021
70	Takamatsu	1.0374	1.0166	1.0120	1.0114	1.0126	1.0173	1.0115	1.0064	1.0016	1.0008	1.0011
50	Tsu-Ise-Matsusaka	1.0155	1.0095	1.0020	1.0067	1.0070	1.0100	1.0060	1.0049	1.0037	1.0043	0.9994
57	Wakayama	1.0266	1.0172	1.0146	1.0288	1.0213	1.0130	1.0056	1.0003	0.9976	0.9987	0.9962
87	Naha	—	1.0958	1.0537	1.0289	1.0145	1.0131	1.0005	1.0053	1.0008	0.9981	0.9994
69	Tokushima	1.0365	1.0167	1.0109	1.0097	1.0093	1.0138	1.0083	1.0068	1.0042	1.0040	0.9996
78	Nagasaki	1.0563	1.0304	1.0213	1.0120	1.0073	1.0106	0.9986	1.0010	0.9979	0.9973	0.9928
37	Fukui	1.0399	1.0092	1.0113	1.0117	1.0092	1.0146	1.0082	1.0076	1.0020	1.0023	0.9974
63	Fukuyama	1.0132	1.0074	1.0115	1.0171	1.0396	1.0267	1.0097	1.0081	1.0030	1.0048	1.0023
48	Toyohashi	1.0312	1.0176	1.0121	1.0206	1.0161	1.0194	1.0135	1.0115	1.0096	1.0087	1.0066
82	Oita	1.0162	1.0147	1.0068	1.0179	1.0285	1.0421	1.0240	1.0159	1.0093	1.0089	1.0044
23	Mito	1.0258	1.0178	1.0168	1.0214	1.0232	1.0264	1.0172	1.0122	1.0052	1.0095	1.0003
35	Kanazawa	1.0213	1.0111	1.0087	1.0141	1.0148	1.0181	1.0111	1.0061	1.0057	1.0050	1.0011
39	Nagano	1.0076	1.0038	1.0029	1.0092	1.0118	1.0145	1.0113	1.0077	1.0059	1.0065	1.0009
38	Kofu	1.0357	1.0213	1.0082	1.0139	1.0116	1.0120	1.0055	1.0031	0.9982	1.0005	0.9950
74	Kochi	1.0311	1.0210	1.0168	1.0210	1.0218	1.0252	1.0138	1.0075	1.0031	1.0031	1.0053
16	Yamagata	1.0113	1.0035	1.0052	1.0054	1.0105	1.0149	1.0152	1.0068	1.0035	1.0040	1.0007
25	Tuchiura-Tsukuba	0.9973	1.0008	0.9914	1.0055	1.0129	1.0277	1.0379	1.0212	1.0181	1.0125	1.0085
21	Koriyama	1.0174	1.0103	1.0074	1.0087	1.0160	1.0183	1.0160	1.0104	1.0085	1.0076	1.0048
30	Hiratsuka-Atsugi	1.0204	1.0201	1.0145	1.0490	1.0466	1.0432	1.0338	1.0243	1.0179	1.0085	1.0041
51	Yokkaichi	1.0236	1.0135	1.0178	1.0224	1.0092	1.0150	1.0067	1.0058	1.0084	1.0083	1.0037
71	Matsuyama	1.0273	1.0230	1.0169	1.0209	1.0213	1.0261	1.0181	1.0121	1.0077	1.0078	1.0053
15	Akita	1.0236	1.0191	1.0138	1.0124	1.0172	1.0206	1.0175	1.0080	1.0040	1.0063	1.0036
19	Fukushima	1.0177	1.0121	1.0040	1.0076	1.0128	1.0162	1.0129	1.0060	1.0049	1.0059	1.0037
40	Matsumoto	1.0038	1.0073	1.0032	1.0084	1.0120	1.0118	1.0069	1.0054	1.0034	1.0047	1.0033
32	Nagaoka	1.0172	1.0119	1.0064	1.0086	1.0095	1.0114	1.0097	1.0039	1.0024	1.0048	1.0031
2	Hakodate	1.0180	1.0117	1.0024	1.0072	1.0079	1.0102	1.0081	0.9994	0.9924	0.9945	0.9924
83	Miyazaki	1.0310	1.0199	1.0118	1.0191	1.0210	1.0293	1.0248	1.0105	1.0058	1.0087	1.0038
3	Asahikawa	1.0391	1.0309	1.0224	1.0256	1.0179	1.0152	1.0193	1.0062	0.9975	1.0008	0.9994
12	Morioka	1.0290	1.0209	1.0179	1.0223	1.0208	1.0225	1.0171	1.0106	1.0042	1.0057	1.0016
11	Hachinohe	1.0420	1.0239	1.0306	1.0167	1.0197	1.0145	1.0120	1.0027	0.9997	1.0013	0.9994
79	Sasebo	1.0339	1.0299	0.9989	0.9880	1.0007	1.0023	1.0004	0.9996	0.9952	1.0002	0.9967
24	Hitachi	1.0186	1.0215	1.0356	1.0219	1.0146	1.0093	1.0022	1.0014	0.9962	0.9971	0.9940
