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Long-term Urban Development of the Finnish Population: Application of the ROXY-index Analytical Method

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1. Introduction

In this paper we study the urbanization process of the Finnish population over a long period of one hundred and twenty years, from 1875 through 1995. We apply the ROXY-index analytical method to the population data for a set of twenty-five large urban spatial units in Finland. Each of these spatial units either ① comprises a large city and its suburbs or ② is a large city itself.

The population data arranged for our analysis are dated backwards: ① from 1995 to 1970 in five-year intervals, and ② from 1970 to 1875 in ten-year intervals. This long-term period of time covers the major stages of the modern industrialization process in Finland, for example, the era of rapid growth of railroad services, which started in 1862 between Helsinki and the inland city Hameenlinna.

During the one hundred and twenty years being investigated in this paper, the large urban centers in Finland seem to have shown the particular trend of the urban-change path. One factor behind this trend is the existence of the agglomeration economies and diseconomies in large urban centers (Isard, 1956). Agglomeration benefits cause the accumulation of social and human capital, which produces in turn more agglomeration benefits. The primary purpose of the present paper is to examine whether or not the agglomeration and deglomeration phenomena observed for the process of population development in a system of spatial urban units in Finland would follow a cyclical path, as has been analytically and theoretically suggested by Van Klaassen (1979, 1981) and empirically tested by Kawashima (1978,1985,1994) and Hiraoka and Kawashima (1993).

2. Background of Population Development

It has been estimated that the Finnish population was approximately 250,000 in the middle of the 16th century. It increased to nearly 430,000 by 1751. It doubled within the following fifty years, and then redoubled within the next sixty years (Source: *A World Population Year Monograph,* 1974). The Finnish population in 1995 was a slightly over five million.

In 1809 Finland became an autonomous state within the Russian Empire, and in 1917 became an independent state. Finland joined the European Union in 1995 (Source: *Statistics Finland*).

Under the above-mentioned historical circumstances, the Finnish industrialization started in the 1870's. Before that, the progress of urbanization was rather modest. Shortly before the year 1870, the crude birth and death rates both began to decline from much higher rates. As a result, the crude birth and death rates dropped to 37.0 permillage and 22.2 permillage respectively by the middle of the 1870's, as indicated by Table 1. From this table, it can also be seen that the decreasing tendency continued until the 1990's for the crude birth rate and until the 1950's for the

Table 1 Mean-population, Live-births, Deaths and Increase in Population (per 1000 mean-population): In Finland For Period 1871-1995 (unit: permillage of mean-population)

Period	Mean-population (Persons)	Live-births (‰)	Deaths (‰)	Increase in population (‰)
1871-1880	1,915,300	37.0	22.2	15.3
1881-1890	2,213,035	35.0	21.1	14.4
1891-1900	2,509,510	32.6	19.9	11.0
1901-10	2,785,425	32.4	18.7	10.3
1911-20	3,072,440	27.0	18.9	6.7
1921-30	3,317,625	23.6	14.9	9.5
1931-40	3,589,696	19.7	14.0	6.5
1941-50	3,817,200	24.3	13.6	11.1
1951-60	4,248,900	20.7	9.3	9.8
1961-70	4,563,100	16.8	9.5	3.3
1971-75	4,663,975	13.1	9.5	4.0
1976-80	4,752,264	13.6	9.3	2.7
1981-85	4,853,338	13.4	9.3	5.1
1986-90	4,949,512	12.6	9.8	3.4
1991-95	5,063,660	12.8	9.8	4.5

crude death rate, in parallel with the development of the industrialization process [1].

From the 1870's, the industrialization process caused dynamic interregional migration within Finland, to influence significantly the age structure of the urban population. The young people rapidly immigrated into urban centers, to make the proportion of the economically-active population in urban centers much greater than in rural areas. In the 1870's, the proportions of elderly people over sixty-five years of age in urban centers were 5.2 percent for men and 7.0 percent for women. In the same decade, the proportion of the urban population rose to 7.5 percent, and continuously increased thereafter for a while, with an average annual growth rate of approximately 3.0 to 4.0 percent.

During the long period of time since the middle of the last century, several important historical incidents took place which influenced the spatial population changes, though some of them may be considered as exogenous to the urbanization process. For example, there were the years of the great famine from 1866 to 1868, which reduced considerably the proportion of children and elderly persons in the population. The industrial breakthrough took place in 1870 through 1917, when foreign trade developed rapidly with Russia, which was experiencing an economic boom at that time.

In the first half of the twentieth century, the first wave of emigration mainly to North America took place between 1901 and 1920, when around 140,000 persons emigrated out of Finland, as indicated by Table 1. After the Russian Revolution in 1917 and the Finnish civil war in 1918, the newly independent Finnish state had to redirect its foreign trade from the USSR to the western countries. The period between World War I (WW I) and World War II (WW II) was a time of political and economic stability for Finland. After WW II, more than 400,000 persons moved out of the regions that had been newly occupied by the USSR, to settle in rural areas and cities within their home country Finland. Some cities, as a consequence, got substantial additions to their populations.

In the 1950's and 1960's, there was the second wave of emigration, this time mainly to Sweden. The net emigration was approximately 70,000 persons in the 1950's, as indicated by Table 1. According to the Swedish population census, 101,000 persons of Finnish origin were living in Sweden in 1960. The majority of them were women (60,000 persons). In the 1960's, the emigration movement to Sweden accelerated. The 1970 population census registered 270,000 persons of Finnish origin living in Sweden in that year (Source: *A World Year Population Monograph,* 1974). It is to be noticed that both of the first and second emigration waves coincide with the periods of industrial stagnation in the economic cyclical variations in Finland.

Meanwhile, the Helsinki metropolitan area, which is the largest conurbation center in Finland, had been receiving the net migration throughout the whole period being investigated in this paper, and still presently continues to grow. In order to balance Helsinki's status as an exceptionally strong urban center in Finland, the national government tried to implement in the 1960's and 1970's various regional policies to create other growth-pole centers in the country. Those efforts nevertheless failed.

The latest milestone in the development of the urbanization process in Finland happened in the early 1970's. Around this time, the natural growth of the population in rural areas became no longer enough to supply for population growth in rural areas, and the continued migration to urban centers from rural areas started to deplete human resources in rural areas. After that, the relative importance of large urban centers has increased even more.

3. Population Data for Urban Spatial Units

For our study, we first chose a set of Finnish cities each of which ① had a population of more than 20,000 in 1990 and ② existed in 1875 as a municipal administrative unit.

During the period from 1875 through 1995, several new cities have been born, some old cities have lost population, and some cities have changed their administrative boundaries. Therefore,

our criteria for choosing cities may perhaps generate a bias in our results in the sense that our list of chosen cities excludes some old cities which used to be more important in the 19th century, and some small cities which have been growing fast recently.

