SPATIAL CYCLE RACE 1985:
ROXY INDEX ANALYSIS OF THE 1985
POPULATION CENSUS FOR THREE RAILWAY-LINE
REGIONS IN THE TOKYO METROPOLITAN AREA

Tatsuhiko Kawashima*

CONTENTS

ABSTRACT

Based on the preliminary counts of the 1985 population census, the degree of "advancement in the spatial cycle stage" is examined by means of the ROXY index method for three major railway-line regions in the Tokyo metropolitan area. The results indicate that, among the three railway-line regions during the 1980–85 period, the Chuo Line region was at the most advanced stage along the circular path in the spatial cycle framework. This region, stretching by the Japanese National Railways Chuo Line, which is the busiest commuting railway line in the Tokyo metropolitan area, moved to the last phase of the post-suburbanization stage with the arrival of the 1980s and would be likely to come close to the rst phase of the recentralization stage around the beginning of the 1990s.

1. INTRODUCTION

Recently, the Japan Statistics Bureau (1985) published a report of the preliminary counts of the population in 1985. These preliminary counts were arranged based on the entries of the "1985 population census summary sheets" which were prepared by the prefectural and municipal governments to ascertain the number of

population and households that were enumerated on October 1, 1985, in their respective jurisdictions.

Primary purposes of the present paper are (1) to calculate, by use of the preliminary counts of the 1985 population as well as the census population data for previous years, the values of ROXY index for five consecutive five-year periods between 1960 and 1985 for three major railway-line regions in the Tokyo metropolitan area and (2) to compare, through the ROXY index method, the degree of "advancement in the spatial cycle stage" for the 1980–85 period among the three railway-line regions.

Tokyo metropolitan area is one of the eighty-six metropolitan areas (FUCs) in Japan[1] and consists of 121 administratively defined localities[2]. Tokyo FUC had a population of 22.1 million in 1985. The distance to its farthest constituent locality from the central business district (CBD) of Tokyo city is 72.5 km, and the average distance to the 121 localities from the CBD is 36.2 km. The five-year growth rate of the total population of Tokyo FUC decreased constantly since 1960 from 18.33% for the 1960–65 period to 5.09% for the 1980–85 period[3].

Out of a number of conceivable railway-line regions in Tokyo FUC, we chose three major railway-line regions for the analyses in this paper. They are the Chuo Line region, the Takasaki Line region and the Joban Line region. The Chuo Line region extends westwards from the CBD of Tokyo city, and is composed of ten localities located along the Japanese National Railways (JNR) Chuo Line which is the busiest commuting railway line in Tokyo FUC. This region had a population of 9.9 million in 1985. The distance to its farthest constituent locality from the CBD of Tokyo city is 40.3 km, while the average distance to the ten localities is 25.5 km. The five-year growth rate of the regional total population decreased continuously from 9.23% for the 1960–65 period to −1.97% for the 1975–80 period, with the positive sign turning negative around 1970. During the 1980–85 period, however, the region slightly recovered its population by 0.81%.

The Takasaki Line region is composed of fourteen localities located along the JNR Takasaki Line, which extends northwards from the CBD of Tokyo city. This region had a population of 10.3 million in 1985. The distance to its farthest constituent locality from the CBD of Tokyo city is 72.5 km, while the average distance to the fourteen localities is 35.1 km. The five-year growth rate of the regional total population decreased continuously from 9.17% for the 1960–65 period to −1.53% for the 1975–80 period, with the positive sign turning negative around the middle of the 1970s. The regional population was recovered by 1.07% during the 1980–85 period.

The Joban Line region is composed of nine localities located along the JNR Joban Line, which extends northeastwards from the CBD of Tokyo city. The regional population was 9.5 million in 1985. The distance to its farthest constituent locality

from the CBD of Tokyo city is 58.5 km, while the average distance to the nine locali-
ties is 35.1 km, exactly like the case of the Takasaki Line region. The five-year
growth rate of the regional total population decreased continuously from 8.36% for
the 1960–65 period to −1.35% for the 1975–80 period, with the positive sign turning
negative around the middle of the 1970s. During the first half of the 1980s, however,
the region recovered its population by 1.19%.

2. VALUES OF ROXY INDEX: 1960 THROUGH 1985

Table 1 shows the distance and population for 121 localities[4] of Tokyo FUC.
From this table we can construct Tables 2 and 3, the former furnishing the five-year
growth rate of population for each locality in Tokyo FUC for the five consecutive
five-year periods between 1960 and 1985, and the latter furnishing the five-year
growth rate of population for respective localities composing each of the three
railway-line regions. Based on them, we obtain the value of ROXY index[5] as
shown in Table 4 for Tokyo FUC and its three major railway-line regions.

It can be seen from Table 4 that the ROXY index for Tokyo FUC increased
continuously from −120.39 for the 1960–65 period to 8.15 for 1980–85, with the
negative sign turning positive around 1975. According to Table N-1, this would
imply that the centralization phenomena were observed in Tokyo FUC until the
middle of the 1970s, with the speed of centralization decelerating. In the second
half of the 1970s onward, however, Tokyo FUC entered the suburbanization stage,
with the speed of its suburbanization process gradually accelerating.

The ROXY index for the Chuo Line region increased from 38.73 for the 1960–65
period to 53.72 for 1965–70. It then began to decrease to 51.86 for the 1970–75
period, 37.66 for 1975–80 and 16.16 for 1980–85. This would imply that the Chuo
Line region was being acceleratingly suburbanized until the late 1960s. After that,
the speed of suburbanization process continued to decelerate throughout the 1970s
and afterwards as well.

