A STUDY ON RELOCATION OF HOUSEHOLDS IN TOKYO METROPOLITAN AREA CAUSED BY NEW RAILWAY PROJECTS

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Abstract: *While the trend toward increase in population in the Tokyo Metropolitan Area (TMA) has ended, migration to more convenient and attractive residential zones inside the TMA is expected to continue. Since new railway projects play an important role in promoting migration, it is necessary that the relocation of households be predicted more precisely during the simultaneous planning of the railway system and the region to ensure the success of future railway projects. This study (1) focuses on the future migration behavior, (2) discusses the important factors that cause people to migrate and (3) models the relocation of households within the Tokyo Metropolitan Area vis-à-vis railway projects.*

1. INTRODUCTION

Over the years Japan has changed into a society with declining birthrate and an aging population as shown in **Figure 1**, so much so that depopulation from 2010 is forecasted by the National Institute of Population especially in the Tokyo Metropolitan Area (TMA) [1), 2)]. **Figure 2** shows the change in the number of migrants to and from the TMA since 1955. The figure shows that the number of migrants to and from the TMA has stabilized, thus the tendency of the total population to remain constant in recent years.

Household locations in the TMA have expanded to the suburbs as a result of developed transportation systems and soaring land price in the inner areas. Generally, access time to business zones, patterns of land use, land price and zone amenities, and so on are changed by new railway projects. These types of projects therefore have a definitive role in promoting the relocation of households as shown in **Figure 3** that exemplify remarkable population growths in areas where new railway lines were operated. Because of this, it is foreseen that the population inside the TMA may continue to shift to more convenient and attractive residential zone with the introduction of new railway lines.

The traffic congestion during peak commuting periods is one of the most serious problems in the TMA. It may be argued that one of the reasons for peak hour congestion is the imbalance in the location of nighttime population among municipalities. It is known that OD patterns are changed by the relocation of households hence, it is important to study the patterns and trends in the household location in the TMA to address traffic congestion problems in the area.

This study focuses on future migration behavior and aims to calibrate models on relocation of households in the TMA vis-à-vis the planning of a new railway line. Additionally, this paper discusses the important factors that influence population flows in the TMA under the constraint of almost constant total population size.