Understanding such possibilities, we chose twenty-five cities based on the above criteria. Among the chosen cities, each of the eleven largest ones is combined with its surrounding municipalities which have close functional associations with their core city, to comprise a metropolitan area which we call a functional urban region (FUR). Accordingly, we have in our study a system of the Finnish spatial urban units which consists of eleven FURs and fourteen cities, as shown in Table A-1 in the Appendix. The boundary of each spatial urban unit remains fixed in the 1990 delineation.

The time span our data covers ranges from 1875 through 1995. The earlier part of the data except for the year 1875 (*i.e.*, the data for 1880-1970) are arranged by ten-year periods and the later part of the data (*i.e.*, the data for 1975-95)[2] by five-year periods. As can be seen from Table A-2, the largest spatial urban unit in 1995 is Helsinki FUR with a population of 1,082,201, while the smallest one in the same year is Valkeakoski city, with a population of 21,168. The Helsinki FUR was the largest spatial urban unit in 1875 also with a population of 60,327. In the same year, nine spatial urban units have more than 10,000 inhabitants, while eight spatial urban units have less than 5,000 inhabitants. The smallest one is Varkaus city, with a population of 835.

4. Results of Empirical Analysis

Table 2 shows the value of the Roxy index and its marginal value of each period for the system of the twenty-five spatial urban units in Finland. To obtain the Roxy-index values which appear in this table, we first calculated the gross growth-ratio of the population for each spatial urban unit by each period as shown in Table A-2. This table enables us to gain the annual-growth ratio of a population, as shown in Table A-3. Based on Tables A-1 and A-3, we estimate the population level in the middle year of each period (*i.e.*, middle-point population), as given by Table A-4. By using the annual-growth ratio of a population together with the middle-point population which we employ as the weighting factor for each period, we get the Roxy-index value as shown in Table 2. On the basis of this table, we draw both Figure 1 which shows changes in the Roxy-index value by wavelike-cyclic form, and Figure 2 which shows them by circular-cyclic form. The results could be stated as follow:

(1) The spatial concentration of population towards larger urban centers in the system of the twenty-five urban spatial units in Finland, is most intense in the following two periods: ① at the beginning of the present century, and ② in the 1990's, nearly one hundred years after the first occasion.

Table 2 Value of Roxy Index and Its Marginal Value for a System of Twenty-five Spatial Urban Units in Finland: For 1875 - 1995

Period	Roxy index	Marginal value of Roxy index
1875-80	9.34	-2.55
1880-90	2.01	0.60
1890-00	28.99	3.07
1900-10	54.91	-7.68
1910-20	-13.71	-3.49
1920-30	-14.92	1.21
1930-40	10.40	-2.35
1940-50	-61.91	1.35
1950-60	37.49	4.90
1960-70	36.15	0.37
1970-75	41.70	-4.67
1975-80	0.28	-2.20
1980-85	19.65	3.75
1985-90	37.76	3.60
1990-95	55.66	3.56

Figure 1 Value of Roxy Index (Wavelike-cyclic Form): For 1875 - 1995

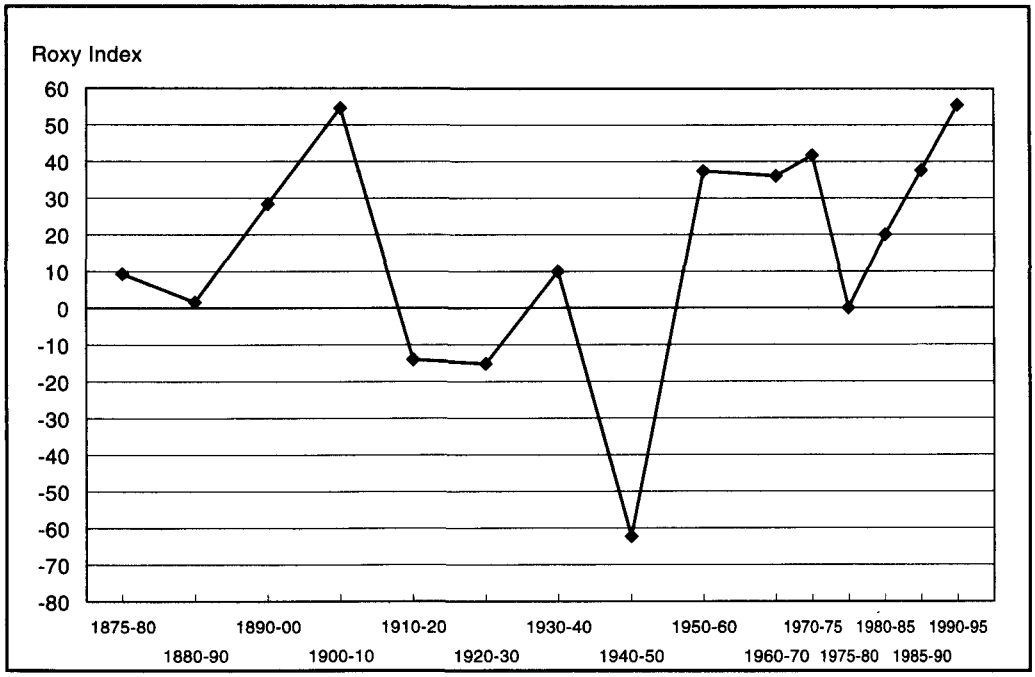
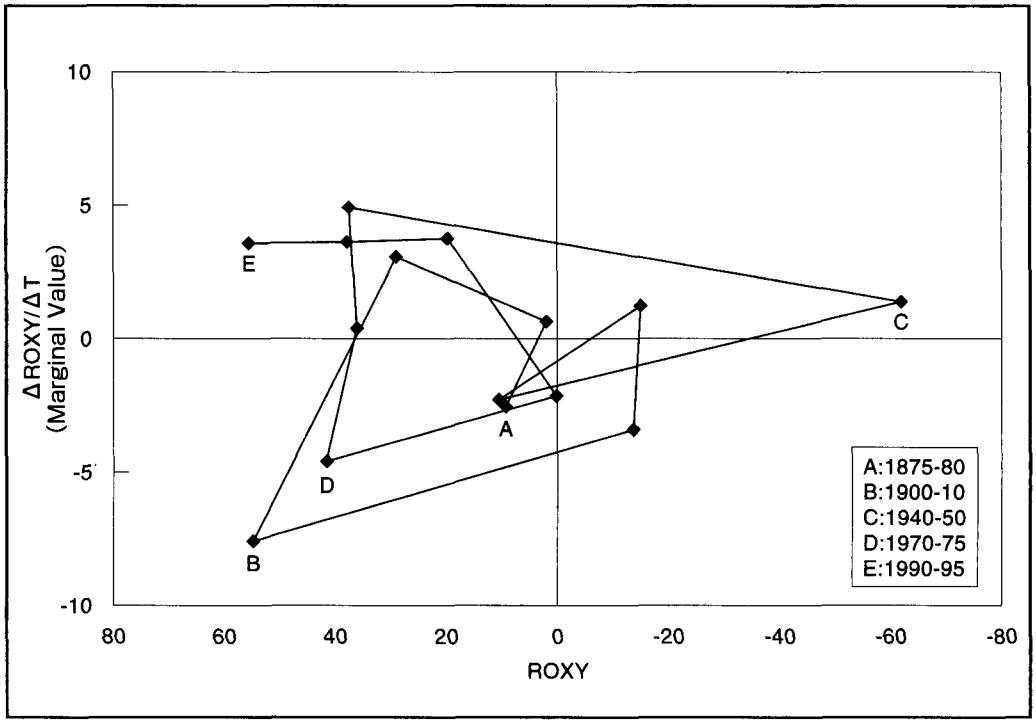