The ROXY index for the Takasaki Line region increased from −75.63 for the
1960–65 period to 38.94 for the 1975–80 period, with the negative sign turning posi-
tive around 1965. It then began to decrease to 27.93 for the 1980–85 period. This
would imply that the population within the Takasaki Line region was deceleratingly
centralized during 1960–65. Around 1965, the region began to be suburbanized, with
the speed of suburbanization accelerating until the late 1970s. After that, the speed
of suburbanization process started decelerating.

The ROXY index for the Joban Line region increased from −82.28 for the
1960–65 period to 36.05 for 1975–80, with the negative sign turning positive around
1970. It then began to decrease to 30.12 for tht 1980–85 period. This would imply
that the Joban Line region was being deceleratingly centralized in the 1960s and

Table 1 Distance and Population for 121 Localities of Tokyo FUC (1960–1985)
(unit : distance=km, population=person)

Code	DIST	1960	1965	1970	1975	1980	1985
13100	7.4	8310030	8893090	8840940	8642800	8349210	8353670
12301	12.9	16847	18463	21880	32250	64673	93756
11203	14.8	173692	249112	305886	345547	379357	403012
12203	16.8	157301	207988	261055	319272	364244	397806
11221	17.0	38533	80707	123269	167176	186618	194204
11226	17.2	20711	37403	51377	56693	55952	55424
11224	17.2	30752	52312	69511	77138 .	78343	76960
14130	17.2	632975	854866	973486	1015020	1040700	1088610
13219	17.4	25252	39978	60297	70019	70824	73646
11234	17.5	13307	21772	37323	56127	62734	67635
12207	17.8	86372	160001	253591	344552	400870	427479
11307	18.0	17242	31034	39512	46504	49718	55212
11223	18.0	50952	69715	77225	76312	70876	70407
13204	18.5	98038	135873	155693	164852	164449	166175
13203	18.5	120337	133516	136959	139493	136895	138810
11237	19.5	17738	24207	42753	79354	98222	107963
13217	19.7	46768	71303	86194	91537	91251	91563
12204	20.0	135038	223989	325426	423106	479437	506967
11227	20.2	24182	51527	67938	81755	90088	94432
13208	20.3	68621	117995	157488	175858	180535	191076
13216	21.2	31323	49113	58466	67432	66972	71333
11230	22.0	14401	36881	77704	108990	119312	129284
11204	23.2	174437	221323	269397	331145	358180	377233
13222	23.5	19637	47239	78075	100821	106521	110079
12220	23.5	25672	39166	56485	82936	106635	124682
13225	23.7	11012	19345	30817	43921	48154	50749
13210	23.7	45734	76350	94448	102703	102412	104684
11222	23.8	49585	76571	139368	195915	223243	253483
12216	24.0	42167	64477	99951	117851	125154	136365
11305	24.2	12259	20464	31811	43546	50926	58935
12224	24.3	13496	25002	40988	63291	76157	85705
11466	24.5	16300	16761	18524	30786	38895	43616
13221	24.5	17863	36448	51911	60571	61915	65067
13206	25.8	82098	126235	163173	182379	191980	201972
11220	26.0	40840	51746	62802	71045	72326	71598
13211	26.2	52923	105365	137373	156182	154610	158673
13214	27.5	39098	64911	81259	88155	91014	95469
11235	27.6	12030	23767	52011	70392	79591	85698
11324	27.8	4329	5911	14475	23596	28978	31567
11465	27.8	8844	9308	12207	15806	18463	20340
13213	28.0	42946	74857	96545	112657	119382	123794
11205	28.0	169996	215646	268777	327696	354082	373015

Table 1 (Continued)

Code	DIST	1960	1965	1970	1975	1980	1985
12217	28.6	63745	109239	150635	203063	239199	273130
12305	28.7	11849	15262	18480	22148	33706	38027
13224	29.0	9746	18376	30370	65465	95248	122131
13215	29.2	32609	43477	59709	64404	64154	64881
1120	30.0	65903	89346	136611	196868	236477	275165
12326	30.2	8217	8305	10509	12968	24975	32214
11322	30.7	4949	9876	19613	31989	35538	37036
11213	30.7	35169	41946	56449	83825	94695	100904
12221	30.8	21709	35741	66630	113263	134479	142188
12208	30.8	54150	59799	68641	78194	93958	105937
13202	31.0	81951	100699	117057	138097	142600	146531
11321	31.2	16652	34050	51747	58332	57929	57641
13220	31.3	14239	31709	46173	58465	65415	69879
12222	31.7	27063	33216	49240	76218	101061	111661
13209	32.2	71269	115918	202801	255303	295354	321182
11214	32.7	34280	42460	84919	121639	155556	171889
13212	33.2	43394	67979	98557	126754	145417	156006
13342	35.0	12065	14049	41275	50842	57194	60930
11468	35.0	15808	16780	18909	25217	32356	35131
11238	35.6	20743	25070	31935	39043	45594	53991
13207	36.3	44805	59655	75662	83856	89343	97544
8217	36.5	22582	26179	40287	52821	71246	78609
11219	36.5	38889	54776	110792	146359	166244	178589
11201	37.0	107523	127155	171038	225467	259317	285435
14209	37.2	101655	163381	278326	377341	439257	482778
11215	37.5	32785	40183	60886	98548	124025	144366
11225	37.7	36903	51835	65369	83996	104034	118603
11442	38.2	11152	13025	16656	22526	29538	31213
11464	38.5	16457	17634	20244	28074	34549	37006
11445	38.6	16026	17937	21990	27691	31623	34171
12327	38.6	17315	16863	16114	16832	17896	23373
14216	39.7	15402	29948	56727	80565	93501	99994
13218	40.0	21985	30790	37938	46456	48710	51481
11231	40.2	21309	28108	38717	48034	55746	61499
13201	40.3	164622	207753	253527	322558	387162	426650
8563	41.4	12606	13002	16309	20407	26464	29757
13302	42.0	11003	16027	22783	33124	42018	47202
12212	42.0	36869	40941	60433	80807	101180	121213
11346	42.2	16443	15594	15049	15999	17393	19865
12328	42.3	5213	5052	4566	4585	4622	4668
13304	42.7	14433	17271	28357	38272	42805	45762
12325	43.0	7912	7639	7331	7444	7452	7704
11232	43.2	23114	26773	34028	45799	54410	58635