22	Iwaki	1.0274	1.0065	0.9967	0.9931	0.9959	1.0019	1.0071	1.0049	1.0030	1.0027	0.9997
10	Hirosaki	1.0194	1.0103	1.0048	1.0012	1.0078	1.0091	1.0123	1.0009	0.9984	1.0037	0.9990
60	Matsue	1.0112	1.0129	1.0052	1.0075	1.0132	1.0155	1.0124	1.0065	1.0042	1.0062	1.0070
76	Omuta	1.0487	1.0100	1.0040	0.9882	0.9799	0.9893	0.9964	0.9956	0.9885	0.9928	0.9909
9	Aomori	1.0433	1.0261	1.0129	1.0125	1.0136	1.0194	1.0171	1.0044	0.9957	1.0044	1.0025
20	Aizuwakamatsu	1.0051	1.0088	1.0034	1.0054	1.0035	1.0087	1.0106	1.0062	1.0016	1.0009	0.9974
33	Jyoetsu	0.9936	1.0061	0.9991	1.0047	1.0018	1.0049	1.0071	1.0044	0.9992	1.0032	1.0038
28	Oyama	1.0031	1.0021	0.9993	1.0166	1.0305	1.0268	1.0113	1.0108	1.0117	1.0108	1.0067
66	Yamaguchi	1.0080	1.0075	1.0045	0.9942	1.0041	1.0098	1.0158	1.0160	1.0083	1.0093	1.0071
52	Hikone	1.0042	0.9955	0.9921	1.0044	1.0110	1.0155	0.9968	1.0239	1.0110	1.0079	1.0083
67	Tokuyama	1.0192	1.0128	1.0110	1.0136	1.0106	1.0166	1.0083	1.0021	0.9969	0.9959	0.9925
59	Yonago	1.0145	1.0135	1.0041	1.0084	1.0096	1.0164	1.0148	1.0068	0.9995	1.0050	1.0059
4	Muroran	1.0452	1.0227	1.0335	1.0205	1.0010	0.9958	0.9890	0.9806	0.9715	0.9859	0.9879
6	Obihiro	1.0295	1.0647	1.0177	1.0305	1.0233	1.0151	1.0165	1.0115	1.0054	1.0051	1.0015
58	Tottori	1.0174	1.0141	0.9998	1.0027	1.0078	1.0157	1.0139	1.0090	1.0078	1.0054	1.0056
5	Kushiro	1.0829	1.0507	1.0473	1.0294	1.0197	1.0151	1.0075	0.9999	0.9925	0.9928	0.9923
65	Ube	1.0505	1.0173	1.0081	0.9906	0.9923	1.0115	1.0085	1.0067	1.0004	1.0001	0.9992
84	Miyakonojo	1.0146	1.0105	0.9980	0.9952	0.9935	1.0060	1.0175	1.0047	0.9970	1.0039	0.9988
41	Ueda	0.9996	0.9975	0.9998	1.0048	1.0061	1.0111	1.0119	1.0082	1.0055	1.0064	1.0034
14	Ishinomaki	1.0059	1.0090	1.0083	1.0095	1.0166	1.0153	1.0096	1.0033	0.9989	0.9987	0.9977
72	Imabari	1.0311	1.0086	1.0070	1.0086	1.0124	1.0150	1.0058	1.0030	0.9968	0.9952	0.9962
81	Yatsushiro	1.0200	1.0177	1.0081	0.9981	0.9987	1.0036	1.0085	1.0011	0.9988	0.9992	0.9971
73	Niihama	1.0256	1.0099	1.0079	0.9992	1.0014	1.0089	1.0010	0.9998	0.9954	0.9981	0.9963
36	Komatsu	1.0087	0.9976	1.0013	1.0046	1.0097	1.0094	1.0080	1.0033	1.0001	1.0035	1.0012
18	Sakata	1.0145	1.0064	1.0019	0.9965	1.0002	1.0034	1.0098	0.9976	0.9989	1.0008	1.0002
68	Iwakuni	1.0164	1.0267	1.0206	1.0109	1.0003	1.0092	1.0026	0.9988	0.9958	0.9961	0.9970
85	Nobeoka	1.0534	1.0234	1.0097	1.0024	1.0068	1.0095	1.0031	0.9997	0.9914	0.9938	0.9970
17	Tsuruoka	1.0118	1.0054	0.9953	0.9985	0.9990	1.0017	1.0078	1.0009	0.9994	1.0013	1.0002
42	Iida	1.0007	0.9947	0.9928	0.9958	0.9986	1.0044	1.0056	1.0305	0.9996	1.0005	1.0011
8	Tomakomai	1.0844	1.0552	1.0398	1.0557	1.0442	1.0546	1.0278	1.0079	1.0026	1.0112	1.0032
7	Kitami	1.0362	1.0248	1.0240	1.0226	1.0202	1.0204	1.0237	1.0083	0.9999	1.0059	1.0029
	Average	1.0276	1.0191	1.0131	1.0141	1.0136	1.0154	1.0105	1.0067	1.0024	1.0029	1.0011