Figure 2 Value of Roxy Index and Its Marginal Value (Circular-cyclic Form): For 1875-1995



(2) The spatial concentration of population is relatively intense in the following two periods: ① during the period between 1950 and the beginning of the 1970's, and ② in the 1930's.

(3) The spatial deconcentration of population out of larger urban centers in the system of the twenty-five urban spatial units in Finland is most intense in the 1940's.

(4) The spatial deconcentration of population is relatively intense in the following three periods: ① in the 1880's, ② during the period between 1910 and 1930, and ③ in the latter half of the 1970's.

In light of the aforementioned, the following can be pointed out:

(1) If we interpret that WW II created "a temporary phenomenon of the spatial deconcentration of population in the 1940's," then we perceive two and a half times of spatial cycles in the whole time span of one hundred and twenty years, from 1875 through 1995, for the system of the twenty-five urban spatial units in Finland.

(2) If we interpret that the phenomenon of the spatial deconcentration of population in the 1940's does not necessarily indicate a temporary one, then we perceive three and a half times of spatial cycles for the period of 1875 through 1995.

In the above, we have examined the spatial-cycle characteristics of the system of the twenty-five urban spatial units in Finland, merely based on the empirically obtained values of the Roxy-index

for the period 1875 through 1995. We now look at twelve blocs of the periods of time, the spatial-cycle characteristics based not only on the Roxy-index values but also together with historical factors of the socio-economic development in and around Finland.

4-1. For the Period 1875-80-90

By the year of 1875, the modern industrialization had already started in Finland[3], while the Finnish society had almost recovered from the serious famine of 1866-68. In this period of 1875-90, the economic progress of Finland benefited considerably from the economic growth of Russia, as well as from the fast development of the Russian railroad network into which the Finnish railroad system was functionally integrated. For its economic progress towards the end of the 19th century, Finland also owed a great deal to its geographical closeness to St. Petersburg (the then capital of Russia) and other European major market cities. With this background, the general increase in the import-export trade of Finland favored the dynamic growth of Finnish cities along the waterways and on the coast, which possessed relative locational advantages in terms of transportation functions. Meanwhile, the commodity prices in the world market had on the whole remained reasonably stable until 1910 since the 1870's. In such economic circumstances, Finland started the export of wood and wood products.

As to the phenomena of the concentration and deconcentration of population in the system of the twenty-five urban spatial units in Finland, the spatial-cycle process of the urban system was at the stage of decelerating concentration for the period of 1875-80 (RI= 9.34, MRI= - 2.55)[4], and then moved to the stage of accelerating concentration for the period of 1880-90 (RI= 2.01, MRI= 0.60). The change in the values of RI and MRI would imply, for the period of 1875-80-90, a tendency towards "slower concentration of population within the stage of spatial concentration." In this period, the data indicate that the medium-sized urban units grew together with the larger-sized urban units.

4-2. For the Period 1890-1900

The favorable environments for the Finnish economic growth continued in this period.

The spatial-cycle process of the Finnish urban system was at the stage of accelerating concentration (RI= 28.99 and MRI= 3.07), implying that the larger-sized urban units grew faster. In fact, the annual growth rates of population for this period were ① high for Helsinki, Tampere and Oulu, and ② exceptionally high for Kotka (a port city) and Joensuu (an inland city on the waterway). The completion of the railroad construction connecting the inland city of Hameenlinna with Helsinki in the 1860's, however, seems not to have given any remarkable growth impact

upon Hameenlinna yet at that time[5].

4-3. For the Period 1900-10

During this period, the industrial progress in Finland continued. The export of wood and wood products brought a handsome trade income to major inland cities and port towns. Regarding the political aspect, the Russian administration took a stronger grip on the border regions of the Empire. In Finland, a kind of political tension developed between the ruling party and the opposition. As a result, some new political rights were granted to the latter.

The Roxy-index value for this period is the second highest throughout the whole time span of one hundred and twenty years being investigated in this paper (RI=54.91), while its marginal value is the lowest (MRI= -7.68). This would imply that the Finnish urban system was at the turnabout stage from accelerating concentration to decelerating concentration. Besides Helsinki, the data indicate that the annual growth rates of population were high for the larger and medium-sized inland urban units such as Lahti and Kajaani and port urban units such as Kotka and Lappeenranta.

4-4. For the Period 1910-20

A significant feature of this period is marked by the outbreak of WW I in 1914, which suddenly increased the demand for the Finnish products required by Russia for war preparations. Soon after the Russian Revolution had broken out in 1917, Finland declared its independence and separated from Russia in the same year. The civil war erupted in the spring of 1918 which lasted only a few months, although it was bloody on some battlefields[6]. Neither WW I nor the civil war touched Finland so severely as usual war conditions perhaps might have done.

The spatial-cycle process of the Finnish urban system got in the stage of accelerating deconcentration (RI= -13.71, MRI= -3.49), implying the higher annual growth rates of population for the medium and smaller-sized urban units.

4-5. For the Period 1920-30

Finland enjoyed both political and industrial stability throughout this decade, except at the very end of this period. In this decade, the import-export relationships of Finland with Russia were redirected to new foreign-trade partnerships with western countries. Towards the end of the 1920's, the stable economic growth was interrupted by the disturbance of the international monetary market and the calamity of the great world depression. In these circumstances, Finland

adopted a self-sufficiency policy to secure the food-supply conditions.

During the Russian regime before 1917, the provincial administrative system in Finland was fairly well developed. This system became more intensified after the separation of Finland from Russia. As a result, each provincial capital became an increasingly important regional center and grew quickly regardless of population size. Therefore, despite of (and simultaneuously because of) Helsinki's continuous growth, the spatial-cycle process moved into the stage of decelerating deconcentration (RI= -14.92, MRI= 1.21).

