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A Study of the Impact of the Central City Growth on the Peripheral City Structure

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Abstract

The purpose of this paper is to analyze the effect of the central city growth to the structure of the perpheral area. We analyze the influences of the growth of Sapporo city on the population, industory and local finace structures on H. town area. We constructed the regional system model of the peripheral area which contains economic relationship between central and peripheral cities and we simulated this model under some assumptions.

key word : central city, perpheral city, local finance, population structure, industry structure, reginal system model

1. Introduction

Metoropolitan growth is caused by migration of population. The more the metropolitan grows, the stronger the relationship between central city and peripheral city becomes. The growth of central city has a big influence on the peripheral city. This influence from the central city is one-sided. Economically it has external effects. But, whether the external effects is external economies or diseconomies are not clear. The policy makers of the local government in periphery need to predict the growth of the central city and the influence from this growth to it's own local government area, in order to decide to carry out regional policies.

The purpose of this study is to analyze how the growth of central city influences the structure of the peripheral city in metropolitan area. We selected Sapporo city as a central city and H. town as a peripheral one. The former has shown the most long-run growth among big cities in Japan. The latter is the one of the most influenced local government in the Sapporo periphery. We will analyze the influences of the growth of Sapporo city on the population, industry and local finance structures on H. town area.

To fasilitate the analysis, we will construct the H. regional system model used the System Dynamic Method (SD) which includes the population, industry and local finance

structures and simulate this regional model. There have been few regional models for municipalities as the one we costructed for H. town. More over the strong point of this system model is to include the local finance sector.

2. The Outline of H. town

We will explain the movement of population of the characteristics of H. town.

As shown in Table 2-1, the population of H. town was 24,381 in 1975 and 41,330 in 1986. Population increase rate was 1.7 times from 1975 to 1986, 1.4 times from 1975 to 1980, 1.2 times from 1980 to 1986. The rate of increase goes down.

In Table 2-1, net migration influences the population. Out-migration to other places was 2,168 in 1975, 2,974 in 1986. It is increasing. In-migration from other places was 5,589 in 1975, 3,403 in 1986. It is decreasing. Population increasing rate goes down by the decrease of in-migrants and the increase of out-migrants.

Table 2-1 Population of H. town

Year	Population	In-migrants	Out-migrants	Birth	Death	Other Increase
1 9 7 5	24,381	5,589	2,168	433	109	35
1 9 7 6	27,695	5,137	2,321	560	91	144
1 9 7 7	29,471	4,125	2,780	505	115	58
1 9 7 8	31,247	3,997	2,666	536	104	35
1 9 7 9	32,894	4,213	2,962	502	131	33
1 9 8 0	34,332	4,171	3,171	508	121	52
1 9 8 1	36,109	4,379	2,978	473	132	38
1 9 8 2	37,452	3,940	2,966	472	136	33
1 9 8 3	38,929	4,046	2,923	446	133	44
1 9 8 4	39,551	3,428	3,120	468	192	39
1 9 8 5	40,651	3,316	2,650	387	164	211
1 9 8 6	41,330	3,403	2,974	400	191	41

data : "Jyuminn Kihon Daichou"

Table 2-2 shows night and day populations. The rate of in flow was 13.1% in 1975, 14.3% in 1980, 16.1% in 1985. This rate is increasing. The rate of outflow was about 23-24% from 1975 to 1985. This change is small. However, their real numbers are increasing.

Table 2-3 shows the usual place of residence of employed persons. It also shows where employed persons in H. town work in. The number of employed persons in H. town was 5,042 (55.0% of total employed persons) in 1975, 6,602 (48.6%), in 1980, 7,790 (47.5%) in 1985. The number of persons is increasing, but its ratio is decreasing.

The number of employed persons working in other place, particularly Sapporp-city, of the total employed persons was 40.5% in 1975, 44.4% in 1980, 45.1% in 1985. It is increasing. The number of employed persons in Sapporo-city of the total employed persons in other places was 90% in 1975, 86.4% in 1980, 85.9% in 1985. It is decreasing. The real number and ratio of employed persons in Ebetu-city, Chitose-city, Eniwa-city, Naganuma-town are

Table 2-2 Night population and Day population

(%)

	1975	Ratio	1980	Ratio	1985	Ratio
Night population	22,264		34,148		40,853	
Out flows						
Total	2,912	100.0	4,870	100.0	6,591	100.0
Office attendance	2,448	84.1	3,719	76.4	4,981	75.6
School attendance	464	15.9	1,151	23.6	1,610	24.4
Ratio of in flows	13.1		14.3		16.1	
In flows						
Total	5,123	100.0	8,204	100.0	9,905	100.0
Office attendance	4,129	80.6	6,986	85.2	8,611	86.9
School attendance	994	19.4	1,218	14.8	1,294	13.1
Ratio of in flows	23.0		24.0		24.2	
Day population	20,053		30,814		37,539	
Ratio of day /night	90.1		90.2		91.9	

data : "Census taking"
notes : Ratio of in flow=in flow/night population
Ratio of out flow=out flow/night population
Day population=night population+in flows−out flows
Ratio of day/night=day population/night population

Table 2-3 Usual place of residence of employed persons

	1975 real number	Ratio over total	Ratio over other place	1980 real number	Ratio over total	Ratio over other place	1985 real number	Ratio over total	Ratio over other place
Total	9,171	100.0		13,588	100.0		16,401	100.0	
in H. town	5,042	55.0		6,602	48.6		7,790	47.5	
other place	4,129	45.0	100.0	6,986	51.4	100.0	8,611	52.5	100.0
Sapporo-city	3,715	40.5	90.0	6,037	44.4	86.4	7,399	45.1	85.9
Otaru-city	19	0.2	0.5	16	0.1	0.2	17	0.1	0.2
Yubari-city				18	0.1	0.3	18	0.1	0.2
Iwamizawa-city	15	0.2	0.4	30	0.2	0.4	26	0.2	0.3
Tomakomai-city	23	0.3	0.6	46	0.3	0.7	51	0.3	0.6
Ebetu-city	53	0.6	1.3	129	0.9	1.8	180	1.1	2.1
Chitose-city	62	0.7	1.5	207	1.5	3.0	286	1.7	3.3
Eniwa-city	128	1.4	3.1	294	2.2	4.2	370	2.3	4.3
Ishikari-town							18	0.1	0.2
Tobetu-town							11	0.1	0.1
Nanporo-town				14	0.1	0.2	31	0.2	0.4
Yuni-town				11	0.1	0.2	31	0.2	0.4
Naganuma-town	29	0.3	0.7	77	0.6	1.1	104	0.6	1.2
Kuriyama-town				21	0.2	0.3	23	0.1	0.3
Others	85	0.9	2.1	86	0.6	1.2	46	0.3	0.5

data : "Census taking"

increasing.