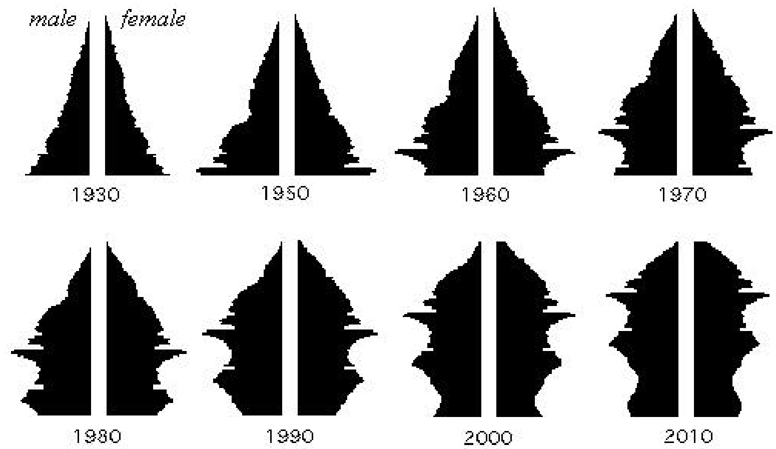


Figure 1. Population Pyramid in Japan from 1930 to 2010

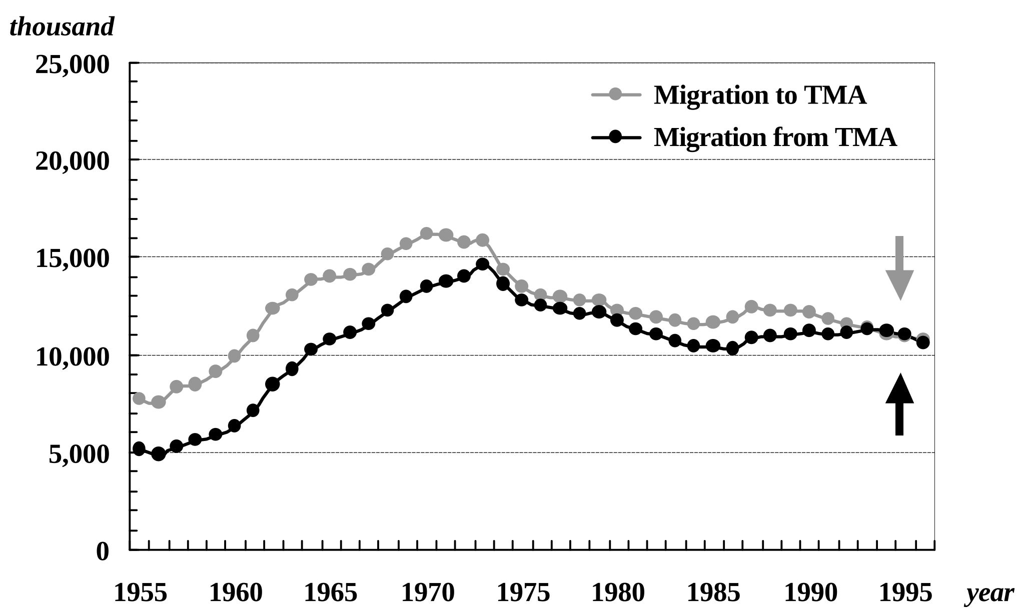


Figure 2. Change of Number of Migrant to/from TMA

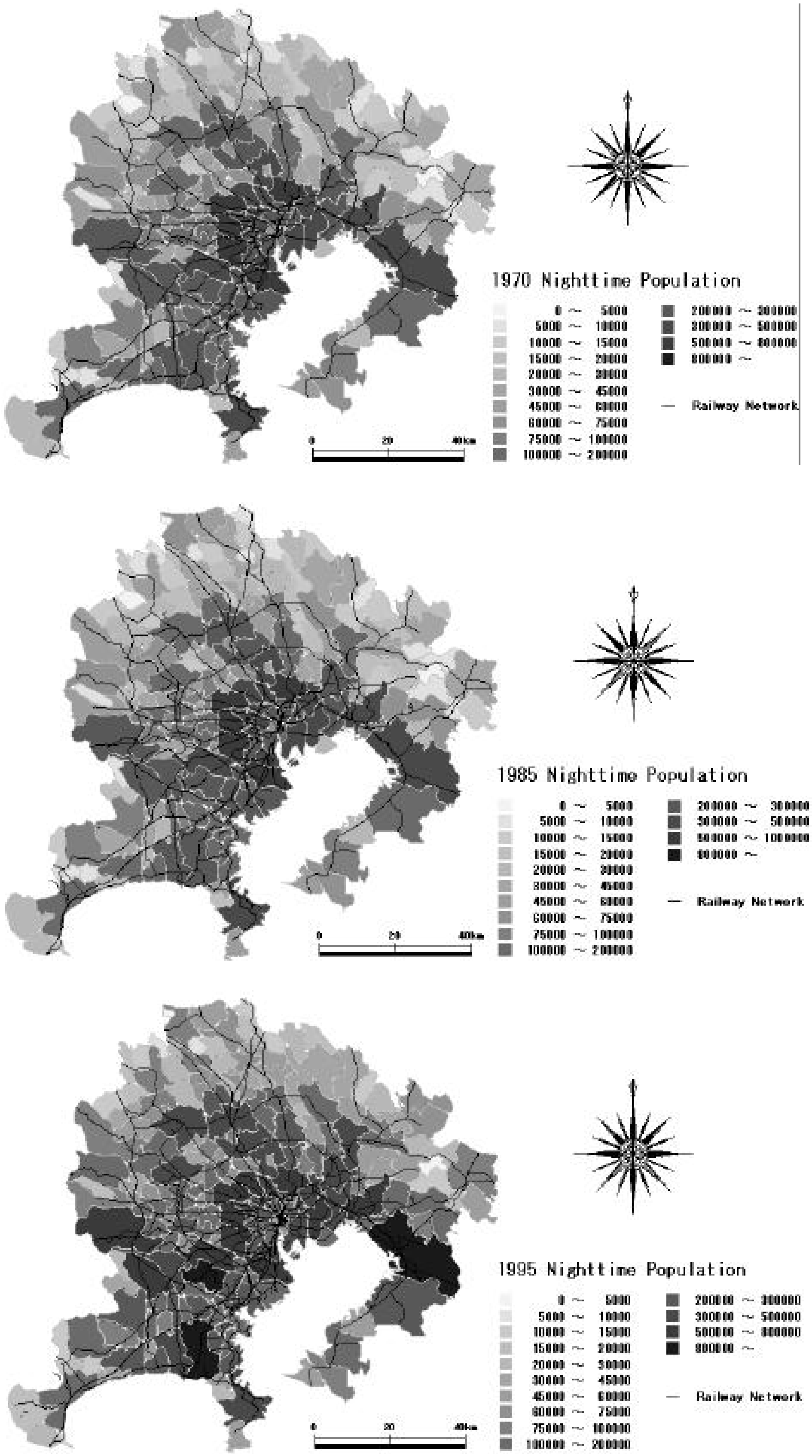


Figure 3. Distribution Map of Nighttime Population from 1970 to 1995

2. POPULATION FORECAST MODEL

2.1 COMPARISON WITH CONVENTIONAL METHOD

In the field of infrastructure planning, a large number of studies have been made on population forecast for the last twenty years[3), 4)]. In order to forecast future population, land use models have been calibrated, one of the more famous models of which is CALUTAS[5)]. The conventional method of forecasting population however, implicitly assumes the increase of population over time and does not analyze population flows themselves. Under the constraint of minimal population growth like that experienced in the TMA in recent years, an unconventional method of analysis that requires the balancing of population flow-out and flow-in, is necessary. This