[Note] See the notes of the table for the population of FUCs.

Table A-4 Estimated Population of FUCs in the Middle Year between the Two Neighbouring Census Years: 1947-2000

(unit: person)

Core No	Functional Urban Core	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
29	Tokyo	4,743,200	6,126,102	7,610,088	8,596,619	8,866,980	8,743,191	8,497,930	8,353,254	8,258,542	8,064,998	8,050,718
54	Osaka	2,103,066	2,602,150	3,175,610	3,645,105	3,819,743	3,714,663	3,549,010	3,466,649	3,450,406	3,429,605	3,409,631
47	Nagoya	1,097,471	1,319,263	1,592,994	1,864,054	2,055,117	2,146,202	2,184,149	2,210,316	2,254,313	2,284,286	2,301,979
27	Kitakanto	849,554	873,388	888,038	921,048	987,845	1,061,662	1,124,279	1,174,030	1,211,099	1,226,781	1,230,676
53	Kyoto	1,074,787	1,168,402	1,251,592	1,324,306	1,391,823	1,439,960	1,467,050	1,476,138	1,470,133	1,462,462	1,465,802
64	Shimonoseki-Kitakyushu	874,262	1,019,299	1,165,910	1,264,995	1,299,053	1,312,985	1,329,527	1,329,796	1,307,203	1,284,232	1,271,603
55	Kobe	754,798	899,843	1,048,183	1,164,144	1,252,236	1,324,248	1,363,973	1,388,942	1,443,738	1,450,353	1,458,180
75	Fukuoka	450,685	537,367	635,508	724,471	818,843	934,685	1,044,502	1,123,940	1,198,139	1,260,703	1,312,827
1	Sapporo	367,045	438,111	547,825	711,087	910,840	1,119,481	1,318,726	1,470,674	1,606,071	1,713,853	1,789,398
62	Hiroshima-Kure	584,980	654,908	731,218	823,216	930,611	1,036,813	1,114,439	1,200,334	1,286,419	1,310,376	1,323,874
13	Sendai	355,061	397,120	436,744	489,043	558,112	651,806	749,541	824,039	887,341	944,477	989,542
61	Okayama-Kurashiki	566,909	601,834	638,190	680,207	759,403	859,517	927,635	967,658	997,205	1,023,397	1,047,723
77	Kurume-Saga	269,810	290,992	307,622	315,893	326,863	347,059	368,543	385,883	394,688	401,970	405,081
43	Gifu-Ogaki	324,200	359,630	404,659	454,910	502,250	534,725	551,323	555,577	558,129	557,748	554,942
34	Toyama-Takaoka	343,615	364,435	383,183	401,752	419,895	444,085	469,827	484,984	493,302	497,850	498,433
31	Niigata	271,831	291,178	312,779	340,301	369,853	403,076	440,147	466,622	480,835	490,414	498,089
80	Kumamoto	346,479	378,821	412,230	439,647	471,365	507,674	548,075	584,867	613,906	638,415	656,151
44	Shizuoka	260,190	295,168	333,249	366,501	399,236	431,394	452,611	463,324	470,275	473,143	471,888
49	Kariya-Toyota-Anjo	201,493	209,906	222,506	255,395	327,516	415,803	482,747	531,910	573,774	605,188	628,778
56	Himeji	278,348	297,601	321,681	353,545	390,618	421,992	441,142	449,574	453,638	462,598	474,633
26	Utsunomiya	206,050	219,009	232,974	251,998	282,906	322,102	360,698	391,317	415,947	431,055	439,562
45	Hamamatsu	273,738	309,882	348,657	383,616	422,413	461,493	491,662	515,096	537,468	554,698	571,759
46	Numazu	245,234	263,132	286,612	317,299	352,340	383,828	403,946	417,729	429,687	437,306	441,586
86	Kagoshima	255,193	290,938	324,163	352,414	386,899	429,251	480,481	517,778	533,618	541,496	549,182
70	Takamatsu	199,985	220,201	236,402	250,527	265,911	286,418	307,703	321,788	328,339	330,343	331,933
50	Tsu-Ise-Matsusaka	289,613	303,515	312,393	319,310	330,441	344,718	358,701	368,535	376,532	384,130	387,677
57	Wakayama	234,119	254,150	275,019	306,134	346,479	377,294	395,221	401,077	398,945	395,217	390,201
87	Naha	—	136,596	195,699	239,518	266,619	285,548	295,392	299,700	304,254	303,359	301,461
69	Tokushima	168,088	184,845	197,912	208,267	218,331	231,231	244,260	253,578	260,606	266,018	268,462
78	Nagasaki	276,802	323,911	368,005	399,644	419,338	438,486	448,640	448,235	446,984	441,607	430,832
37	Fukui	165,135	179,145	188,492	199,595	210,264	223,103	236,114	245,567	251,499	254,169	253,934
63	Fukuyama	195,243	202,823	212,597	228,220	262,328	308,709	337,773	353,074	362,927	370,038	376,647
48	Toyohashi	177,600	194,299	209,156	226,798	248,411	271,254	294,264	313,080	329,967	345,401	358,870
82	Oita	181,710	193,042	203,648	216,570	242,900	288,875	339,762	374,995	399,192	417,638	431,698
23	Mito	113,004	122,689	133,680	146,970	164,112	185,478	206,572	222,174	231,957	240,590	246,543
35	Kanazawa	275,041	291,777	306,441	324,273	348,372	377,945	406,321	424,034	436,631	448,387	455,205
39	Nagano	245,834	251,030	255,244	263,046	277,139	295,805	315,374	330,606	341,963	352,724	359,313
38	Kofu	131,906	146,565	157,699	166,611	177,490	188,191	196,552	200,827	201,514	200,875	198,623
74	Kochi	159,059	175,394	192,605	211,519	235,115	264,031	290,722	306,478	314,646	319,524	326,298
16	Yamagata	177,562	182,164	186,146	191,131	198,864	211,806	228,244	241,065	247,313	251,975	254,928
25	Tuchiura-Tsukuba	154,027	153,698	150,697	149,490	156,495	173,015	203,268	235,046	259,010	279,426	294,402