Table 2-4 shows the working place of employed persons. It also shows where employed persons in H. town work in. The number of employed persons in H. town was 5,042 (67.3% of the total employed persons) in 1975, 6,602 (64.0%) in 1980, 7,790 (61.0%) in 1985. The real

Table 2-4 Place of work of employed persons

	1975 real number	Ratio over total	Ratio over other place	1980 real number	Ratio over total	Ratio over other place	1985 real number	Ratio over total	Ratio over other place
Total	7,490	100.0		10,321	100.0		12,771	100.0	
in H. town	5,042	67.3		6,602	64.0		7,790	61.0	
other place	2,448	32.7	100.0	3,719	36.0	100.0	4,981	39.0	100.0
Sapporo-city	1,416	18.9	57.8	2,399	23.2	64.5	3,231	25.3	64.9
Otaru-city	6	0.1	0.2	16	0.2	0.4	24	0.2	0.5
Iwamizawa-city				13	0.1	0.3	21	0.2	0.4
Tomakomai-city				15	0.1	0.4	24	0.2	0.5
Ebetu-city	118	1.6	4.8	206	2.0	5.5	291	2.3	5.8
Chitose-city	95	1.3	3.9	136	1.3	3.7	160	1.3	3.2
Eniwa-city	636	8.5	26.0	687	6.7	18.5	919	7.2	18.5
Ishikari-town				21	0.2	0.6	32	0.3	0.6
Hamamasu-village	15	0.2	0.6	16	0.2	0.4			
Nanporo-town	23	0.3	0.9	49	0.5	1.3	80	0.6	1.6
Yuni-town	9	0.1	0.4	20	0.2	0.5	16	0.1	0.3
Naganuma-town	56	0.7	2.3	76	0.7	2.0	100	0.8	2.0
kuriyama-town				8	0.1	0.2	9	0.1	0.2
Others	74	1.0	3.0	57	0.6	1.5	74	0.6	1.5

data : "Census taking"

number is increasing, but its ratio is decreasing.

The number of employed persons living in other places, particularly Sapporo city of the total employed persons was 18.9% in 1975, 23.2% in 1980, 25.3% in 1985. It is increasing.

H. town has shown a high population increase, and this is due to the construction and improvement of housing corporation area. Basically, H. town is a neighboring town of Sapporo city, and Sapporo city is highly developing. The inflow and outflow of population of H. town has become more active. Fifty percent of the population in H. town work in other places most in Sapporo city. Sixty Percent of the persons working in H. town live outside of H. town. These show that H. town is a "bed-town".

The other characteristics of H. town is its economic dependence on Sapporo city. The place of head offices in the manufacturing area (kogyo-danchi) in H. town is located in H. town (twenty seven percent of the total enterprise in the manufacturing area), Sapporo city(37%), and Tokyo(19%). The enterprises whose head office are in Sapporo city accept orders from Sapporo city, and those whose head office are in Tokyo also accept orders from Sapporo city. Accordingly, economic activity in H. town is dominated by Sapporo city's economic activity.

We investigated from where and how much the major enterprises in H. town accept orders. The results show that construction and tertiary industry accept orders from H. town and manufacturing accepts most of its orders from Sapporo city. The share of net products of manufacturing of the net products was 17.1% in 1975, 24.8% in 1980 by "Chominn Shotoku Suikei" (town income account).

3. Construction of the model

3-1. Structure of the model

As can be seen from the flow diagram shown in Fig. 3.1-3.8, this model consists of three sub-sectors; the industry-land sector, the population sector and the local finance sector. Its structure is such that the industry-land sector and the population sector affect each other, and that the local finance sector is affected by these sectors, but in itself does not affect them.

The systems of the main industries show that the economic trend of Sapporo City affects the industries in H. Town, and that the industries in H. Town determine the number of employed persons.

The industries including the primary industry, the mining,the wholesale-retail trade, the financing-insurance-real estate and the government are hardly influenced by the economic activity in H. town.

This model introduces explicitly the influence of the economic trend in the central city. As we mentioned in the preceding chapter, we introduced the two features of population and industry in the H. Town into the model as follows.

(a) The amount of orders received

There are many enterprises in the secondary and the tertiary industries at H. town that receive orders from enterprises in Sapporo city. Therefore, we introduced this relationship as the amount of orders received into our model.

(b) The rates of person and territory[1)]

From the viewpoint of the rate of employed persons, we showed the relationship

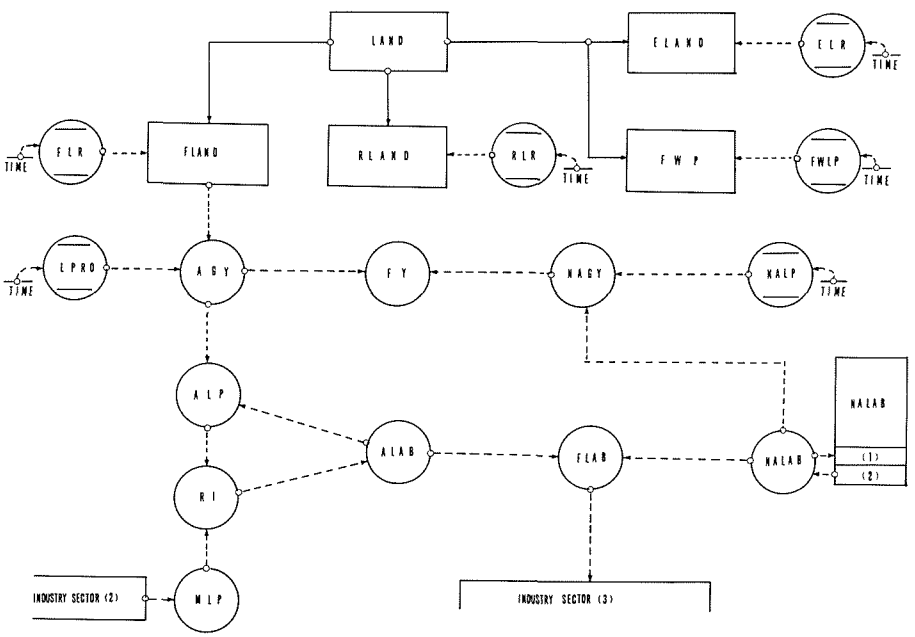

Fig. 3.1. Flow diagram of industry-land sector (1)

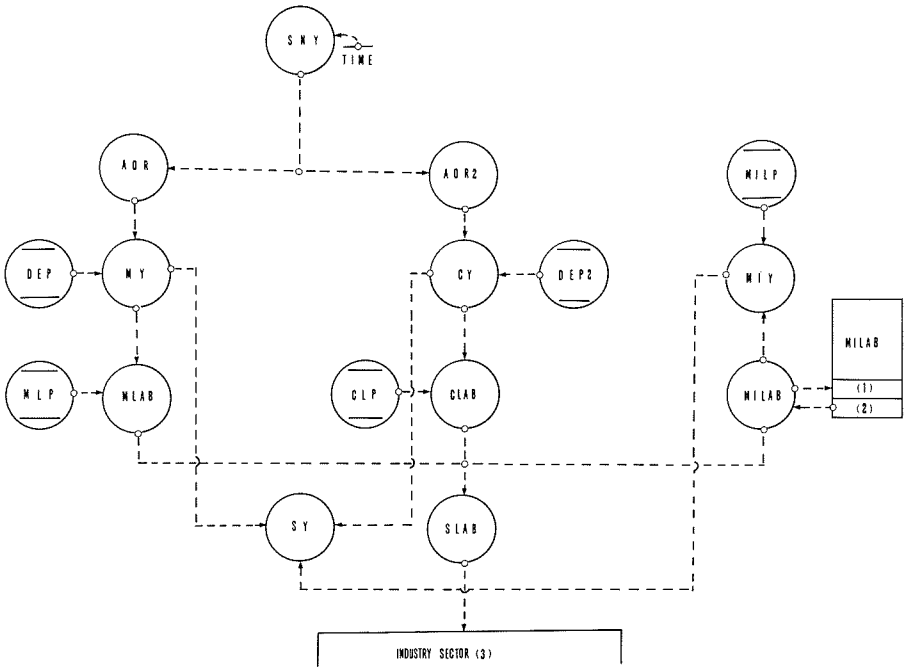

Fig. 3.2. Flow diagram of industry sector (2)