study tries to analyze household relocation in the TMA by considering population flows. In this paper, "migration" means the movement between the TMA and the other external areas, and "flow" means the movement inside the TMA shown in **Figure 4**.

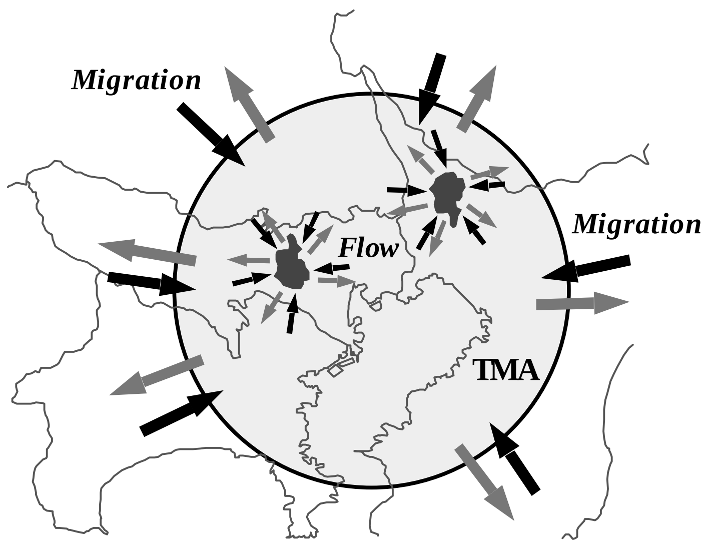


Figure 4. Concept of Migration and Flow

2.2 POPULATION DATA PROFILE

There are several population statistics in Japan. In general, data from the National Census and the Basic Resident Registers are the ones used for population forecasts. A National Census is done every 5 years from which population per municipality can be extracted. On the other hand, law requires resident registration in Japan. The statistics from these resident registers are called the Basic Resident Registers. Some characteristics of these data are mentioned below. Population flows are not readily apparent and they do not describe details regarding age, work place, flow-out place and so on, although they have much higher precise statistics by municipality.