Table 1 (Continued)

Code	DIST	1960	1965	1970	1975	1980	1985
11233	44.0	15483	20576	31699	46632	50888	58114
11209	44.0	44153	47825	52066	55925	61178	66550
11463	44.2	23378	25169	27923	43083	49704	51462
11328	44.3	7008	9583	14634	20994	35843	49381
14212	44.7	46239	61383	82888	108952	145387	175596
11239	44.8	23569	24854	27308	51230	77334	87586
11446	45.0	16054	15500	15238	16166	19462	20946
11329	45.0	16683	17768	21646	32338	43221	48228
8208	45.6	33581	34917	37267	40569	43131	48857
12322	46.0	6093	6040	6259	8463	12807	17463
12329	46.5	9732	9333	8825	8952	9553	14208
11462	47.2	8351	8436	9099	20576	21257	26223
8444	48.0	16131	17203	19372	27674	40170	51926
11217	48.0	31868	36526	41990	51632	57085	60565
11347	48.8	14915	14229	14072	14724	16108	17043
11326	49.8	11173	14885	20006	25807	31197	34467
11461	49.8	12890	14489	16112	18090	19792	20119
14214	50.8	26984	32013	43751	61621	70052	77765
11210	51.2	41756	41547	42149	45184	47590	50538
11212	51.6	38267	42706	50383	57682	63889	70425
11425	51.8	11821	11655	12037	12739	13536	14058
11304	54.5	12095	14482	17247	18775	22606	24990
11401	57.2	7222	6896	6782	6790	7000	7278
8204	58.0	42474	50202	54173	55971	56656	57539
8203	58.5	71378	78971	89958	104031	112517	120175
11216	59.0	42900	43884	45001	46506	48488	51505
14211	59.3	51285	57930	75226	103677	123130	141806
11202	61.7	98168	109575	120841	131486	136807	143496
11402	62.0	7801	7709	8485	9164	10181	11152
9364	62.5	9974	10339	11983	14015	16453	18983
9366	65.0	20299	19624	19397	19952	20377	20413
11406	67.0	9452	9282	9764	10984	11567	11656
11407	70.0	7775	7759	7958	8718	9873	10986
11408	70.5	25478	25298	25137	25846	28466	31720
11403	72.5	21317	20759	20847	22275	24624	27094
11218	72.5	60856	62241	69193	75750	82243	89123
Total	4377.2	13398794	15854143	18014475	19955812	21049510	22120155

(Note) Distance (DIST) is the airline distance from the CBD of Tokyo city to each locality.

Table 2 Five-year % Growth Rate of Population for 121 Localities of Tokyo FUC

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
13100	7.4	7.09	−0.59	−2.24	−3.40	0.05
12301	12.9	9.59	18.51	47.39	100.54	44.97
11203	14.8	43.42	22.79	12.97	9.78	6.24
12203	16.8	32.22	25.51	22.30	14.09	9.21
11221	17.0	109.45	52.74	35.62	11.63	4.06
11226	17.2	80.59	37.36	10.35	−1.31	−0.94
11224	17.2	70.11	32.88	10.97	1.56	−1.77
14130	17.2	35.06	13.88	4.27	2.53	4.60
13219	17.4	58.32	50.83	16.12	1.15	3.98
11234	17.5	63.61	71.43	50.38	11.77	7.81
12207	17.8	85.25	58.49	35.87	16.35	6.64
11307	18.0	79.99	27.32	17.70	6.91	11.05
11223	18.0	36.82	10.77	−1.18	−7.12	−0.66
13204	18.5	38.59	14.59	5.88	−0.24	1.05
13203	18.5	10.95	2.58	1.85	−1.86	1.40
11237	19.5	36.47	76.61	85.61	23.78	9.92
13217	19.7	52.46	20.88	6.20	−0.31	0.34
12204	20.0	65.87	45.29	30.02	13.31	5.74
11227	20.2	113.08	31.85	20.34	10.19	4.82
13208	20.3	71.95	33.47	11.66	2.66	5.84
13216	21.2	56.80	19.04	15.34	−0.68	6.51
11230	22.0	156.10	110.69	40.26	9.47	8.36
11204	23.2	26.88	21.72	22.92	8.16	5.32
13222	23.5	140.56	65.28	29.13	5.65	3.34
12220	23.5	52.56	44.22	46.83	28.58	16.92
13225	23.7	75.67	59.30	42.52	9.64	5.39
13210	23.7	66.94	23.70	8.74	−0.28	2.22
11222	23.8	54.42	82.01	40.57	13.95	13.55
12216	24.0	52.91	55.02	17.91	6.20	8.96
11305	24.2	66.93	55.45	36.89	16.95	15.73
12224	24.3	85.25	63.94	54.41	20.33	12.54
11466	24.5	2.83	10.52	66.20	26.34	12.14
13221	24.5	104.04	42.42	16.68	2.22	5.09
13206	25.8	53.76	29.26	11.77	5.26	5.20
11220	26.0	26.70	21.37	13.13	1.80	−1.01
13211	26.2	99.09	30.38	13.69	−1.01	2.63
13214	27.5	66.02	25.19	8.49	3.24	4.89
11235	27.6	97.56	118.84	35.34	13.07	7.67
11324	27.8	36.54	144.88	63.01	22.81	8.93
11465	27.8	5.25	31.15	29.48	16.81	10.17
13213	28.0	74.30	28.97	16.69	5.97	3.70
11205	28.0	26.85	24.64	21.92	8.05	5.35
12217	28.6	71.37	37.89	34.80	17.80	14.19

