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INFLUENCE OF TRANSPORTATION NETWORK DEVELOPMENT ON DOMESTIC MIGRATION IN JAPAN

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Abstract

A model to explain the mechanisms of domestic migration in Japan is developed. In the model, regional utility is explained by income, land price and interchangeable population, which are treated as exogenous variables. The influence of the development of transportation networks on migration is analysed by simulation using the model.

INTRODUCTION

Recently many people have moved from provincial areas in Japan to the Kanto Area in which Tokyo is located as the central city. As a result, a monocentric society has been created with the Kanto Area emerging as its powerful center. This migration has caused serious problems, for example, an extreme rise in land prices, overpopulation and congestion problems in and around Tokyo. In order to resolve these problems, migration to the Kanto Area should be controlled, if a truly multicentric land is to exist. Several countermeasures must therefore be considered for this purpose.

This study aims to develop a migration model to explain the causes and mechanisms, in order to contribute to future planning of countermeasures. In this study, migration is assumed to occur as a result of the differences in interregional utilities. The utility function is assumed first, and then the migration model between regions is made with the utility included as an exogenous variable. The model can be used for analysing the influence of land price rises, variations in income and reduction in travel time due to the development of infrastructures, on migration. Finally, in order to analyse how much the development of transportation networks planned in the future may influence migration flow, simulation analysis is performed by using the migration model.

EXISTING STUDIES AND CHANGES IN MIGRATION PATTERN IN JAPAN

Migration models have been reviewed in several studies and of these, Suzuki (1980) and Masaoka (1989) constitute remarkable works. Many of the existing models are based on the hypothesis that the flow of migration occurs according to the difference in income level or the opportunity of employment between regions. Migration models where factors concerning living environment such as the development level of infrastructures, land price, etc. are involved, have also been proposed recently. The fundamental ideas to be found in migration models are the differences in wages as proposed by Hicks (1932, 1963) and the existence of job opportunities, Robinson (1947) and Schultz (1945). The flow of migration is assumed by Tachi (1964) to generate itself so as to reduce the difference in income levels between regions. There are many more types of migration model such as the gravity model derived by Isard (1956) and Wilson (1967), the intervening opportunity model by Stouffer (1940), and Anderson's stochastic process model (1954) etc. (see Pickleles, 1980).

The migration between regions and studies of the Japanese model will be focussed on here. In the 1950s and 1960s, a considerable number of people moved from provincial areas to the Tokyo, Nagoya and Osaka Metropolitan Areas because of dramatic growth in the economy. Most of the models in this period were based on theories of the difference in wages as well as the existence of job opportunities. However, in the 1970s, as Okazaki (1974) suggested, the migration flow from metropolitan to provincial areas increased together with a decrease in the flow to the opposite direction. As a result, the number of flows in both directions came to almost equal each other. In order to explain these phenomena, Kuroda (1978) suggested that migration was caused by a difference in living standards and the power of products, and that such differences disappeared during this period. In the 1980s, migration became active again. The flow characteristics at this time were, as Hama (1985) suggested, concentrated only in the Tokyo Metropolitan Area. This migration was considerably influenced by economic conditions, and consequently some theories emerged concerning the difference in wages and attractiveness of job opportunities. To explain the flow, Aoyama and Kondo (1992) suggested the development of transportation facilities as one of the important factors accelerating the flow from rural areas to Tokyo and derived a migration model to explain this distinctive flow.

MIGRATION FLOWS BETWEEN REGIONS

In order to observe the migration flows between areas, Japan is divided into eight blocks as shown in Figure 1. The prefectures included in each region in Figure 1 are listed in Table 1.