21	Koriyama	190,797	200,858	209,901	218,480	232,297	252,918	275,323	293,963	308,089	320,680	330,804
30	Hiratsuka-Atsugi	126,298	136,800	149,045	174,171	220,012	274,046	330,993	381,948	423,994	452,739	467,201
51	Yokkaichi	162,043	173,534	187,532	207,158	224,049	237,952	251,186	259,194	268,532	279,919	288,430
71	Matsuyama	206,578	227,673	251,302	275,982	306,358	344,397	384,129	413,993	434,910	452,059	467,132
15	Akita	167,086	181,412	196,816	210,034	226,035	248,236	272,799	290,574	299,366	307,118	314,774
19	Fukushima	184,705	195,412	203,395	209,386	220,322	236,803	254,556	266,770	274,124	281,611	288,425
40	Matsumoto	149,244	152,852	156,918	161,520	169,913	180,245	188,812	194,695	199,020	203,105	207,239
32	Nagaoka	131,945	139,424	145,910	151,468	158,463	166,935	175,949	181,999	184,844	188,190	191,936
2	Hakodate	246,090	260,240	269,554	276,057	286,602	299,774	313,739	319,674	313,165	303,036	293,205
83	Miyazaki	135,776	149,330	161,554	174,419	192,606	218,036	249,134	271,891	283,203	293,641	302,898
3	Asahikawa	173,948	198,786	226,709	255,273	284,279	308,637	336,190	358,083	361,344	359,819	360,052
12	Morioka	135,857	149,330	164,384	181,593	202,028	224,850	248,000	265,665	275,622	282,459	287,658
11	Hachinohe	125,296	141,355	161,683	181,712	198,857	216,444	231,169	239,799	241,243	241,854	242,287
79	Sasebo	216,633	245,145	263,183	254,660	247,483	249,309	250,958	250,910	247,637	244,793	242,865
24	Hitachi	118,369	128,345	147,732	170,214	186,334	197,743	203,486	205,334	204,098	200,687	196,276
22	Iwaki	326,754	345,805	348,540	339,721	330,505	328,685	336,091	346,295	353,181	358,197	360,368
10	Hirosaki	135,815	143,399	148,894	151,162	154,585	161,216	170,041	175,706	175,392	176,330	177,528
60	Matsue	95,696	100,487	105,115	108,486	114,208	122,632	131,441	137,769	141,473	145,169	149,993
76	Omuta	178,752	196,797	203,742	199,732	184,271	170,494	164,478	161,202	154,874	147,745	141,820
9	Aomori	163,192	185,475	204,243	217,553	232,116	251,853	275,660	290,802	290,910	290,970	296,007
20	Aizuwakamatsu	92,972	95,763	98,712	100,884	103,148	106,333	111,550	116,320	118,609	119,360	118,877
33	Jyoetsu	114,642	115,297	116,805	117,922	119,863	121,905	125,611	129,243	130,387	131,156	133,472
28	Oyama	82,525	83,345	83,633	86,996	97,739	112,585	123,709	130,675	138,181	146,136	152,635
66	Yamaguchi	94,866	97,817	100,782	100,436	100,004	103,539	110,337	119,385	126,810	132,485	137,992
52	Hikone	77,115	76,735	74,387	73,736	76,622	81,849	84,381	88,797	96,825	101,494	105,662
67	Tokuyama	75,415	80,117	85,015	90,376	95,963	102,657	109,195	112,052	111,766	109,780	106,653
59	Yonago	89,450	94,517	98,731	101,839	106,510	113,620	122,770	129,564	131,622	133,097	136,744
4	Muroran	103,355	116,805	134,150	153,268	161,655	160,378	154,398	143,033	126,700	113,739	106,473
6	Obihiro	64,671	79,023	96,586	108,778	124,204	136,576	147,694	158,332	165,143	169,536	172,371
58	Tottori	97,662	103,789	107,416	108,084	110,966	117,642	126,610	134,026	139,737	144,386	148,370
5	Kushiro	82,847	105,639	134,183	161,939	182,809	199,255	210,730	214,617	210,553	202,948	195,494
65	Ube	136,433	153,315	163,293	162,764	155,931	157,387	165,427	171,819	174,891	175,084	174,766
84	Miyakonojo	113,986	119,557	122,101	120,031	116,675	116,531	123,533	130,544	131,122	131,427	132,317
41	Ueda	95,607	94,967	94,329	95,400	98,008	102,286	108,298	113,835	117,795	121,344	124,322
14	Ishinomaki	85,187	87,893	91,775	95,942	102,374	110,803	117,859	121,682	122,325	121,591	120,511
72	Imabari	88,434	94,599	98,353	102,252	107,746	115,345	121,467	124,171	124,110	121,655	119,067
81	Yatsushiro	88,386	95,142	101,430	102,998	102,188	102,774	105,919	108,492	108,462	107,922	106,922
73	Niihama	110,782	117,925	123,252	125,421	125,593	128,841	132,025	132,261	130,658	128,532	126,721
36	Komatsu	88,438	89,046	88,796	90,118	93,396	97,952	102,281	105,182	106,058	107,016	108,293
18	Sakata	91,717	95,220	97,206	96,827	96,029	96,894	100,132	101,994	101,101	101,020	101,270
68	Iwakuni	77,522	84,839	95,352	103,101	106,023	108,564	111,795	112,178	110,676	108,453	106,571
85	Nobeoka	96,184	110,189	119,610	123,261	126,128	131,370	135,556	136,489	133,471	128,611	125,692
17	Tsuruoka	94,291	97,270	97,444	95,963	95,375	95,533	97,823	99,975	100,044	100,213	100,583
42	Iida	95,555	94,397	91,501	88,942	87,709	88,354	90,575	99,010	106,613	106,633	107,076
8	Tomakomai	34,736	44,867	56,582	71,441	91,159	116,000	141,888	154,984	159,086	164,659	170,701
7	Kitami	49,866	55,912	63,073	70,776	78,685	87,012	97,050	105,075	107,264	108,838	111,243
	Total	25,936,049	29,860,765	33,934,698	37,357,461	39,907,195	41,902,789	43,489,592	44,690,295	45,583,182	46,016,061	46,466,759