3. METHOD OF ANALYSYS

3.1 OUTLINE FOR MODELING

It is known that population is increased and decreased by the social change (i.e., migration, flow) and the natural change (i.e., mortality change). This study defines the change of population in the TMA as shown in **Figure 5**. This paper mainly analyzes an Intra-Area Relocation Model based on two assumptions described as follows: (1) that the tendency of the population in the TMA will remain constant will continue unless abnormal events like major natural disasters or a rapid decline of business, etc. occurs, and (2) that improvements in civil infrastructures (e.g., land readjustment projects, new railway projects, etc.) will greatly contribute to the population flows to the inner area.

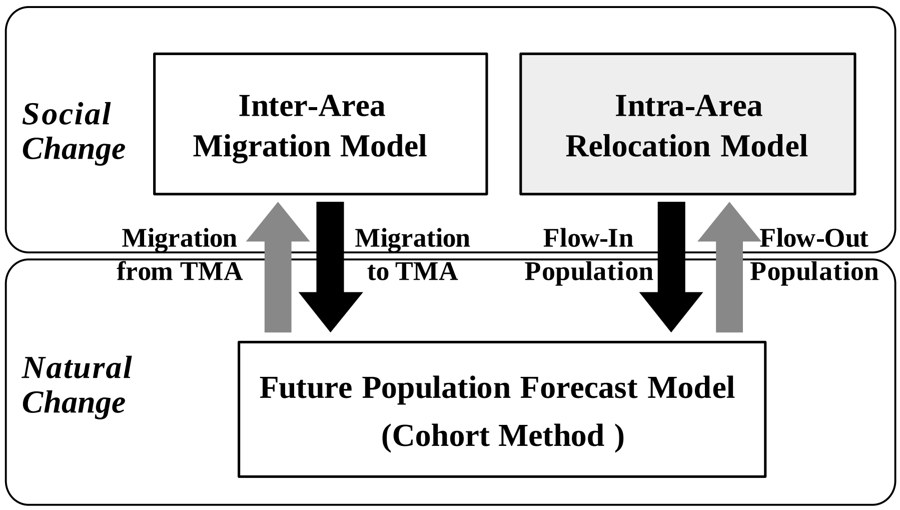


Figure 5. Structure of Population Change

Although a great deal of effort has been made on studies of population forecasts, they have been analyzed based on prefectures and large areas. In order to predict the relocation of households more precisely, this study adopts a regional zone, i.e., independent municipalities such as cites, towns and villages, as the analysis unit. **Figure 6** displays these zones which are located within a distance of approximately 50 kilometers from the Tokyo Station placed at the center of the TMA. The analysis zones consist of over 200 municipalities in Tokyo, Kanagawa, Saitama, Chiba and Ibaraki Prefectures. The study uses several statistical data from the National Census, the Basic Resident Registers and so on. The following explains the Inter-Area Relocation Model and the Future Population Forecast Model that are developed in this study.