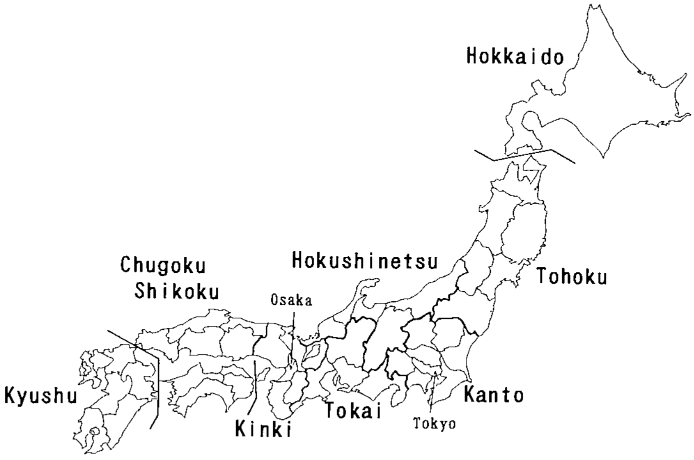

Figure 1 Eight regions in Japan

Table 1 Zones and prefectures

Zone Name	Prefectures in Each Zone
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima I
Kanto	Ibaragi, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi
Hokushinetsu	Niigata, Toyama, Ishikawa, Fukui, Nagano
Tokai	Gifu, Shizuoka, Aichi, Mie
Kinki	Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku- Shikoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Koch
Kyushu	Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, Okinawa

The Kanto, Tokai and Kinki regions can be labeled metropolitan areas, while the rest are country areas. Tokyo and Yokohama are included in Kanto, Nagoya is in Tokai, and Osaka and Kobe are in Kinki. The differences between inflow and outflow for each region from 1986 to 1991 are represented in Figure 2. As this figure shows, the social increase in the Kanto Area has been continuously seen although the difference between inflow and outflow has been reduced. On the contrary, the outflow from provincial regions has been much larger than the inflow into them. Tokai has continuously experienced little social growth since 1986 and inversely Kinki has suffered little social decrease.

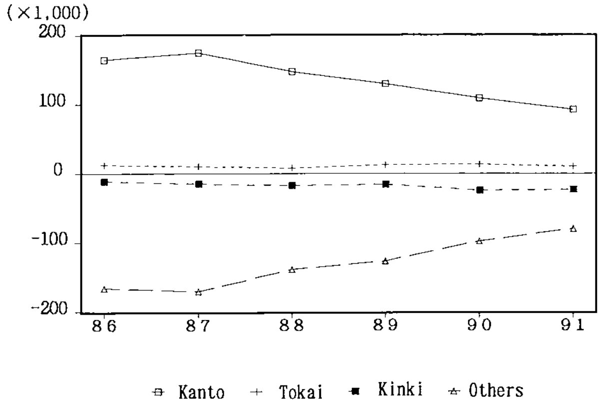

Figure 2 **Social change in population**

Figure 3 shows the average number of inflows and outflows per year between Kanto, Tokai, Kinki and other provincial regions. The flows from provincial regions to the three metropolises can be clearly observed. The provinces show a yearly social decrease of 129,800. About 75 percent of such decreases in these areas are seen to be in the direction of the Kanto Area. Kanto receives inflows from the other three regions and shows an annual population increase of 136,600. There is also a small flow from the Kinki to Tokai regions. Migration flows from provincial regions to the Kanto region, meaning that the region placed at the top of Figure 3 is actually the most attractive as far as migration is concerned.

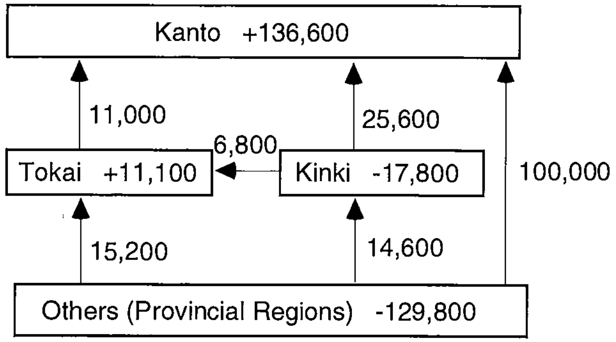

Figure 3 **Inflows and outflows of migration between regions (average number in a year from 1986 to 1991)**

MIGRATION MODEL

Migration model between regions

The flow of migration from region i to j is assumed to be mainly caused by the difference in utilities. However, a flow of migration is even observed from a region being higher in utilities to one whose utility value is apparently lower. This means that the migration cannot be explained solely by the regional utility factor and that another factor is needed. The degree of relationship between regions is then taken into account as the sought after factor. Thus, for this study, the flow of migration per capita is measured by the function of the utility, the degree of relationship and the constant number of people per capita who move without being related to the afore said two factors. Equations (1) and (2) are assumed as the migration model between regions.

$$\frac{X_{ij}}{P_i}=\lambda\cdot(U_j-U_i)+\mu\cdot V_{ij}+C \tag{1}$$

$$\frac{X_{ji}}{P_j}=\lambda\cdot(U_i-U_j)+\mu\cdot V_{ji}+C \tag{2}$$

where

X_{ij} Flow of migration of from region i to j

P_i Population in region i

U_i Utility in region i

V_{ij} Degree of relationship between region i and j

C Constant number of people per capita who move without being related to utility and degree of relationship

λ, μ Parameters ($\lambda, \mu>0$)

Even though the value difference of utility U_j from U_i is negative, a flow of migration can be observed because the degree of relationship V_{ij} bears greater influence and there is a constant movement of people. The degree of relationship between regions does not differ in the directional sense so that $V_{ij}=V_{ji}$ is formed.