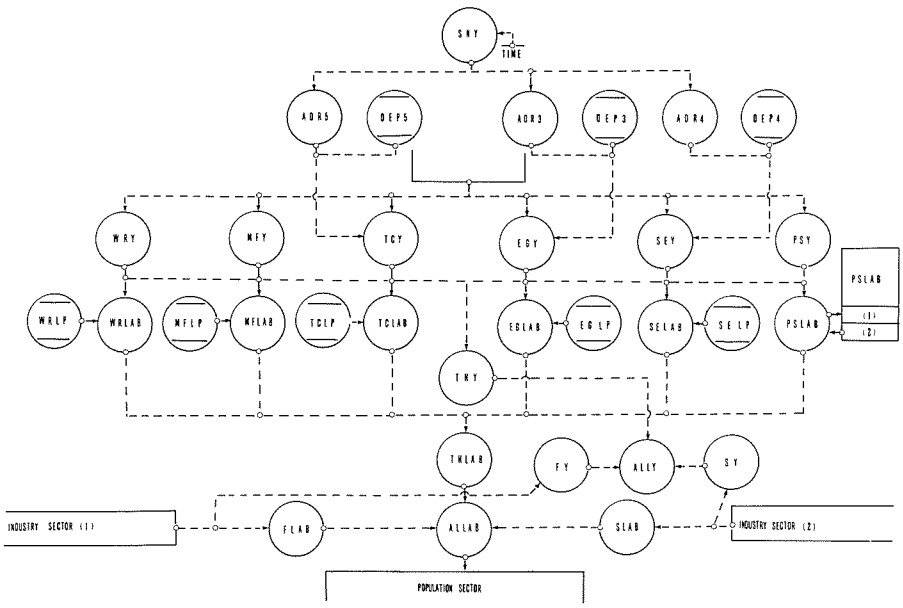

Fig. 3.3 Flow diagram of industry sector (3)

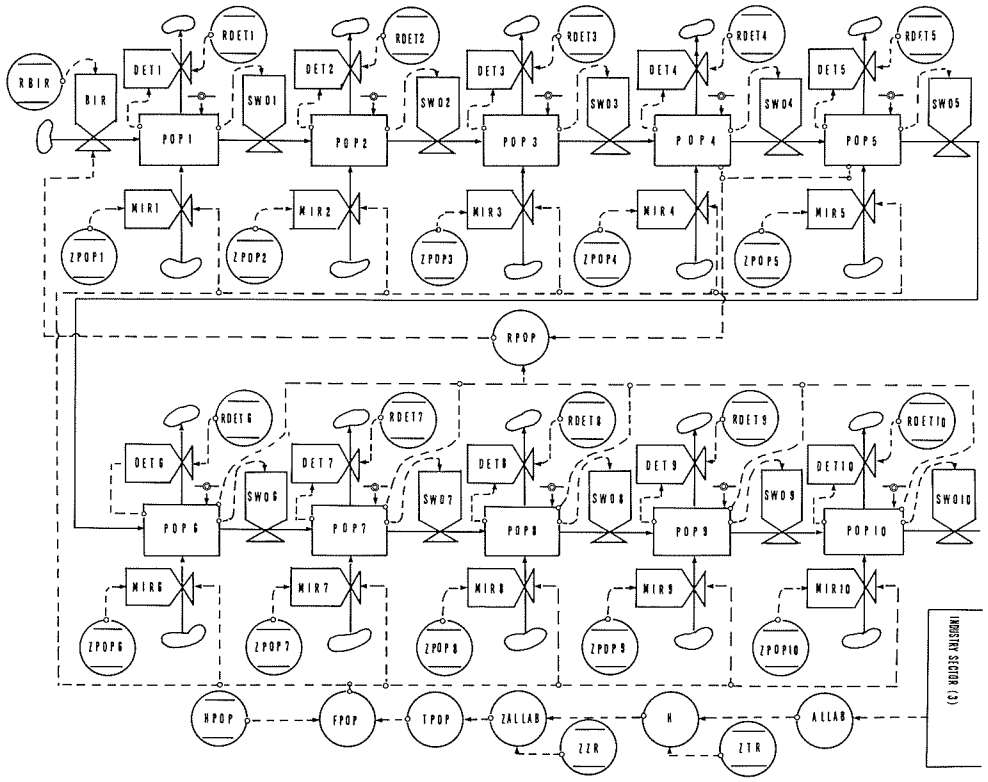

Fig. 3.4 Flow diagram of population sector (1)

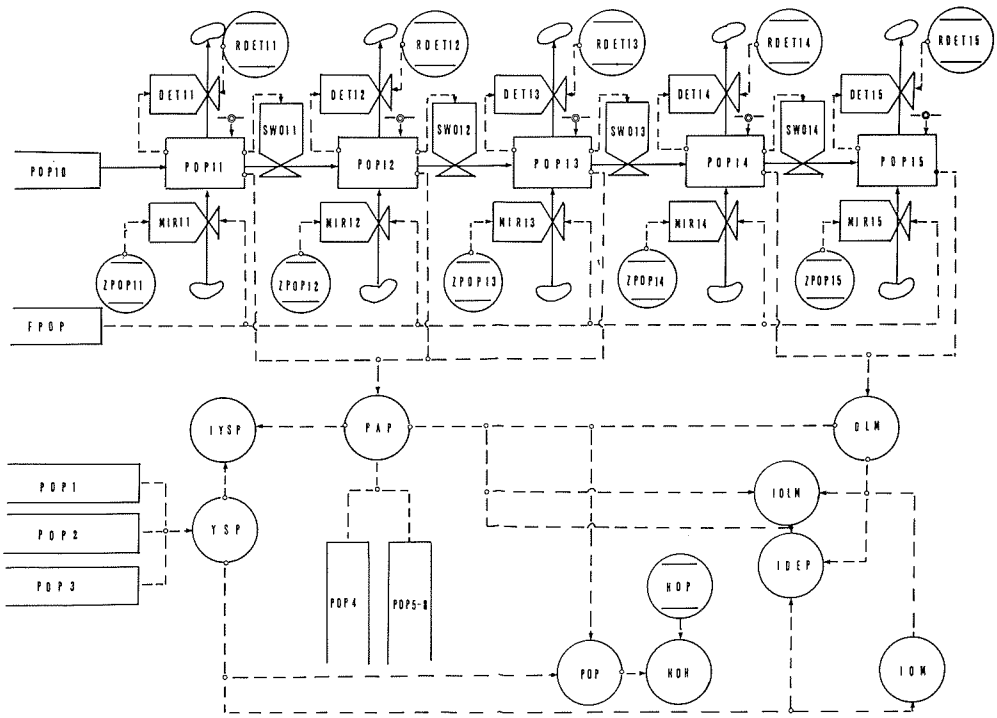

Fig. 3.5. Flow diagram of population tector (2)