4-6. For the Period 1930-40

Finland succeeded in establishing sustainable export markets in western countries in this period, though its economic structure was still strongly based on farming and forestry. Due to the active international trade, the forest industry and wood-product industry created job opportunities both for rural areas as well as for small towns and cities to attract the labour force. For the same reason, the population also increased at a high annual growth rate in such large urban units as Jyvaskyla, Vaasa and Hameenlinna, all serving as regional growth-poles.

At the end of this decade on the eve of WW II, the Winter War erupted with the Soviet Union. Though the war was short, lasting only several months in 1939-40, it resulted in the following:

(1) The war seriously hit various urban centers in Finland.

(2) Approximately 400,000 persons who had been residing in the border areas, removed to the non-border areas in Finland to temporarily escape the ravages of war. Their temporary removal, however, turned out to be permanent movement after the end of the Winter War because the Soviet Union annexed the occupied areas to its own territory. This incident caused the tremendous influx of new population into such spatial urban units in Finland as Valkeakoski, Lahti, Jyvaskyla, Hameenlinna and Joensuu. There had been no such precedent before, and the same scale of interregional migration has never been repeated in Finland since then.

The spatial-cycle process for this period was at the stage of decelerating concentration (RI= 10.40, MRI= -2.35). There is good reason to believe, however, that our ten-year interval data tend to generate sometimes an unsmooth picture of spatial cycles. It seems that the spatial cycle would have developed towards the stage of concentration anyway. As indicated by the negative value of MRI, the Winter War seems to have made the period of spatial concentration shorter. It can also be pointed out that the spatial concentration tendency of this decade may reflect the impact from the Great Depression, in the sense that the relative attractiveness of larger-sized urban units became stronger than smaller-sized urban units during the depression period, though the absolute attractiveness of the former may perhaps have been reduced as compared with the

time before the depression.

4-7. For the Period 1940-50

During WW II, Finland stayed in the war conditions. The war losses from both WW II in 1940-45 and the Winter War in 1939-40, totalled 85,500 persons. The immigration of approximately 400,000 refugees from the border regions occupied by the Soviet Union, became permanent residents at the places where they had settled down. After the end of WW II, the Finnish export markets revived slowly but steadily. However, the heavy war-compensation payments in industrial products to the Soviet Union were tough obstacles to recovery of the level of personal income in Finland for many years to follow.

The Roxy-index value for this period is the lowest among all obtained RI's, which indicates that the spatial-cycle process turned to the stage of strong deconcentration (RI= -61.91, MRI= 1.35). It is also to be kept in mind that the deconcentration stage remained only for this period and that it changed to the stage of concentration again in the next decade of the 1950's. This exceptionally abrupt and strong impact of spatial deconcentration of population in the Finnish urban system seems to have arisen from ① the settlement of the 400,000 refugees in the medium and smaller-sized urban units, ② the mass flight of people from larger-sized urban units for safety from war, and ③ the slow economic recovery after the double-war period of 1939-45.

The double wars in 1939-45 and the lagging economic recovery in the post-war period may have seriously disturbed the normal spatial-cycle path of Finland. If we assume that the spatial deconcentration of population in the period of 1940-50 would be somewhat transient due to the outbreak of the double wars, and if we take it into consideration that the previous concentration stage was considerably short only for the period of 1930-40, then we perceive that the deconcentration stage in 1940-50 generates no additional cycle to the long-term spatial-cycle path of Finland. In contrast with this, if we assume that the spatial deconcentration of population in the period of 1940-50 would not necessarily be transient, then we perceive that the existence of this deconcentration stage adds one completely independent cycle to the long-term spatial-cycle path of Finland.

4-8. For the Period 1950-60

At the beginning of the 1950's, fifty percent of the Finnish labour force was still engaged in the primary industries including forestry. With this initial industrial structure in this decade, Finland enjoyed the shift to the phase of economic growth out of the phase of economic recovery from WW II. The Nordic countries mutually agreed to allow free labor movement across their borders.

The international monetary arrangements such as the Bretton Woods Agreement constructed basic frameworks for the new monetary system to promote international trading activities. To these arrangements, the Finnish economy started to adjust itself by devaluating its currency at approximately ten-year intervals thereafter. Actually, this cyclical devaluation of the currency provided the Finnish domestic markets with heuristic information on how the world market develops and, as a consequence, how the structure of the Finnish labor market should flexibly change in responding to the change in the world market.

The start of the rapid growth of service industries and the continuous growth of manufacturing industries were both observed in this period though there existed distinctive up-and-down variations of the economy. Substantial amount of the labour force shifted from the primary industries to secondary and tertiary industries. As a natural consequence, the urbanization process was accelerated, and large urban units regained the leading growth-positions as they had held at the beginning of this century and also for a short time in the 1930's. The value of the Roxy index states that the spatial-cycle process for this period was at the stage of accelerating concentration (RI= 37.49, MRI= 4.90).

4-9. For the Period 1960-70

There was a huge outflow of population from Finland to Sweden during this period. More concretely, the Finnish economy experienced heavy cyclical fluctuations in the 1950's and 60's. This economic instability first made about 70,000 persons move to Sweden in the late 1950's. After that, during the Finnish recession in the 1960's, about additional 200,000 persons moved to Sweden since there was a scarcity of jobs in Finland and since there was a high demand for labour in Swedish manufacturing industries.

The spatial-cycle process for this period was at the stage of accelerating concentration (RI= 36.15, MRI= 0.37), indicating that the spatial concentration of population in larger-sized urban units continued at the same level as in the 1950's.

4-10. For the Period 1970-75-80

The world-wide oil crisis arose in 1973. By 1975, the Finnish economy had been severely hit by this crisis. This caused the recession in 1977 which immediately led to the devaluation of the Finnish currency.

The natural growth of the rural population sharply declined during this decade, resulting in no population growth in both rural and urban areas for a while. Actually, the rural population start-

ed to decrease. The relative urbanization of the Finnish population started, and the relative importance of the larger-sized urban units has continuously increased since the beginning of the 1970's.

The spatial-cycle process was at the stage of decelerating concentration for the first half of the 1970's (RI= 41.70, MRI= -4.67), and at the stage of extremely slow concentration for the second half of the decade (RI= 0.28, MRI= -2.20). These spatial-cycle stages seem to be well reflecting the above-mentioned phenomena of spatial population movement in Finland for the decade of the 1970's.

4-11. For the Period 1980-85-90

In the first half of this period, the firm economic growth and spatial population concentration were both observed. The spatial-cycle process shows a new concentration tendency (RI= 19.65, MRI= 3.75) after the stage of very slow concentration in the period of 1975-80.