The difference in migration flows between region i and j can be obtained as shown in equation (3) from equations (1) and (2).

$$Z_{ij} = X_{ij} - X_{ji}$$

$$=\lambda\cdot(U_j-U_i)(P_i-P_j)+\mu\cdot V_{ij}(P_i-P_j)+C(P_i-P_j) \tag{3}$$

$$=\lambda\cdot\Delta U_{ij}(P_i-P_j)+\mu\cdot V_{ij}(P_i-P_j)+C(P_i-P_j)$$

where

Z_{ij} Net flow of migration from region i to j

ΔU_{ij} Difference of utility in region i from j

In this study, the utility function in region i is assumed to be as shown in equation (4) with reference to existing studies.

$$U_i=\alpha_1\log I_i+\alpha_2\log R_i+\alpha_3\log E_i+\alpha_4\log W_i \tag{4}$$

where

U_i Utility in region i

I_i Average income in region i

R_i Residential land price in region i

E_i Employment opportunities in region i

W_i One day interchangeable population in region i

$\alpha_1 ... \alpha_4$ Parameters ($\alpha_1>0$, $\alpha_2<0$, $\alpha_3>0$, $\alpha_4>0$)

Regional utility U_i is considered to be in proportion to average income I_i, employment opportunities E_i and one day interchangeable population W_i. The one day interchangeable population in region i is defined as the total number of population which can be counted in areas within three hours one way from region i. This variable can be used for measuring the degree of improvement of transportation facilities since the value of interchangeable population increases as the travel time between regions is reduced (see, Aoyama and Kondo, 1992). On the other hand, regional utility is in inverse proportion to price of land.

The difference of utility ΔU_{ij} between region i and j is drawn from equation (4).

$$\Delta U_{ij} = U_j - U_i$$
$$=\alpha_1 \log(I_j/I_i)+\alpha_2 \log(R_j/R_i)+\alpha_3 \log(E_j/E_i)+\alpha_4 \log(W_j/W_i) \quad (5)$$

By substituting equation (5) for equation (3), the migration model can be obtained.

Land price model

Equation (6) represents the area of land in which the home buyer's purchasing power is expressed as M and the average land price for housing in a region is notated as R.

$$Y = M/R \quad (6)$$

where, Y: Purchasable area of land sought by prospective home buyer

The total amount of demand for land in the region is derived and shown in equation (7), where the total number of households is expressed as H.

$$D = H \cdot Y = H \cdot M/R \quad (7)$$

When the total amount of land supply in a year is fixed and the area of land for housing is expressed as S, equation (8) is realized if the demand and supply are balanced.

$$S = H \cdot M/R \quad (8)$$

The land price is shown in equation (9) under the same conditions.

$$R = M \cdot H/S \quad (9)$$

When the average income per capita in the region is expressed as I, the payable amount of money M is in direct proportion to I^A where A is a parameter. On the other hand, H/S which means the housing density in the region can be assumed to be in direct proportion to the B power of the population density ρ. As a result, equation (9) can be expressed using the average income per capita I and the population density ρ.

$$R=\gamma \cdot I^A \cdot \rho^B \quad (10)$$

where γ, A, B : Parameters

Equation (10) can be transformed into equation (11) by using logarithms. Equation (11) is titled the residential land price model or shortened to the land price model.

$$\log R=\log\gamma + A \cdot \log I + B \cdot \log\rho \quad (11)$$

CALIBRATION OF MIGRATION MODEL

Migration model between regions

By substituting equation (5) for equation (3), equation (12) is obtained.