Table 2 (Continued)

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
12305	28.7	28.80	21.09	19.85	52.19	12.82
13224	29.0	88.55	65.27	115.56	45.49	28.22
13215	29.2	33.33	37.33	7.86	−0.39	1.13
11208	30.0	35.57	52.90	44.11	20.12	16.36
12326	30.2	1.07	26.54	23.40	92.59	28.98
11322	30.7	99.56	98.59	63.10	11.09	4.22
11213	30.7	19.27	34.58	48.50	12.97	6.56
12221	30.8	64.64	86.42	69.99	18.73	5.73
12208	30.8	10.43	14.79	13.92	20.16	12.75
13202	31.0	22.88	16.24	17.97	3.26	2.76
11321	31.2	104.48	51.97	12.73	−0.69	−0.50
13220	31.3	122.69	45.61	26.62	11.89	6.82
12222	31.7	22.74	48.24	54.79	32.59	10.49
13209	32.2	62.65	74.95	25.89	15.69	8.74
11214	32.7	23.86	100.00	43.24	27.88	10.50
13212	33.2	56.66	44.98	28.61	14.72	7.28
13342	35.0	16.44	193.79	23.18	12.49	6.53
11468	35.0	6.15	12.69	33.36	28.31	8.58
11238	35.6	20.86	27.38	22.26	16.78	18.42
13207	36.3	33.14	26.83	10.83	6.54	9.18
8217	36.5	15.93	53.89	31.11	34.88	10.33
11219	36.5	40.85	102.26	32.10	13.59	7.43
11201	37.0	18.26	34.51	31.82	15.01	10.07
14209	37.2	60.72	70.35	35.58	16.41	9.91
11215	37.5	22.57	51.52	61.86	25.85	16.40
11225	37.7	40.46	26.11	28.50	23.86	14.00
11442	38.2	16.80	27.88	35.24	31.13	5.67
11464	38.5	7.15	14.80	38.68	23.06	7.11
11445	38.6	11.92	22.60 ·	25.93	14.20	8.06
12327	38.6	−2.61	−4.44	4.46	6.32	30.60
14216	39.7	94.44	89.42	42.02	16.06	6.94
13218	40.0	40.05	23.22	22.45	4.85	5.69
11231	40.2	31.91	37.74	24.06	16.06	10.32
13201	40.3	26.20	22.03	27.23	20.03	10.20
8563	41.4	3.14	25.43	25.13	29.68	12.44
13302	42.0	45.66	42.15	45.39	26.85	12.34
12212	42.0	11.04	47.61	33.71	25.21	19.80
11346	42.2	−5.16	−3.49	6.31	8.71	14.21
12328	42.3	−3.09	−9.62	0.42	0.81	1.00
13304	42.7	19.66	64.19	34.96	11.84	6.91
12325	43.0	−3.45	−4.03	1.54	0.11	3.38
11232	43.2	15.83	27.10	34.59	18.80	7.77
11233	44.0	32.89	54.06	47.11	9.13	14.20

Table 2 (Continued)

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
11209	44.0	8.32	8.87	7.41	9.39	8.78
1463	44.2	7.66	10.94	54.29	15.37	3.54
11328	44.3	36.74	52.71	43.46	70.73	37.77
14212	44.7	32.75	35.03	31.44	33.44	20.78
11239	44.8	5.45	9.87	87.60	50.95	13.26
11446	45.0	−3.45	−1.69	6.09	20.39	7.63
11329	45.0	6.50	21.83	49.39	33.65	11.58
8208	45.6	3.98	6.73	8.86	6.32	13.28
12322	46.0	−0.87	3.63	35.21	51.33	36.36
12329	46.5	−4.10	−5.44	1.44	6.71	48.73
11462	47.2	1.02	7.86	126.13	3.31	23.36
8444	48.0	6.65	12.61	42.86	45.15	29.27
11217	48.0	14.62	14.96	22.96	10.56	6.10
11347	48.8	−4.60	−1.10	4.63	9.40	5.80
11326	49.8	33.22	34.40	29.00	20.89	10.48
11461	49.8	12.40	11.20	12.28	9.41	1.65
14214	50.8	18.64	36.67	40.84	13.68	11.01
11210	51.2	−0.50	1.45	7.20	5.32	6.19
11212	51.5	11.60	17.98	14.49	10.76	10.23
11425	51.8	−1.40	3.28	5.83	6.26	3.86
11304	54.5	19.74	19.09	8.86	20.40	10.55
11401	57.2	−4.51	−1.65	0.12	3.09	3.97
8204	58.0	18.19	7.91	3.32	1.22	1.56
8203	58.5	10.64	13.91	15.64	8.16	6.81
11216	59.0	2.29	2.55	3.34	4.26	6.22
14211	59.3	12.96	29.86	37.82	18.76	15.17
11202	61.7	11.62	10.28	8.81	4.05	4.89
11402	62.0	−1.18	10.07	8.00	11.10	9.54
9364	62.5	3.66	15.90	16.96	17.40	15.38
9366	65.0	−3.33	−1.16	2.86	2.13	0.18
11406	67.0	−1.80	5.19	12.49	5.31	0.77
11407	70.0	−0.21	2.56	9.55	13.25	11.27
11408	70.5	−0.71	−0.64	2.82	10.14	11.43
11403	72.5	−2.62	0.42	6.85	10.55	10.03
11218	72.5	2.28	11.17	9.48	8.57	8.37
Total	4377.2	18.33	13.63	10.78	5.48	5.09

(Note) The unit of distance (DIST) is km.