The Soviet Union collapsed in the second half of the 1980's, and Finland started preparations to join the European Union. The first step for Finland to achieve this objective was to open its financial markets, which resulted in increasing ① foreign debts and ② prices of estates and equities[7]. Towards the end of this decade, the economy was overheated in the form of "the bubble economy just before the burst" to create excessive demand in the markets. The concentration of population to larger urban units accelerated even more (RI= 37.76, MRI= 3.60). Again, the economic circumstances coincide with the stage of spatial cycles for this period like for the period of 1950-60.

4-12. For The Period 1990-95

The Finnish economy experienced in this period the worst recession in the present century. The economic activities were, at worst, as low as at the level of 1987. The currency was devaluated in 1991-92. The unemployment problems severely hit both larger and smaller-sized urban units as well as rural areas. The unemployment rate increased up to 18% when the recession bottomed out in 1993.

The economic environments as mentioned above for this period may suggest the possible cease of the stage of spatial concentration of population in Finland. However, the Roxy-index value shows the contrary (RI= 55.66, MRI= 3.56), implying that the concentration of population to larger-sized urban units continued to grow in this period.

There are several reasons behind such distinctive spatial concentration of population in the 1990's. They are as follows:

(1) The new wave of technological change which had already started in the 1980's, significantly reduced employment opportunities both in financial services and in traditional manufacturing industries which were situated in smaller-sized urban units and rural areas. At the same time, in larger-sized urban units and in the southern part of Finland, the labor demand increased in the information and communication industries.

(2) Affected by the changes in the relative-price system caused by Finland's participation to the European Union and by the devaluation of the currency in the beginning of the 1990's, agricultural prices collapsed, the demand for services declined, and the level of construction was reduced to about a half of before. As a consequence, a number of economic activities were closed down in smaller-sized urban units and rural areas. Only a few of larger-sized urban units remained as growth centers due to the existence of active urban-service sectors and growing technology-oriented sectors that are located there.

5. Conclusions

The time span investigated in this paper nearly covers the whole period of the modern industrialization process of Finland. For example, it covers almost the whole period for the development of Finnish transportation system, including the railroad networks a part of which started to be constructed in 1862.

For such a long period of time, the Finnish spatial population development shows a super-long-term general tendency of concentration to larger-sized urban units. The periods of deconcentration for which the Roxy-index shows negative values may be regarded as exceptional in the sense that those periods coincide with the world-wide historical upheavals like the world-wide wars or the Great Depression.

The results of the Roxy-index analysis to cover such a long period for the system of the twenty-five spatial urban units in Finland show the following:

(1) Klaassen's hypothesis about the process of the spatial-cycle growth and decline (or spatial cyclic concentration and deconcentration) is favourably verified since the existence of the spatial-cycle path for the Finnish urban system is obvious from the results of our Roxy-index analysis.

(2) Depending on how the stage of deconcentration for the period of 1940-50[8] is interpreted concerning whether this stage is transient or not, we perceive two and a half times (2.5) or three and a half times (3.5) of spatial cycles existing over the past 120 years for the system of the Finnish urban units.

(3) Major historical events like wars or world-wide depressions seem to have affected the path of

spatial cycles. Especially, the coincidence of spatial cyclical variations of the concentration and deconcentration of population with the historical events that carry the same direction-vectors, seems to strengthen the path of spatial-cycles.

(4) The marginal value of the Roxy-index is important for predicting the future stages of spatial cycles.

During the 120 years set for our investigation, the fertility and death rates have both changed considerably. The level of technology, social and economic environments, and characteristics of international markets in and around Finland, have also significantly changed. Regional policies implemented in the 1960's and 70's tried to create growth centers in rural areas. All these factors must have more or less influenced the spatial-cycle path. Nevertheless, for the urban system of Finland which indicates, the Klaassen type of spatial-cycle path seem not to have been unexpectedly distorted by such factors within the framework of the super-long-term tendency of spatial concentration of population.

Notes

1) As for the demographic transition in terms of the crude birth and death rates, both rates have considerably decreased since 1870. As can been seen from Table 1, the crude birth rate had remained relatively high (around 30.0 ‰) until WW I. After that, it started to decline almost continuously except for the 1940's when the rate temporarily jumped up. As a matter of fact, after WW II, the crude birth rate boomed to reach in 1947 as high as in the beginning of this century when the rate was 28 ‰. After 1947, the crude birth rate has declined smoothly, which led to an increase in the proportion of elderly people since the crude death rate has been on a declining trend since 1870. Under these conditions, the annual growth rate of population continued to decrease to become 0.8% by the 1920's and 0.6 % by the 1960's. Compared internationally, the crude birth rate of Finland remained at a high level much longer than other European countries (Source: *Statistics Finland*).

2) The data for the period of 1975-95 have been arranged by Hirvonen for his previous Roxy-index analysis of the spatial redistribution process of population by age group for an urban system of Finland.

3) In Central Europe, the modern industrialization started much earlier than the North-European countries especially as compared with Finland and Russia.

4) "RI" stands for the Roxy-index value, and "MRI" for the marginal value of the Roxy index.

5) The railroad connection from Helsinki to Hameenlinna was constructed in 1862 to serve for strategic purposes to link two military bases. Besides this function, the railroad was also important from the economic point of view.

6) The civil war severely damaged only one big city, Tampere, which was then and is at present the second largest city, serving as an important manufacturing center in Finland.

7) The "convergence" process of the prices and interest rates started among the member countries of the European Union, especially among the countries which had already adopted the common currency. In the case of Finland, the inflation and interest rates declined but the unemployment rate stayed high. For agriculture, the system of subsidies had to be adjusted to the EU agriculture policy, which resulted in lower subsidies for Finnish farmers than before.

8) This period was full of historical events which can be considered, from one point of view, as exogenous factors to the path of spatial population development in Finland. This period includes the direct effects of WW II and strong aftermath of the Great Depression.

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Appendix

Table A-1 Population of Twenty-five Spatial Urban Units (FURs and Cities) in Finland For 1875-1995 (unit : person)