[Note] See the notes of the table for the population of FUCs.

Table A-5 Weighted Annual Population Growth Ratio between the Two Neighbouring Census Years for FUCs: 1947-2000
(Weighting Factor: Population in the Middle Year between the Two Neighbouring Census Years)

Code No	Functional Urban Core	1947-50	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000
29	Tokyo	5,162,001	6,450,320	7,882,696	8,714,004	8,856,555	8,704,393	8,439,211	8,353,798	8,220,422	8,025,903	8,084,201
54	Osaka	2,250,009	2,720,980	3,288,759	3,719,274	3,814,307	3,678,680	3,518,923	3,463,605	3,446,956	3,424,744	3,406,502
47	Nagoya	1,160,773	1,379,075	1,650,458	1,915,870	2,079,123	2,158,542	2,186,941	2,218,035	2,264,249	2,286,310	2,307,051
27	Kitakanto	858,476	877,589	889,687	932,860	1,003,037	1,076,160	1,134,850	1,183,415	1,216,528	1,227,607	1,231,407
53	Kyoto	1,104,522	1,188,472	1,264,778	1,340,439	1,402,696	1,448,363	1,469,453	1,477,369	1,466,514	1,463,006	1,466,595
64	Shimonoseki-Kitakyushu	919,476	1,051,542	1,192,574	1,277,726	1,299,849	1,317,792	1,331,329	1,328,105	1,299,928	1,282,294	1,268,500
55	Kobe	798,283	933,481	1,074,006	1,184,855	1,266,775	1,338,657	1,365,339	1,397,658	1,457,114	1,439,670	1,472,166
75	Fukuoka	475,156	558,538	653,852	742,033	839,596	961,128	1,061,918	1,138,400	1,213,559	1,270,285	1,324,210
1	Sapporo	384,652	457,216	574,022	753,266	949,346	1,166,446	1,351,331	1,499,180	1,632,024	1,730,993	1,802,514
62	Hiroshima-Kure	605,535	671,115	745,722	846,390	950,634	1,059,810	1,122,202	1,227,964	1,292,799	1,313,569	1,326,081
13	Sendai	371,640	404,090	445,854	501,221	574,102	674,232	766,258	837,199	899,636	955,115	996,936
61	Okayama-Kurashiki	576,695	610,101	644,486	690,961	781,255	877,905	936,340	974,997	1,001,677	1,029,448	1,051,397
77	Kurume-Saga	275,743	296,034	309,180	317,654	332,346	350,899	373,373	387,961	396,133	403,444	404,847
43	Gifu-Ogaki	332,926	368,936	413,511	466,511	509,544	540,447	552,196	556,406	558,319	557,406	554,163
34	Toyama-Takaoka	351,288	368,200	386,951	405,442	423,490	450,291	473,913	486,947	494,666	498,302	498,213
31	Niigata	278,287	295,068	317,618	346,613	375,416	411,003	447,119	470,205	482,933	492,151	499,423
80	Kumamoto	354,479	387,247	417,127	445,823	477,970	515,742	556,280	591,412	618,995	643,159	658,489
44	Shizuoka	270,158	303,518	340,199	372,935	406,006	437,551	454,894	465,333	471,043	473,522	471,010
49	Kariya-Toyota-Anjo	203,952	211,822	225,696	266,059	347,275	431,428	493,892	540,471	582,060	609,430	634,025
56	Himeji	283,632	302,240	326,756	361,455	397,618	427,574	443,180	450,908	453,927	465,935	476,100
26	Utsunomiya	209,476	222,208	235,369	257,391	290,098	330,850	367,423	396,881	420,253	432,771	441,256
45	Hamamatsu	283,719	318,720	355,358	391,047	430,667	468,955	496,250	519,927	541,607	557,451	575,871
46	Numazu	250,183	267,427	291,817	324,580	359,175	389,638	406,137	421,089	431,097	438,950	441,650
86	Kagoshima	264,683	299,956	328,315	359,784	393,394	440,076	490,262	522,831	534,869	543,405	550,347
70	Takamatsu	207,460	223,865	239,231	253,378	269,262	291,386	311,256	323,863	328,876	330,607	332,306
50	Tsu-Ise-Matsusaka	294,116	306,411	313,030	321,465	332,757	348,160	360,848	370,327	377,942	385,767	387,453
57	Wakayama	240,345	258,531	279,030	314,952	353,875	382,215	397,444	401,187	397,987	394,684	388,737
87	Naha	—	149,680	206,216	246,436	270,487	289,295	295,546	301,283	304,487	302,771	301,289
69	Tokushima	174,216	187,925	200,060	210,277	220,365	234,418	246,281	255,291	261,702	267,090	268,364
78	Nagasaki	292,398	333,769	375,841	404,436	422,419	443,132	448,020	448,693	446,029	440,416	427,749
37	Fukui	171,719	180,786	190,620	201,937	212,200	226,371	238,042	247,434	251,996	254,742	253,268
63	Fukuyama	197,815	204,326	215,043	232,115	272,704	316,946	341,052	355,931	363,998	371,823	377,502
48	Toyohashi	183,146	197,728	211,677	231,475	252,417	276,510	298,228	316,674	333,150	348,413	361,252
82	Oita	184,649	195,875	205,042	220,456	249,825	301,033	347,902	380,964	402,890	421,350	433,601
23	Mito	115,918	124,869	135,931	150,120	167,916	190,371	210,124	224,874	233,157	242,877	246,621
35	Kanazawa	280,891	295,004	309,093	328,847	353,519	384,781	410,829	426,601	439,115	450,614	455,698
39	Nagano	247,710	251,987	255,973	265,475	280,397	300,091	318,938	333,138	343,979	355,030	359,632
38	Kofu	136,618	149,689	158,997	168,925	179,543	190,446	197,632	201,457	201,158	200,974	197,632
74	Kochi	164,002	179,069	195,848	215,958	240,234	270,678	294,721	308,771	315,613	320,512	328,033
16	Yamagata	179,568	182,802	187,108	192,169	200,953	214,957	231,723	242,694	248,180	252,977	255,104
25	Tuchiura-Tsukuba	153,605	153,820	149,395	150,308	158,520	177,801	210,966	240,017	263,689	282,925	296,897