Table 3 Five-year % Growth Rate of Population for Localities of Three Major Railway-line Regions in Tokyo FUC

(a) Chuo Line Region

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
13100	7.4	7.02	−0.59	−2.24	−3.40	0.05
13204	18.5	38.59	14.59	5.88	−0.24	1.05
13203	18.5	10.95	2.58	1.85	−1.86	1.40
13210	23.7	66.94	23.70	8.74	−0.28	2.22
13206	25.8	53.76	29.26	11.77	5.26	5.20
13214	27.5	66.02	25.19	8.49	3.24	4.89
13215	29.2	33.33	37.33	7.86	−0.39	1.13
13202	31.0	22.88	16.24	17.97	3.26	2.76
13212	33.2	56.66	44.98	28.61	14.72	7.28
13201	40.3	26.20	22.03	27.23	20.03	10.20
Total	255.1	9.23	1.54	−0.29	−1.97	0.81

(b) Takasaki Line Region

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
13100	7.4	7.02	−0.59	−2.24	−3.40	0.05
11203	14.8	43.42	22.79	12.97	9.78	6.24
11226	17.2	80.59	37.36	10.35	−1.31	−0.94
11223	18.0	36.82	10.77	−1.18	−7.12	−0.66
11204	23.2	26.88	21.72	22.92	8.16	5.32
11220	26.0	26.70	21.37	13.13	1.80	−1.01
11205	28.0	26.85	24.64	21.92	8.05	5.35
11219	36.5	40.85	102.26	32.10	13.59	7.43
11231	40.2	31.91	37.74	24.06	16.06	10.32
11233	44.0	32.89	54.06	47.11	9.13	14.20
11217	48.0	14.62	14.96	22.96	10.56	6.10
11304	54.5	19.74	19.09	8.86	20.40	10.55
11202	61.7	11.62	10.28	8.81	4.05	4.89
11218	72.5	2.28	11.17	9.48	8.57	8.37
Total	492.0	9.17	2.41	0.61	−1.53	1.07

(c) Joban Line Region

Code	DIST	1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
13100	7.4	7.02	−0.59	−2.24	−3.40	0.05
12207	17.8	85.25	58.49	35.87	16.35	6.64
12217	28.6	71.37	37.89	34.80	17.80	14.19
12222	31.7	22.74	48.24	54.79	32.59	10.49
8217	36.5	15.93	53.89	31.11	34.88	10.33
8563	41.4	3.14	25.43	25.13	29.68	12.44
8208	45.6	3.98	6.73	8.86	6.32	13.28
8444	48.0	6.65	12.61	42.86	45.15	29.27
8203	58.5	10.64	13.91	15.64	8.16	6.81
Total	315.5	8.36	1.41	0.15	−1.35	1.19

(Note) The unit of distance (DIST) is km.

62

Table 4   ROXY Index for Tokyo FUC and Its Three Major Railway-line Regions

Spatial Unit	Number of Localities	Period				
		1960 – 65	1965 – 70	1970 – 75	1975 – 80	1980 – 85
Tokyo FUC	121	−120.39	−68.99	−21.96	3.23	8.15
Chuo Line Region	10	38.73	53.72	51.86	37.66	16.16
Takasaki Line Region	14	−75.63	3.95	25.79	38.94	27.93
Joban Line Region	9	−82.28	−25.47	16.05	36.05	30.12

(Note)   The values of ROXY index in this table have been calculated based on the annual growth rates.

that the region began to be suburbanized around 1970, with the suburbanization speed accelerating until the late 1970s. After that, the speed of suburbanization process started decelerating similarly to the phenomena observed for the Takasaki Line region.

3.   SPATIAL CYCLE RACE: RETROSPECT AND PROSPECT

Based on Table 5 in which the marginal values[6] of ROXY index for each five-year period are shown, we can produce Figure 1 in conjunction with the scheme of "spatial cycle paradigm which is conceived in terms of the value of ROXY index and its marginal change"[7]. In this figure, what we have pointed out in Section 2 on the implications of the changes in the value of ROXY index can be described by curve (A) for Tokyo FUC, curve (B) for the Chuo Line region, curve (C) for the Takasaki Line region and curve (D) for the Joban Line region.

Referring to Figure N-2, curve (A) enables us to perceive visually that Tokyo FUC was at the first substage of centralization during the 1960–70 period, and then moved to the second substage of centralization at the beginning of the 1970s. Around the middle of the 1970s, Tokyo FUC entered the first substage of suburbanization and then shifted to the second substage of suburbanization at the turn of the decade.

From curve (B), it can be seen that the Chuo Line region was already at the second substage of suburbanization in the 1960s. Around the year 1970, the region entered the first substage of post-suburbanization and remained in the same substage throughout the 1970s. The region then moved to the second substage of post-suburbanization with the arrival of the 1980s.

The curve (C) would indicate that the Takasaki Line region had entered the second substage of centralization around the beginning of the 1960s, and that the region was at the suburbanization stage from the middle of the 1960s through the end of the 1970s. With the arrival of the 1980s, the region moved to the first substage of post-suburbanization.