FUR or City \ Year	1995	1990	1985	1980	1975	1970	1960	1950	1940	1930	1920	1910	1900	1890	1880	1875
HELSINKI FUR	1,082,201	1,007,990	959,545	908,573	877,928	777,744	639,464	468,082	396,406	284,849	228,025	182,797	132,865	94,596	72,363	60,327
TURKU FUR	225,214	202,670	208,529	216,359	221,886	191,554	162,246	126,487	101,046	88,622	74,221	69,027	57,488	45,173	36,676	34,707
TAMPERE FUR	261,759	249,537	240,452	231,258	226,889	212,031	181,149	146,632	118,660	91,343	79,632	74,914	62,668	42,241	32,936	28,988
PORI FUR	89,406	92,797	91 ,569	89,449	86,276	83,890	73,336	61,132	46,886	37,653	34,769	34,636	31,046	24,229	20,636	18,478
LAHTI FUR	130,331	128,187	127,361	125,049	122,493	112,129	83,445	65,170	38,770	28,869	25,701	22,637	16,409	14,066	11,988	11,053
JYVASKYLA FUR	104,507	98,796	95,116	91,923	87,741	77,773	63,810	50,359	29,533	19,061	16,079	13,309	13,479	11,214	9,201	8,034
OULU FUR	109,094	101,379	97,297	93,806	92,762	84,964	62,938	42,731	33,176	27,719	24,186	23,110	21,117	16,107	12,177	10,810
KUOPIO FUR	84,733	80,613	78,124	74,565	71,930	66,039	56,743	45,976	37,045	34,828	32,126	32,671	29,171	25,548	22,737	21,266
KOTKA FUR	55,903	56,634	58,956	60,752	62,273	60,334	56,891	49,744	42,207	33,548	26,091	23,818	16,198	9,155	5,030	3,838
LAPPEENRANTA FUR	56,664	54,941	55,349	54,866	54,511	52,240	46,452	40,861	34,369	29,352	24,728	22,509	13,715	9,299	7,871	7,446
VAASA FUR	55,502	53,429	54,353	53,758	54,432	50,651	45,455	38,011	36,057	26,253	24,261	22,260	18,739	13,656	9,497	7,726
JOENSUU	50,431	47,554	46,850	44,832	42,459	36,463	28,335	20,067	13,387	9,987	8,221	4,263	5,617	2,819	1,614	1,332
HAMEENL INNA	44,891	43,417	42,382	41,913	40,822	37,584	34,944	27,983	17,500	14,113	12,318	11,640	9,801	8,658	7,323	6,699
KAJAANI	36,860	36,428	36,020	34,574	31,725	29,405	24,389	17,004	12,333	11,673	7,090	5,976	4,388	4,003	3,243	2,995
IMATRA	32,057	33,566	35,085	36,378	35,454	34,410	32,745	28,087	18,922	13,087	9,998	9,074	7,968	6,177	4,958	4,618
ROVANIEMI	57,045	54,014	51,780	48,056	46,651	45,331	45,264	31,389	22,429	17,187	12,592	10,687	8,321	6,596	5,041	4,545
MIKKELI	44,784	43,428	42,702	40,972	39,569	37,704	33,487	29,213	22,436	21,565	18,950	18,180	16,773	14,373	11,741	11,593
RAUMA	38,162	38,372	39,589	39,065	37,854	33,020	28,257	23,237	15,867	14,480	12,189	9,804	8,666	7,188	6,178	5,770
SAVONL INNA	28,867	28,559	28,667	28,341	28,335	29,608	27,231	23,651	18,278	16,406	14,316	13,197	11,732	10,329	9,495	8,489
KEMI	34,107	34,517	35,219	34,649	35,198	33,546	33,797	28,599	22,689	16,629	9,465	8,355	7,082	4,783	3,947	3,437
VARKAUS	24,160	24,576	24,856	24,706	24,415	23,944	22,211	17,640	12,732	3,688	1,918	1,080	989	940	913	835
IISALMI	24,042	23,979	23,612	22,648	21,474	20,371	20,198	18,741	16,176	15,657	19,324	24,861	21,986	19,384	16,526	15,675
TORNIO	23,156	22,879	22,328	21,076	20,273	18,045	17,018	15,903	13,742	13,334	12,591	10,665	9,978	8,682	7,537	7,433
VALKEAKOSKI	21,168	21,724	22,582	22,780	22,600	20,940	19,098	16,701	8,171	7,280	7,637	7,550	6,584	5,579	4,630	3,895
KOKKOLA	35,552	34,635	34,489	33,904	32,929	28,103	22,663	18,475	12,650	10,505	8,110	7,482	8,034	7,468	6,964	6,855
TOTAL	2,750,596	2,614,621	2,552,812	2,474,252	2,418,879	2,197,823	1,861,566	1,451,875	1,141,467	887,688	744,538	664,502	540,814	412,263	331,222	296,844

[Note] FUR: Functional urban region which is conceptually equivalent to the metropolitan area.

Table A–2 Gross Growth Ratio of Population for Each Period : FURs and Cities in Finland for 1875–1995