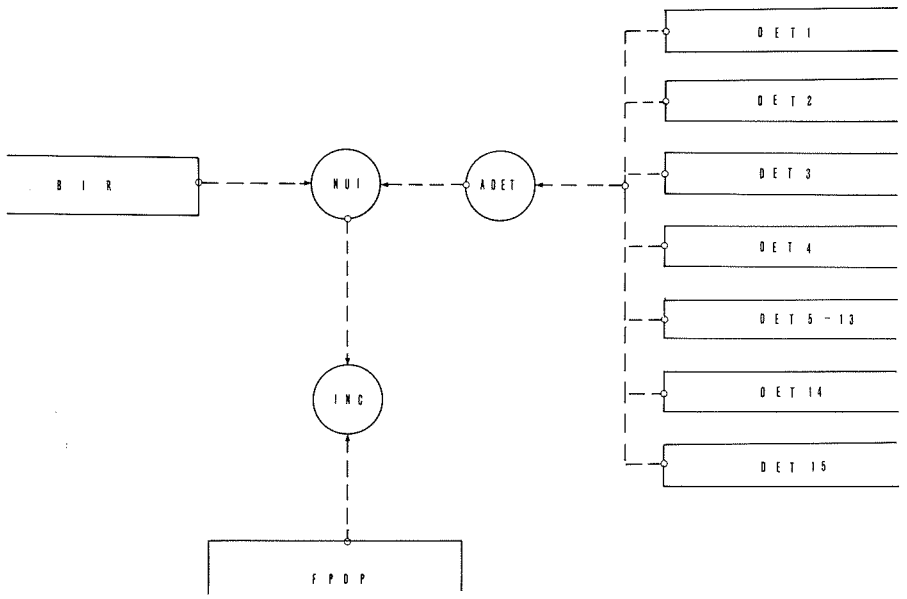

Fig. 3.6 Flow diagram of population sector (3)

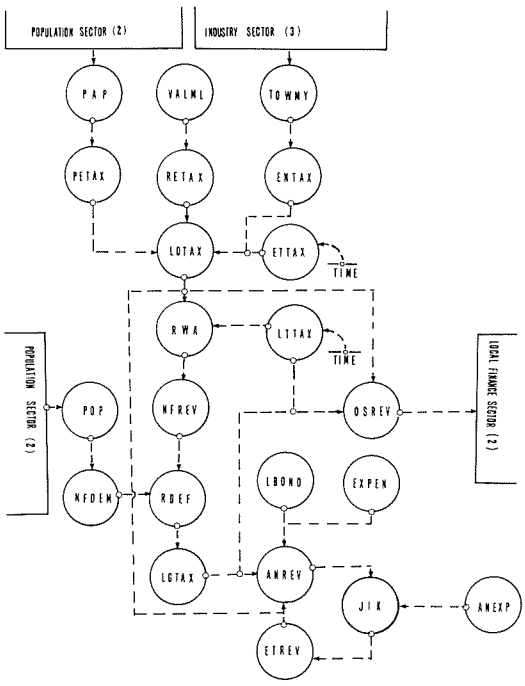

Fig. 3.7. Flow diagram of local finance sector (1)

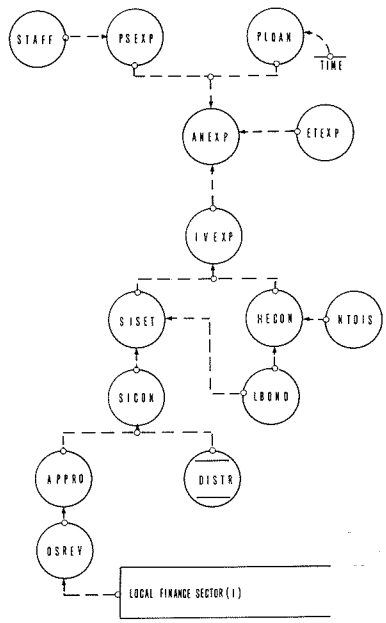

Fig. 3.8. Flow diagram of local finance sector (2)

between Sapporo city and H. town as the rates of person and territory. Therfore, we introduced the concepts of rate of person and rate of territory into our model.

3-2. Data

Data used are as follows.

(Industry-land sector)

* H. cho "Koteishisan Gaiyochosa"
* H. cho "H. Chomin Shotoku Suikei Kekka Hokokusho"
* Sapporo chi "Sapporo Chimin Shotoku Suikei Hokokusho"
* Souri fu "Kokusei Chosa"

(Population sector)

* Souri fu "Jumin Kihon Daicho"
* Souri fu "Kokusei Chosa"

(Local finance sector)

* Hokkaido Gyosei Kyokai "Chityoson no Zaisei Gaiyou"

(*; in Japanese)

3-3. Construction of the model

The model as a whole consists of 20 level equations, 49 rate equations and auxiliary equations, a total of 140 equation systems.

The estimation period of the structural equation is 10 years from 1976 to 1985, and the Ordinary Least Squares method was employed as the estimation method. The values within the parentheses of the equation are standard error of parameters, R2 is decision coefficient, D.W. is Durbin-Watson statistics. The following is an explanation on the causes and effect flow of the variables in each sector, given by means of the DYNAMO language.

1) Industry-Land sector

The land area in H. town is classified into 4 areas, the farmland area, the mountain wild plain-forest, the residential area and the other area.

The farmland area (FLAND) is determined by multiplying land area by ratio of land to farmland.

L FLAND. K=FLR. K * LAND. K .....(1)

The other three areas are also determined in the same way.

The net agricultural products (AGY) is calculated by multiplying the farmland area in land sector to productivity of land (LPRO) as follows.

A AGY. K=LPRO. K * FLAND. K .....(2)

The agricultural productivity of labor of the preceding term (ALP) is determined by the net agricultural product of the preceding term and the agricultural employed persons of the preceding term (ALAB).

A ALP. J=AGY. J/ALAB. J .....(3)

The agricultural employed persons are determined by the relative income of the preceding term (RI). Here, the relative income is the rate of the agricultural productivity of labor to the manufacturing productivity of labor.

A ALAB. K=921.25551+345.98203 * RI. J ……(4)
(20.69693)(41.296275)
R2=0.897 D.W.=2.483

A ALP. J=AGY. J/ALAB.J ……(5)

A RI. J=ALP. J/MLP.J ……(6)

The forestry-fishery employed persons (NALAB) are determined by the forestry -fishery employed persons of the preceding term.

A NALAB. K=1.0469826 * NALAB. J ……(7)
(0.0150378)
R2=0.898 D.W.=2.643

The forestry-fishery products (NAGY) is obtained by the forestry-fishery productivity of labor (NALP) and the forestry-fishery employed persons as follows.

A NAGY. K=NALAB. K * NALP.K ……(8)

The net primary industry products (FY) and the primary industry employed persons (FLAB) are the definition equations.