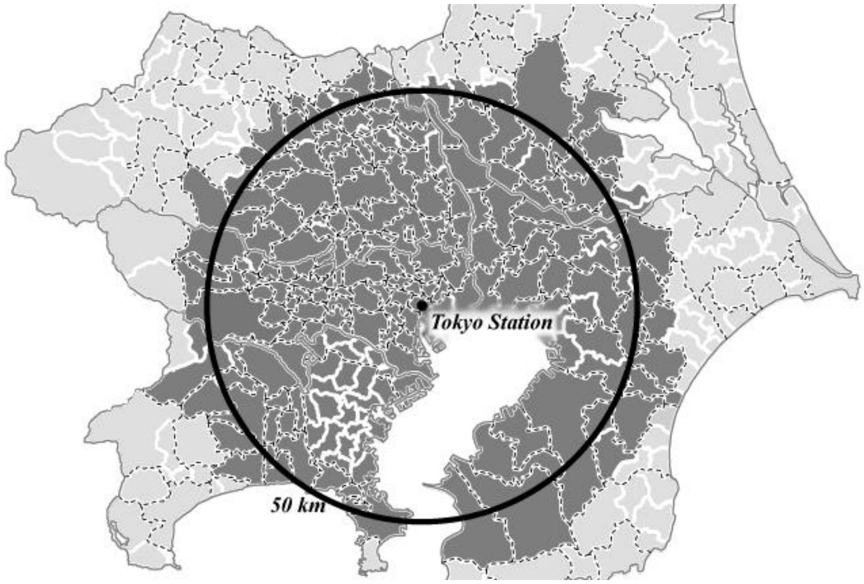


Figure 6. Analysis Zones

The structure of the Inter-Area Migration Model is shown in **Figure 7**. Initially, the total amount of migration to and from the TMA is obtained from Basic Resident Resisters, then this is distributed by weight of population to each zone. This simplistic approach stems from the following reasons: (1) the total population in the TMA continues to be constant, (2) this study mainly focuses on intra-area relocation caused by new railway projects, and (3) lack of detailed data as mentioned above.

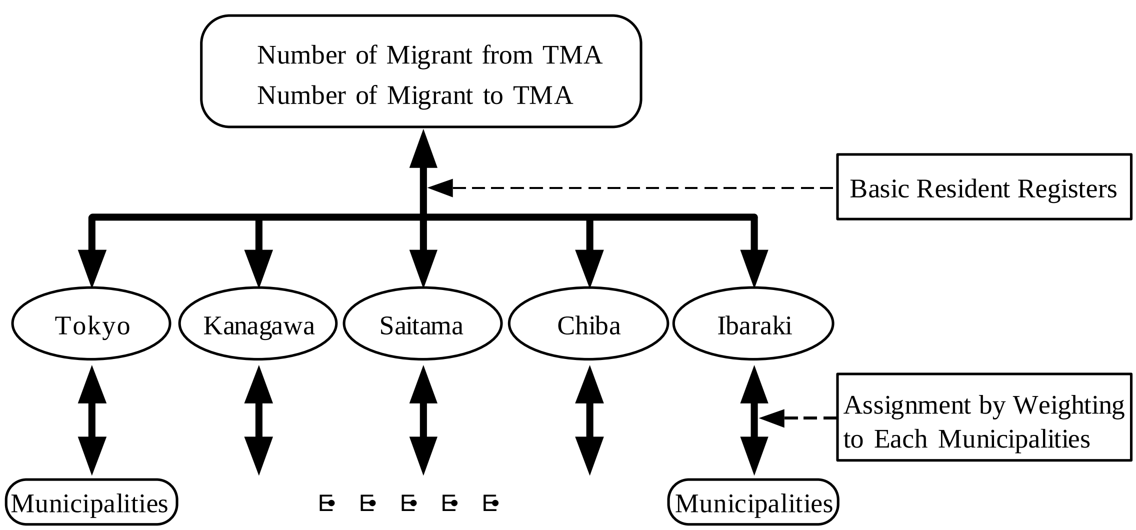


Figure 7. Inter-Area Migration Model

The outline of the Future Population Forecast Model is shown in **Figure 8**. Flow-out population, flow-in population and migration that are calculated by the Intra-Area Relocation Model and the Inter-Area Migration Model, are converted into population by sex and by age and used by the cohort model. The future populations in the different zones are predicted using conventional cohort methods considering natural change[6), 7), 8)]. The study uses the assumptions set by the National Institute of Population, because of little regional differential of survival rate, birth rate, sexuality rate of children born and so on in the TMA.