21	Koriyama	194,117	202,919	211,462	220,370	236,024	257,538	279,722	297,023	310,694	323,127	332,406
30	Hiratsuka-Atsugi	128,870	139,544	151,212	182,714	230,272	285,878	342,184	391,235	431,587	456,598	469,116
51	Yokkaichi	165,865	175,878	190,864	211,809	226,109	241,531	252,880	260,710	270,777	282,249	289,497
71	Matsuyama	212,210	232,913	255,545	281,763	312,871	353,391	391,064	419,013	438,256	455,602	469,621
15	Akita	171,025	184,878	199,526	212,639	229,920	253,360	277,562	292,891	300,561	309,041	315,911
19	Fukushima	187,971	197,776	204,208	210,987	223,148	240,649	257,836	268,360	275,481	283,261	289,500
40	Matsumoto	149,808	153,970	157,423	162,874	171,949	182,366	190,115	195,749	199,696	204,069	207,930
32	Nagaoka	134,216	141,081	146,843	152,773	159,972	168,841	177,660	182,700	185,281	189,099	192,526
2	Hakodate	250,514	263,295	270,200	278,035	288,862	302,822	316,290	319,482	310,785	301,367	290,965
83	Miyazaki	139,984	152,307	163,459	177,751	196,644	224,419	255,307	274,758	284,855	296,195	304,038
3	Asahikawa	180,745	204,921	231,794	261,810	289,374	313,339	342,668	360,292	360,433	360,118	359,845
12	Morioka	139,794	152,450	167,326	185,648	206,227	229,906	252,241	268,487	276,768	284,060	288,131
11	Hachinohe	130,553	144,728	166,635	184,744	202,777	219,578	233,948	240,450	241,169	242,174	242,140
79	Sasebo	223,973	252,475	262,903	251,596	247,649	249,876	251,050	250,799	246,449	244,839	242,052
24	Hitachi	120,570	131,109	152,989	173,948	189,055	199,586	203,930	205,629	203,313	200,109	195,102
22	Iwaki	335,697	348,048	347,386	337,373	329,165	329,295	338,472	347,999	354,231	359,155	360,276
10	Hirosaki	138,448	144,871	149,614	151,347	155,785	162,684	172,137	175,856	175,116	176,985	177,351
60	Matsue	96,767	101,788	105,657	109,301	115,712	124,533	133,077	138,659	142,064	146,064	151,037
76	Omuta	187,464	198,758	204,549	197,368	180,564	168,670	163,885	160,488	153,090	146,675	140,535
9	Aomori	170,260	190,315	206,874	220,279	235,263	256,730	280,373	292,095	289,665	292,245	296,747
20	Aizuwakamatsu	93,448	96,606	99,045	101,424	103,514	107,254	112,732	117,045	118,797	119,472	118,573
33	Jyoetsu	113,914	116,003	116,700	118,478	120,081	122,508	126,498	129,807	130,279	131,575	133,982
28	Oyama	82,780	83,521	83,572	88,442	100,725	115,606	125,104	132,080	139,799	147,715	153,655
66	Yamaguchi	95,626	98,550	101,234	99,850	100,417	104,556	112,079	121,293	127,864	133,714	138,969
52	Hikone	77,442	76,389	73,801	74,060	77,467	83,121	84,108	90,922	97,894	102,295	106,536
67	Tokuyama	76,867	81,145	85,954	91,602	96,978	104,360	110,099	112,286	111,419	109,335	105,856
59	Yonago	90,748	95,791	99,132	102,692	107,537	115,482	124,591	130,451	131,555	133,761	137,546
4	Muroran	108,028	119,451	138,648	156,413	161,816	159,711	152,705	140,263	123,085	112,133	105,183
6	Obihiro	66,578	84,140	98,295	112,092	127,099	138,632	150,131	160,156	166,036	170,404	172,634
58	Tottori	99,361	105,251	107,390	108,379	111,835	119,488	128,372	135,232	140,823	145,160	149,194
5	Kushiro	89,713	110,992	140,532	166,700	186,411	202,255	212,307	214,587	208,979	201,490	193,983
65	Ube	143,319	155,963	164,620	161,242	154,726	159,204	166,830	172,977	174,956	175,097	174,626
84	Miyakonojo	115,647	120,808	121,859	119,449	115,921	117,231	125,695	131,164	130,733	131,940	132,159
41	Ueda	95,572	94,733	94,308	95,854	98,602	103,422	109,584	114,767	118,448	122,116	124,739
14	Ishinomaki	85,688	88,687	92,539	96,855	104,075	112,497	118,987	122,078	122,185	121,436	120,233
72	Imabari	91,181	95,415	99,041	103,134	109,085	117,078	122,171	124,548	123,711	121,077	118,611
81	Yatsushiro	90,157	96,827	102,248	102,803	102,059	103,140	106,823	108,611	108,331	107,837	106,609
73	Niihama	113,615	119,091	124,221	125,315	125,769	129,982	132,151	132,230	130,052	128,285	126,246
36	Komatsu	89,204	88,830	88,911	90,535	94,305	98,874	103,095	105,524	106,065	107,394	108,424
18	Sakata	93,050	95,825	97,394	96,490	96,046	97,225	101,112	101,753	100,985	101,104	101,287
68	Iwakuni	78,795	87,101	97,319	104,224	106,060	109,559	112,086	112,040	110,216	108,025	106,247
85	Nobeoka	101,318	112,773	120,768	123,556	126,989	132,621	135,972	136,446	132,325	127,814	125,318
17	Tsuruoka	95,406	97,795	96,990	95,824	95,279	95,693	98,590	100,065	99,982	100,343	100,601
42	Iida	95,620	93,900	90,846	88,573	87,584	88,739	91,082	102,029	106,566	106,689	107,198
8	Tomakomai	37,668	47,344	58,835	75,421	95,190	122,330	145,837	156,208	159,498	166,511	171,254
7	Kitami	51,670	57,296	64,589	72,375	80,278	88,788	99,355	105,952	107,257	109,481	111,561
	Total	27,081,188	30,748,286	34,688,188	37,979,829	40,310,856	42,309,500	43,719,077	44,942,485	45,689,364	46,083,677	46,580,046