A FY. K=AGY. K+NAGY.K ……(9)

A FLAB. K=ALAB. K+NALAB. K ……(10)

The secondary industry consists of the manufacturing, the construction and the mining sectors.

In this model, the economic trend of Sapporo city influences the products of manufacturing and construction through the amount of orders received. Each of the amount of orders received is calculated by multiplying each products by the rates of orders received obtained from the answers given to a questionnaire and obtained from hearing.

Net Sapporo products (SNY) determines the manufacturing amount of orders received and the construction amount of orders received as follows.

A AOR. K=−4252.502+0.0025475 * SNY.K ……(11)
(260.84254)(0.0001954)
R2=0.955 D.W.=0.974

A AOR2.K=−1375.815+0.0009189 * SNY. K ……(12)
(113.06509)(0.0000847)
R2=0.936 D.W.=0.596

The manufacturing products (MY) is determined by the manufacturing amount of orders received (AOR). The manufacturing employed persons (MLAB) is determined by the manufacturing productivity of labor (MLP).

A MY. K=2092.4623+2.9876918 * AOR. K ……(13)
(161.62397)(0.0464478)
R2=0.998 D.W.=1.110

A MLAB. K=MY. K * /MLP. K ……(14)

We used dummy variables because the large-scale work of the North H. housing development decreased and this influences the construction products. Therefore, the construction products (CY) is determined by the construction amount of orders received (AOR2) and the dummy (DMY).

A CY. K=6616.6729+0.2337187 * AOR2. K
(72.186089)(0.0629388)
+1242.791 * DMY. K ……(15)
(84.095166)
R2=0.970 D.W.=1.484

The construction employed persons (CLAB) are calculated by the net construction products and the construction productivity of labor (CLP).

A CLAB. K=CY. K/CLP. K ……(16)

The mining employed persons (MILAB) are determined by the mining employed persons of the preceding term.

A MILAB. K=2.2415298+0.8702002 * MILAB. J ……(17)
(0.8070984)(0.0313191)
R2=0.990 D.W.=2.399

The net mining products (MIY) is calculated by the mining employed persons (MILAB) and the mining productivity of labor (MILP).

A MIY. K=MILAB. K * MILP. K ……(18)

The secondary industry employed persons (SLAB) and the net secondary products (SY) are the definition equations.

A SLAB. K=MLAB. K+CLAB. K+MLAB. K ……(19)

A SY. K=MY. K+CY. K+MIY. K ……(20)

The tertiary industry consists of the wholesale-retail trade, the financing-insurance -real estate, the transport-communication, the electricity-gas-water, the services and the government sectors.

The tertiary industry is basically influenced by the population scale in H. town. The economic trend of Sapporo city influences the product of transport-communication, electricity-gas-water and services through the amount of orders received. Here, each of the amount of orders received is calculated by multiplying each products by the rate of orders received.

The net Sapporo products (SNY) determines the transport-communication, electricity -gas-water, services amount of orders received.

A AOR5. K=−4182.5+0.0020625 * SNY. K ……(21)
(176.35226)(0.0001321)
R2=0.968 D.W.=2.443

A AOR3. K=−249.3252+0.0001098 * SNY. K ……(22)
(21.340924)(0.0000159)
R2=0.855 D.W.=0.852

A AOR4. K=−6866.447+0.0045688 * SNY.K ……(23)
(516.92398)(0.0003872)
R2=0.946 D.W.=0.595

The net wholesale-retail trade products (WRY), the net financing-insurance-real estate products (MFY) and the net government products (PSY) are determined by the H. town population of the preceding term.

A WRY. K=−2651.576+0.2834484 * POP. J ……(24)
(231.10567)(0.0130176)
R2=0.983 D.W.=1.208

A MFY. K=−1779.406+0.1376182 * POP. J ……(25)
(114.52582)(0.0064509)
R2=0.983 D.W.=1.863

A PSY. K=−1546.404+0.1417756 * POP. J ……(26)
(128.73413)(0.0072511)
R2=0.980 D.W.=1.766

The net transport-communication products (TCY), the net electricity-gas-water products (EGY) and the net services products (SEY) are formulated by H. town population of the preceding term and each of the amount of orders received.

A TCY. K=−430.6592+0.0372115 * POP. J
(27.919775)(0.00113407)
+0.9672984 * AOR5. K ……(27)
(0.0719583)
R2=0.995 D.W.=3.273

A EGY. K=16.880664+0.0088729 * POP. J
(6.1355134)(0.00150258)
+1.3028733 * AOR3. K ……(28)
(0.1758313)
R2+0.998 D.W.=1.825

A SEY. K=4832.094+0.0767399 * POP. J
(44.507820)(0.0119923)
+0.9344465 * AOR4. K ……(29)
(0.03392)
R2=0.997 D.W.=1.541

The wholesale-retail trade employed persons (WRLAB) are calculated by the net wholesale-retail trade products and the wholesale-retail trade productivity of labor (WRLP).

A WRLAB. K=WRY. K/WRLP. K ……(30)

As the above, each of the productivity of labor determine the financing-insurance-real estate employed persons (MFLAB), the transport-communication employed persons (TCLAB), the electricity-gas-water employed persons (EGLAB) and the services employed persons (SELAB).

A MFLAB. K=MFY. K/MFLP. K ……(31)

A TCLAB. K=TCY. K/TCLP. K ……(32)

A EGLAB. K=EGY. K/EGLP. K ……(33)

A SELAB. K=SEY. K/SELP. K ……(34)

The government employed persons (PSLAB) are formulated by the net government products (PSY) and the government employed persons of the preceding term.

A PSLAB. K=108.035+0.0446 * PSY. K
(9.777454)(0.0041467)

$$+0.4381 * PSLAB.\ J \qquad \cdots\cdots(35)$$
$$(0.0414974)$$
$$R2=0.993 \quad D.W.=2.339$$

In calculating equation(35), the multicollinearty occurred and so we used the ridge regression.

The net tertiary industry products (THY) and the tertiary industry employed persons (THLAB) are the definition equations.

$$A\ \ THY.\ K=WRY.\ K+MFY.\ K+TCY.\ K+EGY.\ K+SEY.\ K+PSY.\ K \qquad \cdots\cdots(36)$$
$$A\ \ THLAB.\ K=WRLAB.\ K+MFLAB.\ K+TCLAB.\ K+EGLAB.\ K$$
$$+SELAB.\ K+PSLAB.\ K \qquad \cdots\cdots(37)$$

The total of employed persons in the place of work (ALLAB) and the net H. products are also the definition equations.

$$A\ \ ALLAB.\ K=FLAB.\ K+SLAB.\ K+THLAB.\ K \qquad \cdots\cdots(38)$$
$$A\ \ ALLY.\ K=FY.\ K+SY.\ K+THY.\ K \qquad \cdots\cdots(39)$$

(2) Population sector

The usual place employed persons in H. town (H) are determined by the total employed persons in usual place and the rate of territory (ZTR) as follows.

$$A\ \ H.\ K=ALLAB.\ K * ZTR.\ K \qquad \cdots\cdots(40)$$

The employed persons in the usual place (ZALLAB) are calculated by the usual place employed persons in H. town and the rate of persons (ZZR).

$$A\ \ ZALLAB.\ K=H.\ K * ZZR.\ K \qquad \cdots\cdots(41)$$

The total net immigration (FPOP) is calculated by the increase of employed persons in the usual place (TPOP) and the rate of social increase (HPOP).