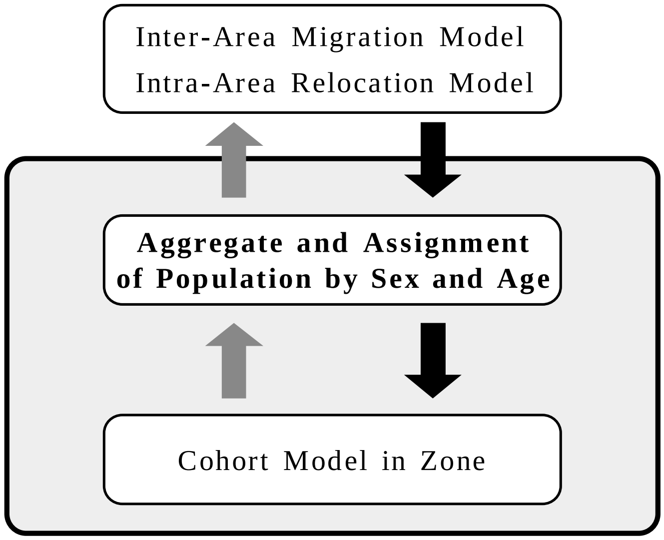
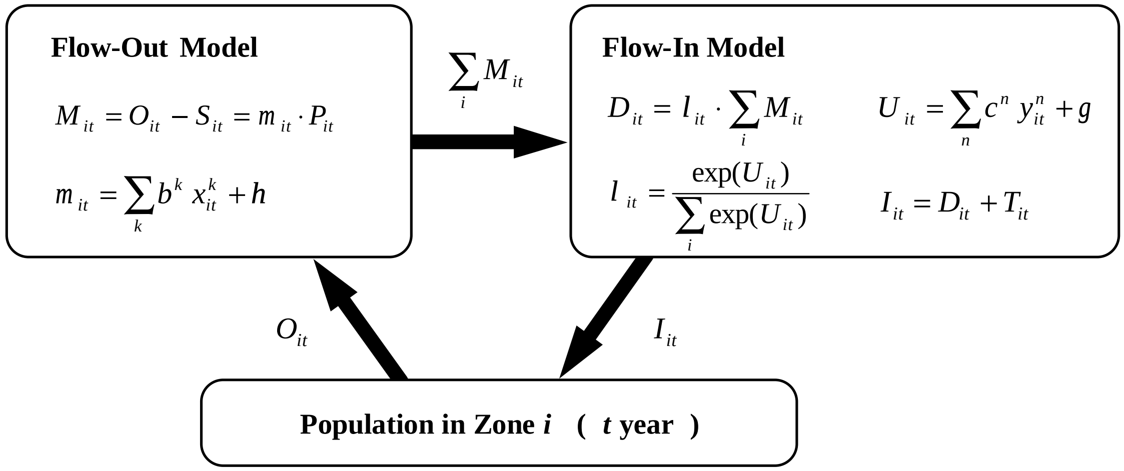


Figure 8. Future Population Forecast Model

3.3 INTRA-AREA RELOCATION MODEL

The Intra-Area Relocation Model is based on the premise that people have the tendency to immigrate to more fascinating residential zones. In order to forecast future populations, it is necessary to identify factors that impact on the population flows. Calibration of the Intra-Area Relocation Model identifies these factors.

The Intra-Area Relocation Model consists of a Flow-Out Model and a Flow-In Model. **Figure 10** summarizes the Intra-Area Relocation Model defining the elements of the different mathematical expressions used. The model is calibrated using multiple regression analysis, using the explanatory variables such as access time, land price, etc. These models calculate the rates of flow-out and flow-in. In turn, these rates are used to determine the amount of flow-out and flow-in population. In the study, it is assumed that the total number of flow-out population is equal to the total number of flow-in population.



O_i	:	total number of migrants from zone *i*
I_i	:	total number of migrants to zone *i*
M_i	:	flow-out population (from zone *i* to inside of TMA)
D_i	:	flow-in population (from inside of TMA to zone *i*)
S_i	:	number of migrants from zone *i* to outside of TMA
T_i	:	number of migrants from outside of TMA to zone *i*
P_i	:	total population of zone *i*
m, l	:	rate of Flow-Out, rate of Flow-In
a, b	:	parameter
h, g	:	constant
k, n	:	number of factors on Flow-Out, number of factors on Flow-In
t	:	year (National Census Year at 5 years interval)

Figure 9. Intra-Area Relocation Model

4. CALIBRATION MODEL

4.1 FLOW-OUT MODEL AND FLOW-IN MODEL

The result of the Flow-Out Model calibration is shown in **Table 1**. Two variables (i.e., the rate of population from 15 to 39 years old and the rate of population in tertiary industry) work positively toward flow-out. The drastic opportunities in people's lives such as marriage, admission to school, start of a new job, transfer to a new office and so on usually bring some change in dwelling place. Municipalities that have a lot of these opportunities and have high flow-out rate in 1995 are Chiyoda, Shibuya, and Nakano ward. It is conceivable that this model grasps the current trend of flow-out in these areas.