Table 5 The Value of ROXY Index and Its Marginal Change:
For Tokyo FUC and Its Three Major Railway-line Regions

Spatial Unit	1960 – 65		1965 – 70		1970 – 75		1975 – 80		1980 – 85	
	ROXY	$\frac{\Delta\text{ROXY}}{\Delta T}$	ROXY	$\frac{\Delta\text{ROXY}}{\Delta T}$	ROXY	$\frac{\Delta\text{ROXY}}{\Delta T}$	ROXY	$\frac{\Delta\text{ROXY}}{\Delta T}$	ROXY	$\frac{\Delta\text{ROXY}}{\Delta T}$
Tokyo FUC	−120. 39	51. 40	−68. 99	49. 22	−21. 96	36. 16	3. 32	15. 06	8. 15	4. 83
Chuo Line Region	38. 73	14. 99	53. 72	6. 57	51. 86	− 8. 03	37. 66	−17. 85	16. 16	−21. 5
Takasaki Line Region	−75. 63	79. 58	3. 95	50. 71	25. 79	17. 50	38. 94	1. 07	27. 93	−11. 01
Joban Line Region	−82. 28	56. 81	−25. 47	49. 17	16. 05	30. 76	36. 05	7. 04	30. 12	− 5. 93

(Note)　1.　Δ T: Five Years

　　　　2.　Δ ROXY/Δ T: Marginal Change in the Value of ROXY Index

　　　　3.　Caluculation 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)
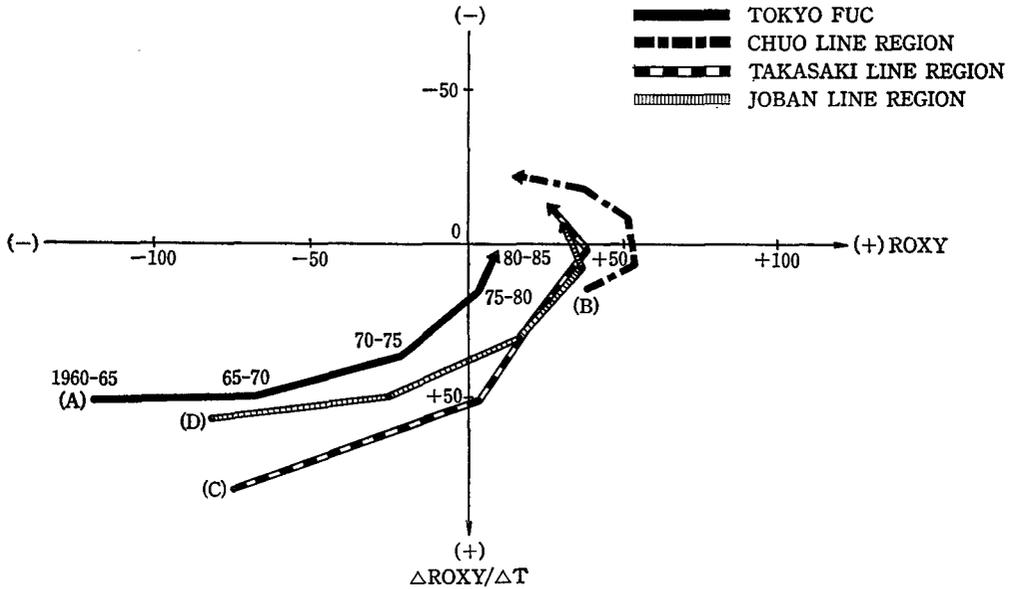
Figure 1 Spatial Cycle Race: ROXY Index and Its Marginal Change for Tokyo FUC and Three Major Railway-line Regions

Table 6 Degree of "Advancement in Spatial Cycle Stage" for 1980 – 85 Period: Tokyo FUC and Its Three Major Railway-line Regions

Spatial Unit	Number of Localities	PCS	PZS	Suburbanization Stage for 1980 – 85	Value of ROXY Index for 1980 – 85	Rank of Spatial Cycle Advancement
Tokyo FUC	121	1975	Z	AS	8. 15	4
Chuo Line Region	10	V	W	DS	16. 16	1
Takasaki Line Region	14	1965	Y	DS	27. 93	2
Joban Line Region	9	1970	Y	DS	30. 12	3

(Note) 1. DC: Decelerating Centralization (Centralization in Type-δ Spatial Cycle Scheme)
2. AS: Accelerating Suburbanization (Suburbanization in Type-δ Spatial Cycle Scheme)
3. DS: Decelerating Suburbanization (Post-Suburbanization in Type-δ Spatial Cycle Scheme)
4. PCS: Turning Point from Centralization Stage to Suburbanization Stage
5. PZS: Zenith Point of Suburbanization Speed (i. e., Period for which the ROXY Index has the Largest Value)
6. V : Before or around 1960
7. W : 1965 – 70
8. X : 1970 – 75
9. Y : 1975 – 80
10. Z : 1980 – 85 or "not yet arrived"
11. The rank of "spatial cycle advancement" is to be comprehensively determined based on the suburbanization stage and the value of ROXY index for the 1980 – 85 period as well as on the time for PCS and PZS.

The curve (D) would tell us that the Joban Line region was at the first and second substages of centralization during the 1960–65 period and 1965–70 period respectively. The region was at the suburbanization stage in the 1970s, and then entered the first substage of post-suburbanization at the turn of the decade.