[Note] See the notes of the table for the population of FUCs.

Appendix B

The following are the publications and presentations by T.Kawashima (including those with collaborators) discussing the Roxy-index method or applying it to empirical studies..

01. "Recent Urban Evolution Processes in Japan: Analysis of Functional Urban Regions," presented at the Twenty-fifth North American Meetings of the Regional Science Association, Chicago, Illinois, USA, 1978.
02. "Urbanization and Metropolitan Analysis," *Shin-toshi*, Toshi Kyokai, Tokyo, August 1981, pp.1-12 (in Japanese).
03. "Recent Urban Trends in Japan: Analysis of Functional Urban Regions," *Human Settlement System : Spatial Patterns and Trends*, T. Kawashima and P. Korcelli (eds.), International Institute for Applied Systems Analysis, Laxenburg, Austria, 1982, pp.21-40.
04. *Human Settlement Systems; Spatial Patterns and Trends*, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1982 (with P. Korcelli, eds.)
05. "Recent Urbanization in Japan: Implication of the 1980 Population Census Figures," *Housing Policy in Urban Areas: Principles, Planning and Policy*, A. Andersson and B. Harsman (eds.), Swedish Council for Building Reserch, Stockholm, 1985, pp.241-255.
06. "Roxy Index: An Indicative Instrument to Measure the Speed of Spatial Concentration and Deconcentration of Population," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.22, No.2, Gakushuin University, Tokyo, September 1985, pp.183-213.
07. "Speed of Suburbanization: ROXY Index Analysis for Intra-metropolitan Spatial Redistribution of Population in Japan," Gakushuin Economic Papers *(Gakushuin Daigaku Keizai Ronshuh*, Vol.22, No.3, Gakushuin University, Tokyo, March 1986, pp.243-304.
08. "People Follow Jobs in Japan ?: Suburbanization of Labour and Job Markets," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.23, No.1&2, Gakushuin University, Tokyo, October 1986, pp.157-183.
09. "Spatial Cycle Race 1985: ROXY Index Analysis of the 1985 Population Census for Three Railway-line Regions in the Tokyo Metropolitan Area," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.23, No.3, Gakushuin University, Tokyo, December 1986, pp.53-70.
10. "Is Disurbanization Foresseable in Japan ?: A Comparison between US and Japanese Urbanization Processes," *Spatial Cycles* (Chapter 7), Leo van den Berg, Leland S. Burns and Leo H. Klaassen (eds.), Gower, Aldershot, England, 1987, pp.100-126.
11. "ROXY Index Analysis of Population Changes in Japan for 1960-85: Spatial (De) centralization and (De) concentration," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.24, No.3, Gakushuin University, Tokyo, December 1987, pp.11-39.
12. "Basic Concepts of the Nature of ROXY Index," *GEM Annual Report (Gakushuin Daigaku Keizai Keiei Kenkyusho Nenpoh)*, Vol.3, Gakushuin University, Research Institute of Economics and Management, Tokyo, October 1989, pp.81-94 (in Japanese).
13. "Metropolitan Analysis: Boundary Delineations and Future Population Changes of Functional

Urban Regions," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.29, No.3 & 4, Gakushuin University, Tokyo Jan. 1993, pp.205-248 (with N.Hiraoka, A.Okabe, and N.Ohtera).

14 "Centralization and Suburbanization: ROXY Index Analysis for Five Railway-line Regions in Tokyo Metropolitan Area," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.30, No.1, Gakushuin University, Tokyo March 1993 pp.203-230 (with N.Hiraoka).

15. "Mathematical Characteristics of ROXY Index (I): Distance and Reversed Distance Used as Weighing Factors," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.30, No.2, Gakushuin University, Tokyo, June 1993,pp.257-297 (with N.Hiraoka).

16. "Mathematical Characteristics of ROXY Index (II) : Periods of Intrametro-politan Spatial-cycle Paths and Theoretically-ideal Formulations of ROXY Index," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.30, No.3, Gakushuin University, Tokyo, October 1993, pp.317-422 (with N.Hiraoka).