$$A\ \ TPOP.\ K=ZALLAB.\ K-ZALLAB.\ J \qquad \cdots\cdots(42)$$
$$A\ \ FPOP.\ K=TPOP.\ K * HPOP.\ K \qquad \cdots\cdots(43)$$

The 0-4 years old population (POP1) is calculated by the 0-4 years old population of the preceding term, the number of birth (BIR), the 0-4 years old number of death (DET1), the 0-4 years old net immigration (MIR1) and the 4-5 year old switching (SWO1) (Formula(42)). The number of birth is calculated by the 15-49 years old woman population (RPOP) (Formula(43))

$$L\ \ POP1.\ K=POP1.\ J+(DT)(BIR.\ JK-DET1.\ JK+MIR.\ JK+SWO1.\ JK) \qquad \cdots\cdots(44)$$
$$R\ \ BIR.\ KL=RBIR.\ K * RPOP.\ K \qquad \cdots\cdots(45)$$
$$R\ \ DET1.\ KL=RDET1.\ K * POP1.\ K \qquad \cdots\cdots(46)$$
$$R\ \ MIR1.\ KL=ZPOP1.\ K * FPOP.\ K \qquad \cdots\cdots(47)$$
$$R\ \ SWO1.\ KL=POP1.\ K/5 \qquad \cdots\cdots(48)$$

Here, the DT is the increase of time.

The 5-9 years old population (POP2) is determined by the 5-9 years old population of the preceding term, the 4-5 years old switching, the 5-9 years old number of death (DET2), the 5-9 years old net immigration (MIR2) and the 9-10 years old switching (SWO2).

$$L\ \ POP2.\ K=POP2.\ J+(DT)(SWO1.\ JK-DET2.\ JK$$
$$+MIR2.\ JK-SWO2.\ JK) \qquad \cdots\cdots(49)$$
$$R\ \ DET2.\ KL=RDET2.\ K * POP2.\ K \qquad \cdots\cdots(50)$$
$$R\ \ MIR2.\ KL=ZPOP2.\ K * FPOP.\ K \qquad \cdots\cdots(51)$$

R SWO2. KL=POP2. K/5 ……(52)

The 10-69 years old population is same as above.

The population over 70 years old (POP15) is calculated by the population over 70 years old of preceding term, the 69-70 years old switching (SWO14), the number of death over 70 years old (DET15) and the net immigration over 70 years old (MIR15).

L POP15. K=POP15. J * (DT)(SWO14. JK−DET15. JK
+MIR15. JK) ……(53)

R DET15. KL=RDET15. K * POP15. K ……(54)

R MIR15. KL=ZPOP15. K * FPOP. K ……(55)

The minor population (0-14 years old, YSP), the population of working age (15-64 years old, PAP), the old age population (65 years old and over, OLM) are the definition equations.

A YSP. K=POP1.K+POP2. K+POP3. K ……(56)

A PAP. K=POP4. K+POP5. K+POP6. K+POP7. K+POP8. K+POP9. K
POP10. K+POP11. K+POP12. K+POP13. K ……(57)

A OLM. K=POP14. K+POP15. K ……(58)

The index of minor population (IYSP),the index of dependence population (IDEP), the index of old age population and the index of aging population (IOM) are calculated as follows.

A IYSP. K=YSP. K/PAP. K ……(59)

A IDEP. K=(YSP. K+OLM. K)/PAP. K ……(60)

A IOLM. K=OLM. K/PAP. K ……(61)

A IOM. K=OLM. K/YSP. K ……(62)

The total population in H. town is the definition equation.

A POP. K=YSP. K+PAP. K+OLM. K ……(63)

The household (HOH) is determined by the total population and the number of the persons per hosehold.

A HOH.K=HOP. K * POP. K ……(64)

The total number of death (ADET), the natural increase (NUI) and the net increase of population (INC) are the definition equations.

A ADET. K=DET1. K+DET2. K+DET3. K+DET4. K+DET5. K+DET6. K
+DET7. K+DET8. K+DET9. K+DET10. K+DET11. K+DET12. K
+DET13. K+DET14. K+DET15. K ……(65)

A NUI. K=BIR. K−ADET. K ……(66)

A INC. K+NUI. K+FPOP. K ……(67)

In this model, the net teritary industry products and the total employed persons in the industory sector are linked by the total population and the net total immigration.

(3) Local finance sector

The town individual inhabitant tax (PETAX) is determined by the population of working age (PAP).

A PETAX. K=−1.11 +92.604 * PAP. K ……(68)
(57741.3) (5.293)
R2=0.975 D.W.=1.110

The town corporatin tax (ENTAX) is determined by the net products (AALY).

A ENTAX. K=−30812.01 +3.821 * ALLY. K ……(69)
(30944.4) (1.027)
R2=0.634 D.W.=1.245

The fixed assets tax and city planning tax (RETAX) are obtained by the composite variable (VALML) which is constructed from price index, number of houses and number of establishments.

A RETAX. K=1135651.5 +336613.87 * VALML. K ……(70)
(38668.71) (16259.1)
R2=0.982 D.W.=1.610

The other local tax (ETTAX) is formulated in terms of time and dummy variable (DAMI).

A ETTAX. K=407578.45−1769.388 * TIME. K+128225.72 * DAMI. K ……(71)
(14865.7) (1791.1) (17148.13)
R2=0.915 D.W.=1.264

The local tax (LOTAX) is the definition equations.

A LOTAX. K=PETAX. K+ENTAX. K+RETAX. K+ETTAX. K ……(72)

The local transfered tax (LTTAX) is formulated by time.

A LTTAX. K=−347613.2 +8315.54 * TIME. K ……(73)
(12237.86) (8315.54)
R2=0.826 D.W.=1.105

The sum of local tax and local transfer (RWA) of the preceding term are defined as follows.

A RWA. J=LOTAX. J+LTTAX. J ……(74)

The basic financial revenue (NFREV) of determined by RWA of the preceding term.

A NFREV. K=293253.7 +0.723 * RWA. J ……(75)
(55631.6) (0.027)
R2=0.989 D.W.=2.803

The basic financial demand (NFDEM) is formulated by the population of the preceding term.

A NFDEM. K=−1131440 +149.865 * POP. J ……(76)
(123206.27) (149.865)
R2=0.983 D.W.=1.444

The local allocatin tax (LGTAX) is determined by the difference between basic financial demand and basic financial revenue we used this in stead of a definition equation.

A RDEF. K=NFDEM. K−NFREV. K ……(77)

A LGTAX. K=−4095.087 +1.105 * RDEF. K ……(78)
(24985.01) (0.021)
R2=0.997 D.W.=1.739

The revenue (ANREV) and the general revenue (OSREV) are defined as follows.

A ANREV. K=LGTAX. K+EXPEN. K+LTTAX. K+ETREV. K+LOTAX. K
+LBOND. K ……(79)

A OSREV. K=LOTAX. K+LTTAX. K+LGTAX. K ……(80)

The personnel expenses (PSEXP) is determined by the number of office workers (STAFF).