$$Z=\left\{\beta_1\log(I_j/I_i)+\beta_2\log(R_j/R_i)+\beta_3\log(E_j/E_i)+\beta_4\log(W_j/W_i)\right\}(P_i+P_j)+\beta_5V_{ij}(P_i-P_j)+\beta_6(P_i-P_j) \tag{12}$$

where $\beta_1 ... \beta_6$ Parameters

The degree of relationship Vij is assumed to be measured by the travel time between region i and j. Parameters in equation (12) are estimated by multiple regression analysis. Data for the analysis is gathered in the eight regions shown in Table 1. The data for migration flow is gathered from 1986 to 1991, and that for independent variables from 1985 to 1990. A one year time lag is assumed between independent and dependent variables. In calibration, the two stage least squares method is applied. The value of land price which has previously been estimated by the land price model shown in equation (10), is used as exogenous data to calibrate equation (12). When the interchangeable population is measured, travel time by car is used.

The result of the estimation of parameters is shown in Table 2. In estimation, a high degree of correlation coefficient between the income and the number of opportunities is found. Since it is considered to cause multicolinearity, the income is taken out from the independent variables in regression analysis. The degree of relationship between regions Vij is not found to be an efficient variable to explain the migration. One of the reasons for this is that the model is derived on a macro level in which migration flows between large regions are treated. Differences in migration flows between regions are not clearly explained by using travel time as a variable for the degree of relationship.

Table 2 shows that parameters estimated here do not have any logical contradiction, and that migration flows between regions are influenced by the land price in residential areas, the number of employment opportunities and the interchangeable population. Flow of migration increases with an increment in the number of employment opportunities and the interchangeable population but deceases with a rise in land prices. Since the interchangeable population varies corresponding to the reduction of travel time due to the improvement of transportation facilities, this result proves that the migration flow between regions in Japan has been influenced considerably by the improvement of expressway networks.

Table 2 Result of calibration of migration model

Variable	Parameter	T-Value
Land Price (Yen/m^2)	-0.2892	-5.313
Employment Opportunities	0.4819	9.858
Interchangable Population	0.1598	6.751
Constant	0.3013	2.921
Coefficient of Determination		R^2=0.855
Number of sample		140

Land price model

By using data from eight regions between 1985 and 1988, the parameters in equation (11) are estimated by multiple regression analysis. The result is shown in Table 3. As the table shows, the price of land rises accordingly with the increment in population density and income.

Table 3 Result of calibration of land price model

Variable	Parameter	T-Value
Income (x 1,000Yen)	1.0782	9.086
Population Density (Per/km^2)	1.2196	19.652
Constant	-8.0447	-9.718
Coefficient of Determination		R^2=0.815
Number of Sample		184

SIMULATION ANALYSIS OF MIGRATION FLOW BY THE IMPROVEMENT OF TRANSPORTATION FACILITIES

The interchangeable population included in the utility function can explain the migration flow between regions. It increases with the reduction of travel time due to the improvement of transportation facilities. In this section, the influence of the improvement of transportation facilities on migration is quantitatively analysed by simulation using the migration model as shown in equation (12) having parameters as shown in Table 2. In this study, as travel time is measured on roads, the improvement of expressway networks is considered to reduce it. In analysis, a completed network of expressways is proposed as shown in Figure 4, where all prefectural capital cities are linked with each other by expressways. Figure 5 shows the existing expressway network in 1995. All of the prefectures have expressways or national roads, although there are several prefectures not linked with other prefectures by expressways.

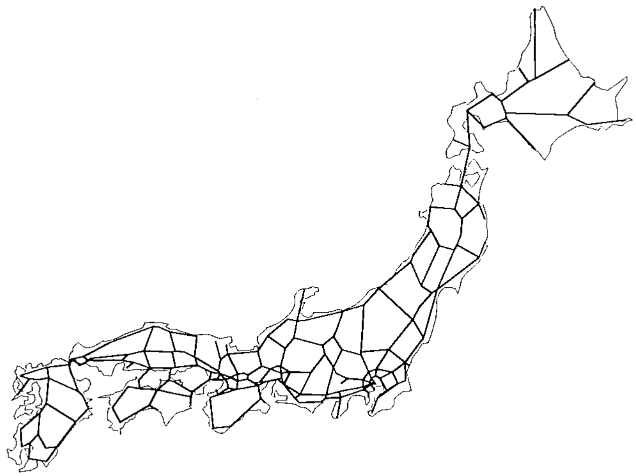

Figure 4 Expressway network in the future

Travel time between all of the prefectures is measured on the networks shown in Figure 4 and Figure 5. It is assumed that travel time will be reduced from the network in Figure 5 to that in Figure 4 in 10 years. Values of variables in the utility function which are not influenced by the improvement of transportation facilities are fixed at those of recent years. After the amount of migration flow is estimated in equation (12), the price of land in residential areas is calculated by equation (10) having parameters as shown in Table 3 with population density which is varied by the migration each year. Calculated value of land price is used for estimation of migration flow in the following year. This procedure is repeated ten times and migration flow between regions in the ten years until the completion of the expressway network in Figure 4 is simulated. The new data for travel time between regions is calculated in each year according to the expressway network.