FUR or City \ Period	1990–95	1985–90	1980–85	1975–80	1970–75	1960–70	1950–60	1940–50	1930–40	1920–30	1910–20	1900–10	1890–1900	1880–90	1875–80
HELSINKI FUR	1.0736	1.0505	1.0561	1.0349	1.1288	1.2162	1.3661	1.1808	1.3916	1.2492	1.2474	1.3758	1.4046	1.3072	1.1995
TURKU FUR	1.1112	0.9719	0.9638	0.9751	1.1583	1.1806	1.2827	1.2518	1.1402	1.1940	1.0752	1.2007	1.2726	1.2317	1.0567
TAMPERE FUR	1.0490	1.0378	1.0398	1.0193	1.0701	1.1705	1.2354	1.2357	1.2991	1.1471	1.0630	1.1954	1.4836	1.2825	1.1362
PORI FUR	0.9635	1.0134	1.0237	1.0368	1.0284	1.1439	1.1996	1.3038	1.2452	1.0829	1.0038	1.1156	1.2814	1.1741	1.1168
LAHTI FUR	1.0167	1.0065	1.0185	1.0209	1.0924	1.3437	1.2804	1.6809	1.3430	1.1233	1.1354	1.3795	1.1666	1.1733	1.0846
JYVASKYLA FUR	1.0578	1.0387	1.0347	1.0477	1.1282	1.2188	1.2671	1.7052	1.5494	1.1855	1.2081	0.9874	1.2020	1.2188	1.1453
OULU FUR	1.0761	1.0420	1.0372	1.0113	1.0918	1.3500	1.4729	1.2880	1.1969	1.1461	1.0466	1.0944	1.3110	1.3227	1.1265
KUOPIO FUR	1.0511	1.0319	1.0477	1.0366	1.0892	1.1638	1.2342	1.2411	1.0637	1.0841	0.9833	1.1200	1.1418	1.1236	1.0692
KOTKA FUR	0.9871	0.9606	0.9704	0.9756	1.0321	1.0605	1.1437	1.1786	1.2581	1.2858	1.0954	1.4704	1.7693	1.8201	1.3106
LAPPEENRANTA FUR	1.0314	0.9926	1.0088	1.0065	1.0435	1.1246	1.1368	1.1889	1.1709	1.1870	1.0986	1.6412	1.4749	1.1814	1.0571
VAASA FUR	1.0388	0.9830	1.0111	0.9876	1.0746	1.1143	1.1958	1.0542	1.3734	1.0821	1.0899	1.1879	1.3722	1.4379	1.2292
JOENSUU	1.0605	1.0150	1.0450	1.0559	1.1644	1.2869	1.4120	1.4990	1.3404	1.2148	1.9285	0.7589	1.9926	1.7466	1.2117
HAMEENL INNA	1.0339	1.0244	1.0112	1.0267	1.0862	1.0755	1.2488	1.5990	1.2400	1.1457	1.0582	1.1876	1.1320	1.1823	1.0931
KAJAANI	1.0119	1.0113	1.0418	1.0898	1.0789	1.2057	1.4343	1.3787	1.0565	1.6464	1.1864	1.3619	1.0962	1.2344	1.0828
IMATRA	0.9550	0.9567	0.9645	1.0261	1.0303	1.0508	1.1658	1.4844	1.4459	1.3090	1.1018	1.1388	1.2899	1.2459	1.0736
ROVANIEMI	1.0561	1.0431	1.0775	1.0301	1.0291	1.0015	1.4420	1.3995	1.3050	1.3649	1.1783	1.2843	1.2615	1.3085	1.1091
MIKKELI	1.0312	1.0170	1.0422	1.0355	1.0495	1.1259	1.1463	1.3021	1.0404	1.1380	1.0424	1.0839	1.1670	1.2242	1.0128
RAUMA	0.9945	0.9693	1.0134	1.0320	1.1464	1.1686	1.2160	1.4645	1.0958	1.1880	1.2433	1.1313	1.2056	1.1635	1.0707
SAVONL INNA	1.0108	0.9962	1.0115	1.0002	0.9570	1.0873	1.1514	1.2940	1.1141	1.1460	1.0848	1.1249	1.1358	1.0878	1.1185
KEMI	0.9881	0.9801	1.0165	0.9844	1.0492	0.9926	1.1818	1.2605	1.3644	1.7569	1.1329	1.1798	1.4807	1.2118	1.1484
VARKAUS	0.9831	0.9887	1.0061	1.0119	1.0197	1.0780	1.2591	1.3855	3.4523	1.9228	1.7759	1.0920	1.0521	1.0296	1.0934
IISALMI	1.0026	1.0155	1.0426	1.0547	1.0541	1.0086	1.0777	1.1586	1.0331	0.8102	0.7773	1.1308	1.1342	1.1729	1.0543
TORNIO	1.0121	1.0247	1.0594	1.0396	1.1235	1.0603	1.0701	1.1573	1.0306	1.0590	1.1806	1.0689	1.1493	1.1519	1.0140
VALKEAKOSKI	0.9744	0.9620	0.9913	1.0080	1.0793	1.0964	1.1435	2.0439	1.1224	0.9533	1.0115	1.1467	1.1801	1.2050	1.1887
KOKKOLA	1.0265	1.0042	1.0173	1.0296	1.1717	1.2400	1.2267	1.4605	1.2042	1.2953	1.0839	0.9313	1.0758	1.0724	1.0159
TOTAL	1.0520	1.0242	1.0318	1.0229	1.1006	1.1806	1.2822	1.2719	1.2859	1.1923	1.1204	1.2287	1.3118	1.2447	1.1158

[Note] FUR: Functional urban region

Table A-3 Annual Growth Ratio of Population for Each Period: FURs and Cities in Finland for 1875-1995

FUR or City \ Period	1990-95	1985-90	1980-85	1975-80	1970-75	1960-70	1950-60	1940-50	1930-40	1920-30	1910-20	1900-10	1890-1900	1880-90	1875-80
HELSINKI FUR	1.0143	1.0099	1.0110	1.0069	1.0245	1.0198	1.0317	1.0168	1.0336	1.0225	1.0224	1.0324	1.0346	1.0272	1.0371
TURKU FUR	1.0213	0.9943	0.9927	0.9950	1.0298	1.0167	1.0252	1.0227	1.0132	1.0179	1.0073	1.0185	1.0244	1.0211	1.0111
TAMPERE FUR	1.0096	1.0074	1.0078	1.0038	1.0136	1.0159	1.0214	1.0214	1.0265	1.0138	1.0061	1.0180	1.0402	1.0252	1.0259
PORI FUR	0.9926	1.0027	1.0047	1.0072	1.0056	1.0135	1.0184	1.0269	1.0222	1.0080	1.0004	1.0110	1.0251	1.0162	1.0223
LAHTI FUR	1.0033	1.0013	1.0037	1.0041	1.0178	1.0300	1.0250	1.0533	1.0299	1.0117	1.0128	1.0327	1.0155	1.0161	1.0164
JYVASKYLA FUR	1.0113	1.0076	1.0069	1.0094	1.0244	1.0200	1.0240	1.0548	1.0448	1.0172	1.0191	0.9987	1.0186	1.0200	1.0275
OULU FUR	1.0148	1.0083	1.0073	1.0022	1.0177	1.0305	1.0395	1.0256	1.0181	1.0137	1.0046	1.0091	1.0275	1.0284	1.0241
KUOPIO FUR	1.0100	1.0063	1.0094	1.0072	1.0172	1.0153	1.0213	1.0218	1.0062	1.0081	0.9983	1.0114	1.0133	1.0117	1.0135
KOTKA FUR	0.9974	0.9920	0.9940	0.9951	1.0063	1.0059	1.0135	1.0166	1.0232	1.0255	1.0092	1.0393	1.0587	1.0617	1.0556
LAPPEENRANTA FUR	1.0062	0.9985	1.0018	1.0013	1.0085	1.0118	1.0129	1.0175	1.0159	1.0173	1.0094	1.0508	1.0396	1.0168	1.0112
VAASA FUR	1.0076	0.9966	1.0022	0.9975	1.0145	1.0109	1.0180	1.0053	1.0322	1.0079	1.0086	1.0174	1.0321	1.0370	1.0421
JOENSUU	1.0118	1.0030	1.0088	1.0109	1.0309	1.0255	1.0351	1.0413	1.0297	1.0196	1.0679	0.9728	1.0714	1.0574	1.0392
HAMEENL INNA	1.0067	1.0048	1.0022	1.0053	1.0167	1.0073	1.0225	1.0481	1.0217	1.0137	1.0057	1.0173	1.0125	1.0169	1.0180
KAJAANI	1.0024	1.0023	1.0082	1.0173	1.0153	1.0189	1.0367	1.0326	1.0055	1.0511	1.0172	1.0314	1.0092	1.0213	1.0160
IMATRA	0.9908	0.9912	0.9928	1.0052	1.0060	1.0050	1.0155	1.0403	1.0376	1.0273	1.0097	1.0131	1.0258	1.0222	1.0143
ROVANIEMI	1.0110	1.0085	1.0150	1.0060	1.0058	1.0001	1.0373	1.0342	1.0270	1.0316	1.0165	1.0253	1.0235	1.0273	1.0209
MIKKELI	1.0062	1.0034	1.0083	1.0070	1.0097	1.0119	1.0137	1.0267	1.0040	1.0130	1.0042	1.0081	1.0156	1.0204	1.0025
RAUMA	0.9989	0.9938	1.0027	1.0063	1.0277	1.0157	1.0198	1.0389	1.0092	1.0174	1.0220	1.0124	1.0189	1.0513	1.0138
SAVONL INNA	1.0021	0.9992	1.0023	1.0000	0.9912	1.0084	1.0142	1.0261	1.0109	1.0137	1.0082	1.0118	1.0128	1.0085	1.0227
KEMI	0.9976	0.9960	1.0033	0.9969	1.0097	0.9993	1.0168	1.0234	1.0316	1.0580	1.0126	1.0167	1.0400	1.0194	1.0281
VARKAUS	0.9966	0.9977	1.0012	1.0024	1.0039	1.0075	1.0233	1.0331	1.1319	1.0676	1.0591	1.0088	1.0051	1.0029	1.0180
IISALMI	1.0005	1.0031	1.0084	1.0107	1.0106	1.0009	1.0075	1.0148	1.0033	0.9792	0.9751	1.0124	1.0127	1.0161	1.0106
TORNIO	1.0024	1.0049	1.0116	1.0078	1.0236	1.0059	1.0068	1.0147	1.0030	1.0057	1.0167	1.0067	1.0140	1.0142	1.0028
VALKEAKOSKI	0.9948	0.9923	0.9983	1.0016	1.0154	1.0093	1.0135	1.0741	1.0116	0.9952	1.0011	1.0138	1.0167	1.0188	1.0352
KOKKOLA	1.0052	1.0008	1.0034	1.0059	1.0322	1.0217	1.0206	1.0386	1.0188	1.0262	1.0081	0.9929	1.0073	1.0070	1.0032
TOTAL	1.0102	1.0048	1.0063	1.0045	1.0194	1.0167	1.0252	1.0243	1.0255	1.0177	1.0114	1.0208	1.0275	1.0221	1.0222