A PSEXP. K=−1043279 +7686.549+STAFF. K ……(81)
(99101.6) (722.24)
R2=0.934 D.W.=2.172

The public debt (PLOAN) and the other expenses (ETEXP) are a function of time.

A PLOAN. K=−5033408 +105035.94 * TIME. K ……(82)
(95580.8) (10523.1)
R2=0.926 D.W.=1.024

A ETEXP. K=−6741721 +169016.35 * TIME. K ……(83)
(173209.2) (19069.7)
R2=0.908 D.W.=0.809

The sum of general revenue and some undefined amount is a General revenue in the broad sense (APPRO), but this relation is a functinal form because of the presence of some undefined amount.

A APPRO. K=35649.73 +1.066 * OSREV. K ……(84)
(1256445) (0.037)
R2=0.99 D.W.=2.007

Distributed general revenue to a part of the independent municipal public works expenses (SICON) is obtained by multiplying the rate of distribution (DIST) by the general revenue (APPRO). The independent municipal public works expenses (SISET) is determined by the SICON and the local bond (LBOND).

A SICON. K=DISTR. K * APPRO. K ……(85)

A SISET. K=327043.9 +0.642 * SISCON. K +0.446 * LBOND. K ……(86)
(157115.9) (0.449) (0.134)
R2=0.625 D.W.=1.696

The municipal public works expenses with state subsidy (HECON) is formulated by local bond and the disbursement (EXPEN).

A HECON. K=−71860.7 +0.944 * LBOND. K +0.501 * EXPEN. K ……(87)
(347876.7) (0.290) (0.337)
R2=0.748 D,W=2.551

The public works expenses (IVEXP) and the expenditures (ANEXP) are the definition equations.

A IVEXP. K=SISET. K+HECON. K ……(88)

A ANEXP. K=PSEXP. K+PLOAN. K+IVEXP. K+ETEXP. K ……(89)

The linkage among local finance sector, industrial sector and population sector are as follows. Individual inhabitant tax and basic financial demand in the local finance sector are connected with the number of population of working age and total population. The net products in the industry sector is connected with town corporation tax. The total population, total employed persons and total net immigration in the population sector are

connected with the net tertiary industry products in the industry sector.

(4) Test Of The Model

A series of total tests to prove the appropriateness of the model was made for a period of eleven years from 1975 to 1985. In this series of tests, the evaluation of the degree of adaptability of the model to the reality was done based on the coefficient of disagreement.

As a result of the test, all the coefficients of disagreement are close to 0. Table 3-1 shows the degree of adaptability of the main variables in terms of the coefficients of disagreement.

Table 3-1 Inequality Coefficient

factor	Theil-U	factor	Theil-U	factor	Theil-U
ALAB	0.01868	EGY	0.14296	LGTAX	0.05032
NALAB	0.14708	SEY	0.03214	PSEXP	0.05157
MY	0.04882	PSY	0.06513	RETAX	0.02813
CY	0.01056	PSLAB	0.02399	HECON	0.14327
MILAB	0.02187	PETAX	0.08548	APPRO	0.03354
WRY	0.05919	ENTAX	0.15018	SISET	0.10121
MFY	0.06248	ETTAX	0.03827	PLOAN	0.09992
TCY	0.05268	LTTAX	0.09364	ETTAX	0.13268

4. Simulations

(1) Set a case of simulation

We take three variables for simulation, namely, the rate of territory-person, disbursement, local bond. This paper's purpose is to analyze how the growth of central city influence the structure of population, industry, local finace in peripheral area. Accordingly, given the growth of central city, we set the relation growth of Sapporo city with H. town.

Before setting a case of simulation, we set the net products of Sapporo city. The net products of Sapporo city is based on the results of the forecast in the "Sapporo Si Dai 3 Ji Sinn Choki Keikaku" (The 3rd newly longrun total plan of Sapporo city). Based on the "Choki Keikaku", net products of Sapporo city is forecasted to be 8 trillion 4 hundred billion yen in 2005.

By intercorpolation, we set 5 trillion 5 hundred billion yen in 1995.

We set three cases of simulation.

Case 1: Set the rate of territory-person, disbursements, local bond as constant using 1985 year value up to 1995.

Case 2: Set the rate of territory-person as the trend from 1975 to 1985, up to 1995. It means inflow and outflow of population in H. town become more active. Disbursement and local bond are determined as Case 1.

Case 3: Set disbursement and local bond as constant up to 1995 using the average value from 1981 to 1985. Rate of territory-person is determined as Case 2.

Other table variables are settled as follows. In the land sector, table variables are determined as the trend from 1975 to 1985, up to 1995. In industry sector, table variables in

primary industry are determined as continuing the trend from 1975 to 1985, up 1995, and in the secondary and tertiary industrys are determined as constant up to 1995 using 1985 year value. In population sector, table variables as birth rate, death rate, in-migrants rate, out -migrants rate, household rate are determined as constant up to 1995 using 1985 year value.

Table 4-1 Simulation Cases

	Teritary-person	Grants and Local bond
Case 1	Constant in 1985 value up to 1995	Constant in 1985 value up to 1995
Case 2	Continuing the trend from 1975 to 1985 up to 1995	Constant in 1985 value up to 1995
Case 3	Continuing the trend from 1975 to 1985 up to 1995	Constant in average value from 1981 to 1985 up to 1995

Table 4-2 Results of simulation

	Year	1985	1987	1989	1991	1993	1995	unit
Variables	Case		Real number	Real number	Real number	Real number	Real number	
Total population	1	40853	44375	48556	52836	57150	61477	
	2		45462	50141	54903	59717	64560	
	3		45462	50141	54903	59717	64560	
Household	1	12728	13845	15150	16485	17831	19181	
	2		14184	15644	17130	18632	20143	
	3		14184	15644	17130	18632	20143	
Total employed persons	1	12756	13896	15269	16671	18081	19494	
	2		13975	15418	16874	18339	15390	
	3		13975	15418	16874	18339	19810	
Net H. town products	1	67756	74322	82374	90596	98867	107162	million
	2		74827	83296	91846	100453	109098	yen
	3		74827	83296	91846	100453	109098	
Net primary industry products	1	1751	1745	1743	1742	1741	1741	
	2		1745	1743	1742	1741	1741	〃
	3		1745	1743	1742	1741	1741	
Net secondary industry products	1	26320	29168	32053	34952	37863	40782	
	2		29168	32053	34952	37863	40782	〃
	3		29168	32053	34952	37863	40782	
Net tertiary industry products	1	39684	43410	48578	53902	59263	64638	
	2		43914	49501	55152	60850	66574	〃
	3		43914	49501	55152	60850	66574	
Revenue	1	9723124	10842400	11803300	12793500	13789800	14788000	thousand
	2		10997200	12059400	13135300	14219900	15309500	yen
	3		11199000	12261200	13337100	14421800	15511300	
Local tax	1	3495190	4024330	4533990	5040420	5539360	6029680	
	2		4093350	4636210	5174610	5706630	6230850	〃
	3		4093350	4636210	5174610	5706630	6230850	
Local allocation tax	1	2071187	2301800	2552460	2835580	3132290	3439570	
	2		2387530	2706240	3043160	3395190	3759900	〃
	3		2387530	2706240	3043160	3395190	3759900	
Expenditure	1	9557852	10613900	11458800	12305900	13153500	14008900	
	2		10625500	11478100	12331700	13185900	14048200	〃
	3		10534100	11386600	12240200	13094500	13956800	
Municipal public works expenses with state subsidy	1	1224336	1347760	1406290	1467020	1528210	1589550	
	2		1359410	1425570	1492770	1560620	1628840	〃
	3		1261740	1327900	1395090	1462950	1531170	

(2) Results

In table 4-2, the results of major variables are showed.