Table 2 shows the result of the Flow-In Model. Annual expenditure of local government is the most effective explanatory variable of flow-in. There is generally a trade-off between accessibility and land price [9), 10)]. In other words, in the event of dwelling place relocation, people desire to be able to access their offices at a shorter time, and to pay less costs associated to their new residences. This tendency is clearly shown in this model.

Table 1. Estimated Parameters of Flow-Out Model

Explanatory Variable	Partial Regression Coefficient
x^1 : Access Time to Tokyo Station (100 minutes)	-0.0052 (-2.16)
x^2 : Land Price (Billion Yen / m^2)	0.013 (1.10)
x^3 : LOG (Rate of Employee in Primary Industry)	-0.0028 (-2.12)
x^4 : LOG (Rate of Employee in Secondly Industry)	-0.039 (-7.81)
x^5 : LOG (Rate of Employee in Tertiary Industry)	0.026 (2.72)
x^6 : LOG (House Ownership Rate)	-0.018 (-2.45)
x^7 : LOG (Rate of Population from 15 to 39 Years Old)	0.22 (14.08)
x^8 : Population in Daytime / Population in Nighttime	0.0014 (4.69)
h : Constant	0.12 (14.60)

R^2 = 0.7816, () : t Value

Table 2. Estimated Parameters of Flow-In Model

Explanatory Variable	Partial Regression Coefficient
y^1 : Accessibility Function [10)]	0.0078 (1.42)
y^2 : Land Price (Billion Yen / m^2)	-0.0067 (-2.60)
y^3 : The Number of Changed Factory	0.0017 (3.93)
y^4 : Population Growth in Daytime / Population Growth in Nighttime	-0.0045 (-1.56)
y^5 : Annual Expenditure of Local Government (10 Billion Yen)	0.0011 (38.57)
g : Constant	0.0049 (1.71)

R^2 = 0.7805, () : t Value

4.2 FITNESS OF MODELS

To test the model, the population by sex and by age of Inzai City, Chiba prefecture in 1995 were estimated using 1990 data. The results from the model were then compared with the 1995 National Census data. Comparisons of actual and modeled data are shown in **Figure 10** and **Figure 11**. These graphs show that the model system is able to forecast the population by sex and by age with a high degree of precision (although the estimated population is a little less than the actual). These discrepancies may be due to some assumptions made regarding social change. Future studies will address these differences.