Figure 5 Expressway network in 1995

In simulation, two cases for improvement of the expressway network are proposed, and the calculated travel time between regions is based on them. The first case involves improving the network equally throughout Japan. First, the difference in travel time between the networks presented in Figures 4 and 5 is calculated. The travel time between regions after 1995 is reduced by 10 percent of the difference from that in 1995. The result of the simulation by using the data of this travel time is shown in Figure 6.

The second case involves reducing the travel time between prefectures in provincial regions first. One of the reasons why population is concentrated in metropolitan areas in Japan is considered to be that the expressway network between them and linking them has been more developed than the network between provincial regions. This is clear from the road network shown in Figure 5. In order to solve this problem, it is important to raise the utility level in provincial regions by developing transportation facilities. This will result in increasing the migration flow from metropolitan areas to provincial regions and creating a better distribution pattern of population in Japan. In this simulation, the completed network of expressways is the same as for the former case as shown in Figure 5. However, all of the annual budget for expressways is assigned to develop the roads linked to prefectures in provincial regions in the first 5 years, then the expressways between prefectures in metropolitan areas are to be improved in the last 5 years. In other words, the reduction of travel time in provincial regions begins in the first year and finishes in the fifth year, and then that in metropolitan areas begins in the sixth year and finishes in the last year. The result of the simulation is shown in Figure 7.

From Figures 6 and 7, the difference between inflow and outflow in Kanto is a positive value but decreasing continuously, and that in Chugoku and Shikoku will change from a negative value to a positive one. Chugoku and Shikoku are two typical provincial regions in Japan. The contribution of the improvement of the expressway network can be seen in these figures. The difference between inflow and outflow in Chugoku and Shikoku becomes positive earlier in Figure 7 than in Figure 6. The decrease in the said difference in Kanto and Tokai, belonging to metropolitan areas, can also be seen in an earlier year, and in the provincial regions of Hokushinetsu and Tohoku better effects are seen in Figure 7. As shown above, the second case for improvement of the expressway network contributes to realizing better migration flows than the first case.