The results of population and industry sector are the same in Case2 and Case3, because no effect was felt from the finance sector. The population, employed persons and net products can be seen increased more in Case2 and Case3 than Case1. Similar results can be seen in other variables.

For instance, total population is forecaseted 61,677 in Case1, 64,560 in Case2 and Case3 in 1995. Total employed persons is forecasted 19,494 in Case1, 19,810 in Case2 and Case3 in 1995. Total net products is forecasted 107,612 million yen in Case1, 109,098 million yen in Case2 and Case3 in 1995. Revenue is forecasted 14,788 million yen in Case1, 15,310 million yen in Case2, 15,513 million yen in Case3 in 1995. Expenditure is forecasted 14,009 million yen in Case1, 14,048 million yen in Case2, 13,957 million yen in Case3 in 1995.

The results of the primary industry are the same in the three cases, becase the inflow and outflow of population and local finance had no effect. The results of the secondary industry are also the same in the three cases because of the effect of the economy of Sapporo had no effect. The results of population, employed population, net products are effected largely by the activation of the relationship between H. town and Sapporo city causing by the growth of Sapporo city.

Conclusion

In this study, we analyzed the influence of the central city growth on the peripheral city structure in a metrapolitan area. We selected Sapporo city as the central city and H. town as the peripheral municipality. We constructed the H. regional system model and we linked it with the growth of Sapporo city using the System Dynamics method. This regional model was simulated under different assumption.

The following points were clarified.

1)The growth of Sapporo city has a big influence on the population structure and industry structure of H. town. Especially, the tertiary industry is influenced by the net products and the population growth of Sapporo city.

2)The increasing dairy inflow and outflow of employed person and population, expresses the stronger relations between Sapporo city and H. town and this causes a more rapid structural change.

3)The H. local govenment finance shows that local tax and local allocation tax increased. However the revenue structure mainly depends on national and prefectural disbursement and local bond which are exogenous factores.

4)Public works by H. town goverment which an effect of the growth of Sapporo city depend on national and prefectural disbursement and local bond.

Note

1) The concepts of the rate of territory and the rate of person define as follows.

i) The rate of territory

=(Employed persons of usual place in H. Town)/(Employed persons of usual place in H. Town + Employed persons of usual place in other regions)

ii) The rate of persons

=(Employed persons of usual place in H. Town + Employed persons of other place in H. town)/(Employed persons of usual place in H. Town)

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Materials. List of Variables

Variables	Variable Names
ADET	: Total number of death
AGY	: Net agricultural products
ALAB	: Agricultural employed persons
ALLAB	: Total employed persons (place of work)
ALLY	: Net H. town products
ALP	: Agricultural productivity of labor
ANEXP	: Expenditure
ANREV	: Revenue
AOR	: Manufacturing amount of orders received
AOR2	: Construction amount of orders recived
AOR3	: Electricity-gas-water amount of orders received
AOR4	: Services amount of orders received
AOR5	: Transport-communication amount of orders received
APPRO	: General revenue in the broad sense
BIR	: Number of birth
CLAB	: Construction employed persons
CLP	: Construction productivity of labor

CY : Net construction products
DEP : Manufacturing rate of orders received
DEP2 : Construction rate of orders received
DEP3 : Electricity-gas-water rate of orders received
DEP4 : Services rate of orders received
DEP5 : Transport-communication rate of orders received
DET1-15 : Age classification number of death
DIST : Rate of distribution
EGLAB : Electricity-gas-water employed persons
EGLP : Electricity-gas-water productivity of labor
EGY : Net electricity-gas-water products
ELAND : Other land area
ELR : Rate of other land area to land area
EMPW : Number of employee
ENTAX : Town corporation tax
ENTM : Establishment
ETEXP : Other expenses
ETREV : Other revenue
ETTAX : Other local tax
EXPEN : Disbursement
FLAB : Primary industry employed persons
FLAND : Farmland area
FLR : Rate of farmland area to land area
FPOP : Total net immigration
FWLP : Rate of mountain forest-wild plain to land area
FWP : Mountain forest-wilf plain area
FY : Net primary industry products
H : Employed persons of usual place in Hiroshima town
HECON : Municipal public works expenses with state subsidy
HOH : Household
HOP : Number of the persons per household
HPOP : Rate of social increase
IDEP : Index of dependence population
INC : Net increase of population
IOLM : Index of old age population
IOM : Index of aging population
IVEXP : Public works
IYSP : Index of minor population
LAND : Land area
LBOND : Local bond
LGTAX : Local allocation tax
LOTAX : Local tax
LPRO : Productivity of land
LTTAX : Local transfered tax
MFLAB : Financing-insurance-real estate employed persons
MFLP : Financing-insurance-real estate productivity of labon
MFY : Net financing-insurance-real estate product

MILAB : Mining employed persons
MILP : Mining productivity of labor
MIRI-15 : Age classification net immigration
MIY : Net mining products
MLAB : Manufacturing employed persons
MLP : Manufacturing productivity of labor
MY : Net manufacturing products
NAGY : Net foresty-fishery-products
NALAB : Foresty-fishery employed persons
NALP : Foresty-fishery productivity of labor
NFDEM : Basical financing demand
NFREV : Basic financial revenue
NUI : Natural increase
OLM : Old age population
OSREV : General revenue
PAP : Population of working age
PETAX : Town individual inhabitant tax
PLOAN : Public debt
POP : Total population
POP1-15 : Age classification population
PRICE : Price index
PSEXP : Pesonnel expense
PSLAB : Government employed persons
PSY : Net government products
RBIR : Rate of birth
RDEF : Difference between basic financial demand and basic financial revenue
RDET1-15 : Age classification rate of death
RETAX : Fixed assets tax and city planning tax
RI : Relative income
RLAND : Residential area
RLR : Rate of residential area to land area
RPOP : 15-49 years old woman population
RWA : Sum of local tax and local transfered tax
SELAB : Services employed persons
SELP : Services productivity of labor
SEY : Net services products
SICON : Public works
SISET : Independent municipal public works expenses
SLAB : Secondary industry employed persons
SNY : Net Sapporo products
STAFF : Number of office workers
SWO1-15 : Age classification number of swithing
SY : Net secondary industry products
TCLAB : Transport-communication employed persons
TCLP : Transport-communication productivity of labor
TCY : Net transport-communication products
THLAB : Tertiary industry employed persons

THY : Net tertiary industry products
TPOP : Increase of employed persons
VALML : Valuation multiplier
WRLAB : Wholesale-retail trade employed persons
WRLP : Wholesale-retail trade productivity of labor
WRY : Net wholesale-retail trade products
YSP : Minor population (0-14 years old)
ZALLAB : Total employed persons (usual place)
ZPOP1-15 : Age classification net immigration rate
ZTR : Rate of territory
ZZR : Rate of persons