Based on Table 4 and Figure 1, we can construct Table 6 to summarize the above discussion on the spatial cycle stage for each of the four spatial units, including Tokyo FUC. It can be noted from this table that, among the three major railway-line regions in Tokyo FUC, the suburbanization process started first in the Chuo Line region before or around 1960, then in the Takasaki Line region around 1965, and in the Joban Line region around 1970. We can also see, comparing the three railway-line regions in their spatial cycle stage attained during the 1980–85 period, that the Chuo Line region was at the most advanced stage along the circular path in the spatial cycle paradigm during the 1980–85 period, to be followed by the Takasaki Line region, and then by the Joban Line region[5].

The above examination would perhaps enable us to have a tentative prospective view that the Chuo Line region will come close to the first substage of recentralization around the beginning of the 1990s, that the Takasaki Line region will get into the second substage of post-suburbanization around the year 1990, and that the Joban Line region will closely follow the Takasaki Line region for the coming ten years or so in its pattern of suburbanization. Meanwhile, the post-suburbanization phenomena will possibly be observed for Tokyo FUC around the year 1990.

4. CONCLUSION

This paper has provided a small but interesting amount of empirical evidence for the existence of statistical regularities reasonably supporting the spatial cycle hypothesis, the original scheme of which was developed by Klaassen et al. (1981). It has at the same time demonstrated somewhat that the method of ROXY index would be a useful instrument for spatial redistribution analyses in order to get a deeper insight into the fundamental phenomena of intra-metropolitan as well as inter-metropolitan spatial changes in various socio-economic activities[9]. It should, though, always be borne in mind that the Roxyian approach[10] is merely one of many possible methods applicable for spatial redistribution analyses and that this approach is to be further improved.

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NOTES

1) There exist eighty-six metropolitan areas in Japan. They are the Japanese version of Standard Metropolitan Statistical Areas (SMSAs) in the U.S., and are called Functional Urban Cores (FUCs). The boundaries of FUCs have been delineated by T. Kawashima and N. Glickman. They are those boundaries observed as of 1970 and have been fixed over time. See Kawashima (1982) for the details of the delineation of FUCs.

2) Each locality can be either *shi* (city), *machi* (town) or *mura* (village).

3) For Japan as a whole, the total population level (including Okinawa prefecture) changed since 1960 as follows; 94,301,623 (1960), 99,209,137 (1965), 104,665,171 (1970), 111,939,643 (1975), 117,060,396 (1980), and 121,025,700 (1985). The growth rate of the total population in Japan for each of the five-year period turns out to be; 5.20% (1960–65), 5.50% (1965–70), 6.95% (1970–75), 4.57% (1975–80), and 3.39% (1980–85).

4) The name list of the 121 localities with the same locality code-numbers as used in Table 1, is provided in Kawashima (1986).

5) The value of ROXY index is calculated through the following mathematical formulation for the intra-metropolitan spatial redistribution analysis to be conducted in this paper. The implications of the value of ROXY index as calculated above are summarized in Table N-1. For the discussion on the ROXY index developed for the analyses of inter- and intra-metropolitan spatial redistribution processes, see Kawashima (1985, 1986a and 1986b).

ROXY Index for the Period between Year t and Year t+1
(Weighting Factor: Distance to CBD from Subarea i)

$$= \left(\frac{\text{weighted average growth ratio}}{\text{simple average growth ratio}} - 1.0 \right) \times 10,000$$

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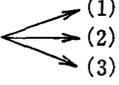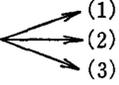
$$= \frac{n \sum_{i=1}^{n} d_i r_i^{t, t+1} - \sum_{i=1}^{n} d_i \times \sum_{i=1}^{n} r_i^{t, t+1}}{\sum_{i=1}^{n} d_i \times \sum_{i=1}^{n} r_i^{t, t+1}} \times 10^4,$$

where d_i: distance from subarea i (or locality i) to CBD.

$r_i^{t, t+1}$: population growth ratio of subarea i (or locality 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 (or localities).

Table N-1 Implications of ROXY Index for Intra-metropolitan
Spatial Redistribution Processes of Population
(Weighting Factor: Distance to CBD)

(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	Suburbanization of Population (Dispersion 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	Cannot be specified
ROXY<0	Centralization of Population (Agglomeration of Population)	(1) (2) (3)	(1) Decelerating (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 distance-zone groups of localities.)
2. BSGD: Bell-shaped Growth or Decline (Namely, the growth rate curve is bell-shaped, reflecting the "medianization" of population over distance-zone groups. This "medianization" means increase in population share by middle distance-zone groups of localities and, at the same time, decrease in population share by near and far distance-zone groups of localities.)
3. CSGD: Cup-shaped Growth or Decline (Namely, the growth rate curve is cup-shaped, reflecting the "bipolarization" of population over distance-zone groups. This "bipolarization" means increase in population share by near and far distance-zone groups of localities and, at the same time, decrease in population share by middle distance-zone groups of localities.)
4. The four stages of accelerating centralization (AC), decelerating centralization (DC), accelerating suburbanization (AS), and decelerating suburbanization (DS) in this table respectively correspond to the stages of reurbanization, urbanization, suburbanization and disurbanization in the spatial cycle paradigm originally conceived by Klaassen et al. (1981). In the spatial cycle paradigm of the "type-δ spatial cycle scheme" discussed in Kawashima (1986b), the above four stages of AC, DC, AS and DS respectively correspond to the stages of recentralization, centralization, suburbanization and post-suburbanization.

6) Table N-2 shows another possible set of values of ROXY index and marginal values of ROXY index. From this table, we can produce Figure N-1.