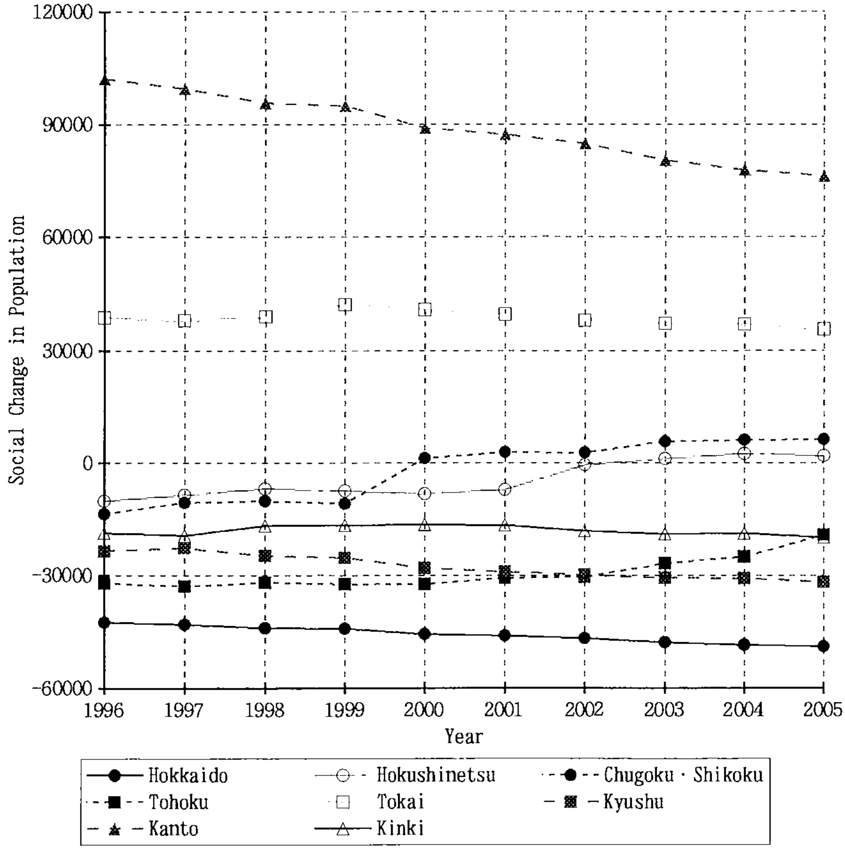

Figure 6 Result of simulation in the first case

CONCLUSION

In this study, migration flows between eight regions in Japan were observed, and a model was then derived and calibrated. Where the migration flow in recent years is concerned, it was noted that the outflows from the provinces and the inflows to the Kanto region were large from 1986 to 1991. In fact, about 75 percent of the outflow from provincial areas went to Kanto. The migration model between regions and the land price model are proposed, and sufficient results were finally obtained after these models had been formulated. In the migration model the land price, the interchangeable population and the availability of employment opportunities clearly influenced migration. Furthermore, the land price proved to be a negative factor against such migration.

The influence of the improvement of transportation facilities on migration is quantitatively analysed by simulation using the estimated migration model. As a result, the improvement of expressway networks greatly increases the regional utility in several provincial regions and has a beneficial influence on the migration flows. It is clear, when the two proposed ways for improving roads are compared, that if the expressways linked to provincial regions from other areas are improved earlier than other roads, better migration flows will be realized. In fact, the improvement of expressways is planned to create a much better road network than before, and construction of expressways can be seen all over Japan. The rapid improvement of the expressway network is expected to realize a better distribution of population, as shown in this study.

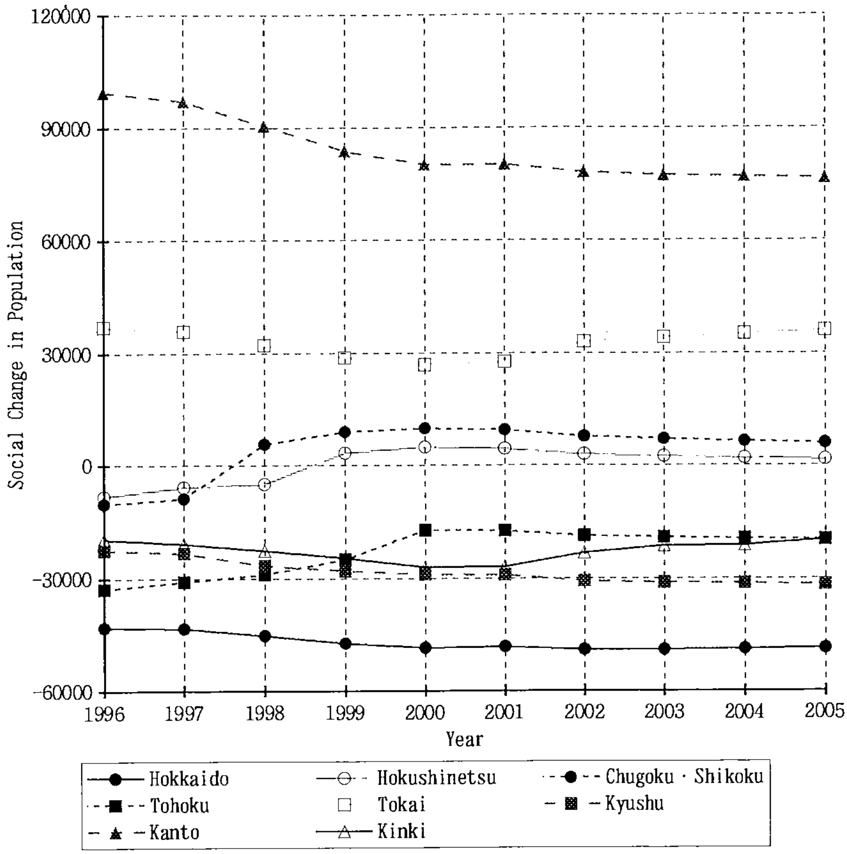

Figure 7 Result of simulation in the second case

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