[Note] FUR: Functional urban region

Table A–4 Population in the Middle Year between the Two Neighbouring Census Years: FURs and Cities in Finland for 1875–1995

FUR or City \ Year	1992.5	1987.5	1982.5	1977.5	1972.5	1965	1955	1945	1935	1925	1915	1905	1895	1885	1877.5
HELSINKI FUR	1,044,437	983,469	933,711	893,119	826,319	705,223	547,103	430,756	336,030	254,858	204,162	155,844	112,109	82,736	66,071
TURKU FUR	213,645	205,579	212,408	219,105	206,163	176,292	143,255	113,053	94,630	81,102	71,577	62,994	50,960	40,703	35,678
TAMPERE FUR	255,575	244,952	235,810	229,063	219,334	195,983	162,979	131,907	104,109	85,287	77,237	68,518	51,451	37,299	30,899
PORI FUR	91,086	92,181	90,503	87,848	85,075	78,436	66,957	53,537	42,107	36,182	34,702	32,792	27,427	22,360	19,527
LAHTI FUR	129,255	127,773	126,200	123,764	117,196	96,730	73,744	50,266	33,455	27,239	24,120	19,273	15,192	12,985	11,511
JYVASKYLA FUR	101,611	96,939	93,506	89,808	82,607	70,446	56,687	38,565	23,726	17,507	14,629	13,394	12,294	10,158	8,598
OULU FUR	105,166	99,317	95,536	93,283	88,777	73,126	51,859	37,652	30,325	25,892	23,642	22,091	18,443	14,005	11,473
KUOPIO FUR	82,647	79,359	76,324	73,236	68,922	61,215	51,077	41,270	35,919	33,450	32,397	30,871	27,299	24,102	21,989
KOTKA FUR	56,267	57,783	59,847	61,508	61,296	58,587	53,198	45,821	37,629	29,585	24,929	19,642	12,178	6,786	4,394
LAPPEENRANTA FUR	55,796	55,145	55,107	54,688	53,363	49,261	43,567	37,475	31,762	26,941	23,592	17,570	11,293	8,555	7,656
VAASA FUR	54,456	53,889	54,055	54,094	52,507	47,983	41,567	37,021	30,767	25,237	23,239	20,424	15,997	11,388	8,566
JOENSUU	48,971	47,201	45,830	43,629	39,347	32,143	23,845	16,390	11,563	9,061	5,920	4,893	3,979	2,133	1,466
HAMEENL INNA	44,148	42,896	42,147	41,364	39,170	36,240	31,270	22,129	15,716	13,185	11,974	10,681	9,212	7,963	7,004
KAJAANI	36,643	36,223	35,290	33,119	30,543	26,780	20,364	14,481	11,998	9,097	6,509	5,121	4,191	3,603	3,117
IMATRA	32,803	34,317	35,726	35,913	34,928	33,567	30,327	23,053	15,736	11,439	9,525	8,503	7,016	5,534	4,785
ROVANIEMI	55,509	52,885	49,883	47,348	45,986	45,297	37,693	26,533	19,634	14,711	11,600	9,430	7,408	5,766	4,787
MIKKELI	44,101	43,063	41,828	40,264	38,625	35,533	31,277	25,601	21,996	20,215	18,561	17,462	15,527	12,991	11,667
RAUMA	38,267	38,976	39,326	38,455	35,354	30,546	25,624	19,202	15,158	13,285	10,932	9,217	7,892	6,664	5,971
SAVONL INNA	28,713	28,613	28,504	28,338	28,965	28,395	25,378	20,792	17,317	15,325	13,745	12,443	11,008	9,903	8,978
KEMI	34,311	34,866	34,933	34,922	34,362	33,671	31,090	25,473	19,424	12,546	8,893	7,692	5,820	4,345	3,683
VARKAUS	24,367	24,716	24,781	24,560	24,178	23,061	19,794	14,986	6,852	2,660	1,439	1,033	964	926	873
IISALMI	24,010	23,795	23,125	22,053	20,915	20,284	19,456	17,411	15,914	17,394	21,918	23,379	20,644	17,898	16,095
TORNIO	23,017	22,602	21,693	20,671	19,127	17,524	16,451	14,783	13,536	12,957	11,588	10,316	9,307	8,089	7,485
VALKEAKOSKI	21,444	22,149	22,681	22,690	21,754	19,998	17,859	11,682	7,713	7,456	7,593	7,050	6,061	5,082	4,247
KOKKOLA	35,091	34,562	34,195	33,413	30,420	25,237	20,462	15,288	11,528	9,230	7,790	7,753	7,746	7,212	6,909
TOTAL	2,681,335	2,583,250	2,512,947	2,446,255	2,305,235	2,021,558	1,642,883	1,285,127	1,004,454	811,843	702,215	598,388	471,419	369,188	313,427

[Note] FUR: Functional urban region