17. "Mathematical Characteristics of ROXY Index (III): Functional Relationship between 'Theoretically-ideal ROXY Index with CBD Distance Used as Weighing Factor' and 'That with Reversed CBD Distance'," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.30, No.4, Gakushuin University, Tokyo Feburary 1994 pp.451-478 (with N.Hiraoka).

18. "Aged Population in Spatial Cycles: ROXY Index Analysis for Chuo-line Region in Tokyo Metropolitan Area," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh*, Vol.31, No.1, Gakushuin University, Tokyo, March 1994, pp.13-35 (with N.Hiraoka).

19. "Chronological Time-lags over Spatial-cycle Path: Comparative Analysis on Inter-city Agglomeration and Deglomeration of Population in Indonesia, Japan, Sweden and USA," *GEM Annual Report (Gakushuin Daigaku Keizai Keiei Kenkyusho Nenpoh)*, Vol.7, Gakushuin University Research Insititute of Economics and Management, Tokyo, March 1994, pp.31-44 (with I.J.Azis and M.Tene).

20. "Mathematical Characteristics of ROXY Index (IV): ROXY Index as Compared with Correlation Coefficient," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.31, No.3, Gakushuin University, Tokyo, October 1994, pp.155-171 (with Y.Asami, S.Funamoto, N.Hiraoka and J.H.Paelinck).

21. "Mathematical Characteristics of the ROXY Index (V): Comparison of the ROXY Index with Other Major Yardsticks Measuring Convergence and Divergence," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.32, No.2, Gakushuin University, Tokyo, July 1995, pp.81-101 (with N.Hiraoka).

22. "Relative Positions along the Spatial-cycle Path: Inter-city Concentration and Deconcentration of Population in Australia, Indonesia, Japan, Sweden and USA," *Cities and the New Global Economy, Joint OEDCD/Australian Government Conference Proceedings*, Volume 2, Commonwealth of Australia, Melbourne, 1995, pp.386- 406 (with I.J.Azis, M.Tene and N.Hiraoka).

23. "Roxy-index Analysis on the Spatial-cycle Path for Six Spatial Systems in Japan," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.32, No.4, Gakushuin University, Tokyo, December 1995, pp.201-255 (with N.Hiraoka).

24. "Robustness of Roxy Index in Analysis of Three Systems of Largest Thirty Cities in Japan:

Constantly Fixed, Backwardly Variable and Forwardly Variable Member Cities," *GEM Annual Report (Gakushuin Daigaku Keizai Keiei Kenkyusho Nenpoh)*, Vol.12, Gakushuin University Research Institute of Economics and Management, Tokyo, December 1998, pp.55-70 (with N.Hiraoka).

25. "Long-term Urban Development of the Finnish Population: Application of the ROXY-index Analytical Methods," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.36, No.2, Gakushuin University, Tokyo, August 1999, pp.43-263 (with M.Hirvonen and N.Hiraoka).
26. "Urbanizaiton, Suburbanization and Revived-urbanization: ROXY-index Analysis for the Chuo-line Region of Tokyo," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.36, No.3, Gakushuin University, Tokyo, October 1999, pp.389-414 (with A.Fukatsu).
27. "Its Own Built-in Urban Genes: On Spatial Cycle Path for Systems of Both Functional Urban Regions (FURs) and Functional Urban Cores (FUCs) in Japan," *GEM Annual Report (Gakushuin Daigaku Keizai Kennkyuusho Nempoh)*, Vol.14, Gakushuin University Research Institute of Economic and Management, Tokyo, December 2000, pp.13-31 (with N.Hiraoka).
28. "Spatial-Cycle Race for Urbanization and Suburbanization: The Tokyo, Osaka and Nagoya Metropolitan Areas," Regional Science Perspectives in Economic Analysis: *A Festschrift in Memory of Benjamin H. Stevens*, M.L.Lahr and R.E.Miller (eds.), Elsevier Science B.V., Amsterdam, The Netherlands, 2001, pp.131-146, (with N.Hiraoka).
29. "Roxy Index Analysis of Spatial Cycles for Population Changes in Japan: Larger Metropolitan Areas and Smaller-and-Non-Metropolitan Areas," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.37, No.3· 4 , Gakushuin University, Tokyo, January 2001, pp.227-244 (with Hiraoka).
30. "Urban Spatial Cycles and Housing Policy," *Quarterly Journal of Housing and Land Economics*, No.40, Housing Research and Advancement Foundation Center of Japan, Spring 2001, pp.2-7 (in Japanese).
31. "Counter Urbanization in the US and Population Changes of the Three Largest Metropolitan Areas in Japan," *Gakushuin Economic Papers (Gakushuin Daigaku Keizai Ronshuh)*, Vol.38, No.1, Gakushuin University, Tokyo, April 2001, pp.1-11 (in Japanese).
32. "Urban Cycles and Urban Design: Population Changes in Large Metropolitan Areas and Demand Pressure to the Housing Investment," *Proceedings on Housing and Land-use Issues*, No.23, Housing Research and Advancement Foundation Center of Japan, Tokyo, September 2001, pp.63-109 (in Japanese).
33. "Reurbanization along the Urban-cycle Path and the Concentration of Green Trekking Parks in the Center of Tokyo," *Parks and Open Spaces (Kouen Ryokuchi)*, Vol.63, Parks and Open Space Association of Japan, June 2002, pp.9-14 (in Japanese).