Table N-2 The Value of ROXY Index and Its Marginal Change (Alternative Values): For Tokyo FUC and Three Major Railway-line Regions

Spatial Unit	1960/65 – 65/70		1965/70 – 70/75		1970/75 – 75/80		1975/80 – 80/85	
	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$	ROXY	$\frac{\Delta ROXY}{\Delta T}$
Tokyo FUC	−94.69	51.40	−45.48	47.03	− 9.32	25.28	5.74	4.83
Chuo Line Region	46.23	14.99	52.79	− 1.86	44.76	−14.20	26.91	−21.50
Takasaki Line Region	−35.84	79.58	14.87	21.84	32.37	13.15	33.44	−11.01
Joban Line Region	−53.88	56.81	− 4.71	41.52	26.05	20.00	33.99	− 5.93

(Note) 1. ΔT: Five Years

2. $\Delta ROXY/\Delta T$: Marginal Change in the Value of ROXY Index

3. Value of ROXY Index in this Table:

For the period 1960/65 – 65/70;

ROXY (1960/65 – 65/70) = {ROXY (1960 – 65) + ROXY (1965 – 70)}/2

The same rule applies correspondingly to the rest.

4. Calculation of the Marginal Change in the Value of ROXY Index:

For the period 1960/65 – 65/70;

ROXY (1965 – 70) — ROXY (1960 – 65)

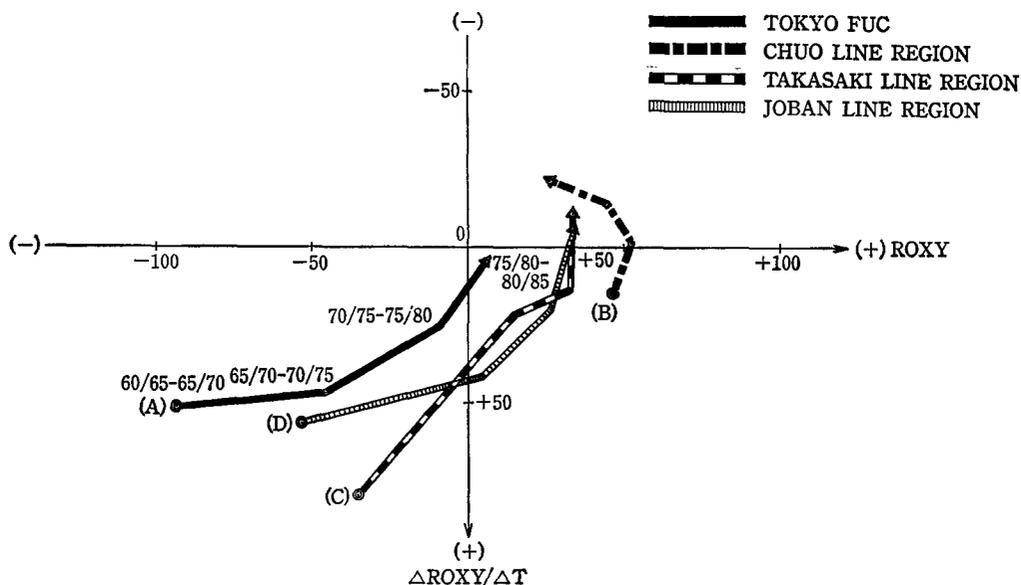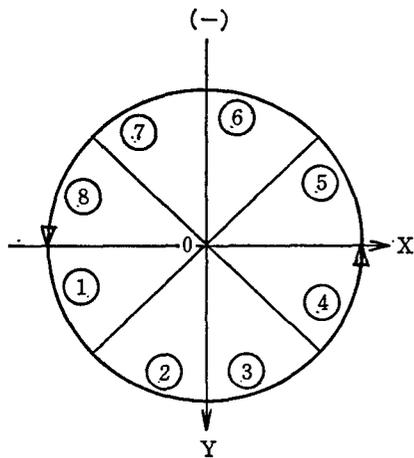The same rule applies correspondingly to the rest.

Figure N-1 ROXY Index and Its Marginal Change (Alternative Diagram)

7) The essence of this spatial cycle paradigm can be presented through the circular diagram shown in Figure N-2. For a more detailed discussion on the type-δ spatial cycle scheme, see Kawashima (1986b).

(Note)
1. X : Value of ROXY Index
2. Y : Marginal Change in Value of ROXY Index
3. Number Enclosed with a Circle : Substage Number
   Centralization Stage : Substages ① and ②
   Suburbanization Stage: Substages ③ and ④
   Post-suburbanization
              Stage: Substages ⑤ and ⑥
   Re-centralization Stage: Substages ⑦ and ⑧
4. It should be noted that the lower portion of the vertical axis in the "Circular Diagram" presents positive values and that its upper portion presents negative values.

Figure N-2 Circular Diagram of Type-δ Spatial Cycle Scheme

8) It is to be noted that Tokyo FUC was at the least advanced stage if we include Tokyo FUC in the participants in the "spatial cycle race" to compete with the three major railway-line regions.

9) Among such possible analyses would be the studies on the spatial distribution changes in industrial location patterns. Putting it more concretely, the method of ROXY index will be useful for both intra- and inter-metropolitan studies to analyze the basic relationship of the dynamic spatial redistribution of industrial activities by sector with that of population, public capital investment or other factors which generate external agglomeration economies for the benefit of industrial activities or external agglomeration diseconomies unfavourably affecting industrial activities. In such studies, the magnitude of industrial activities will be measured through employment level, production level, sales level or the level of private capital investment. Depending on the purpose of study, the employment should be disaggregated into appropriate subcategories based on, for example, the skillfulness of labour. The same considerations of disaggregation should be applied to the levels of production, sales, private capital investment, population and public capital investment.

10) The "analytical approach applying the ROXY index method" may be referred to as "Roxyian approach" for short.