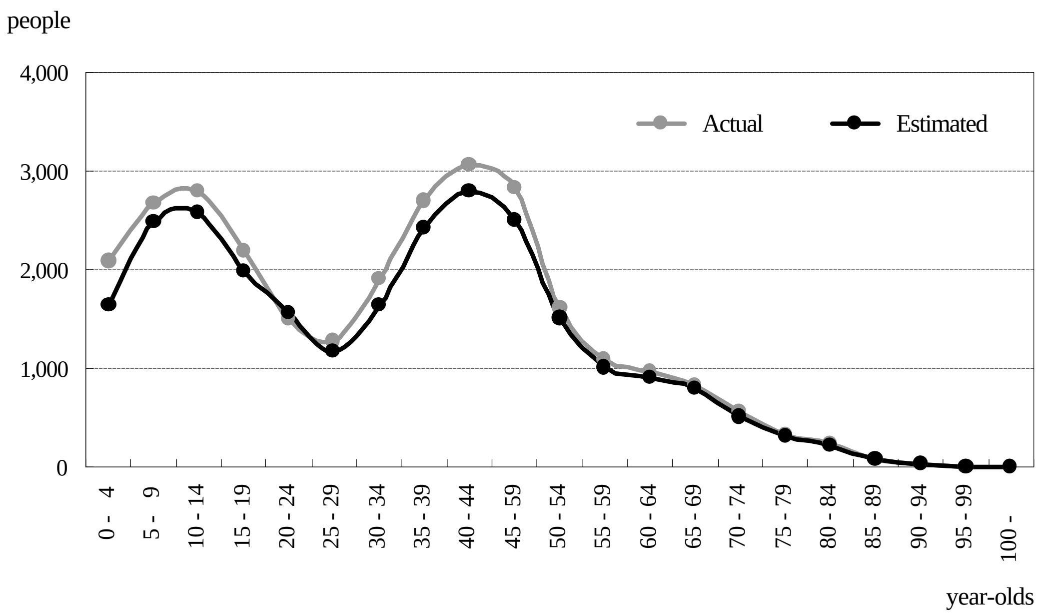


Figure 10. Estimated Population of Male by age in Inzai City

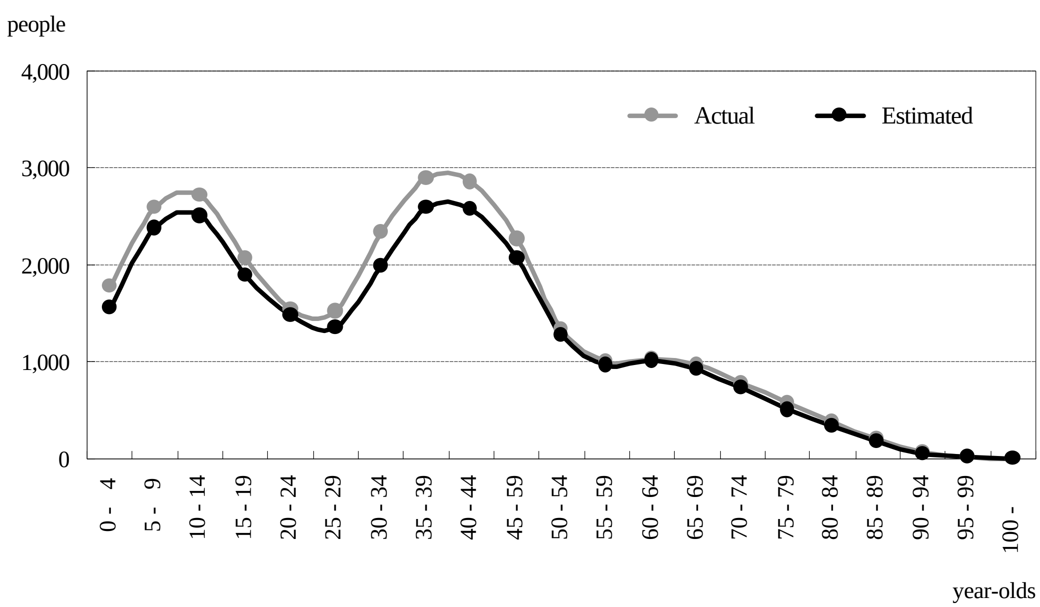


Figure 11. Estimated Population of Female by age in Inzai City

5. CASE STUDY

The model system is applied to Nagareyama City, northeast of Chiba prefecture, as a case study. There is a plan to construct a new railway line named Joban Shin Line across Nagareyama City. **Figure 12** shows the geographical location of the case study area together with the alignment of the proposed rail line. The analysis controls several explanatory variables, in order to see the difference in the year 2000 population of the city with and without the new railway project. The explanatory variables considered to be greatly affected by the project and thus controlled, are accessibility, land price, and annual expenditure of local government.

Figure 13 and **Figure 14** explain the results of the case study. If the Joban Shin Line (from Akihabara Station to Tsukuba Station) were operated, the population would increase to approximately 156,000 people (a difference of approximately 4,000) as shown in **Figure 12**. In **Figure 13**, it can be observed that the generations of 0-15 and 25-45 year-olds are exceptionally increased. This result grasps the tendency that a lot of households with children will migrate to this city in order to have a detached house.

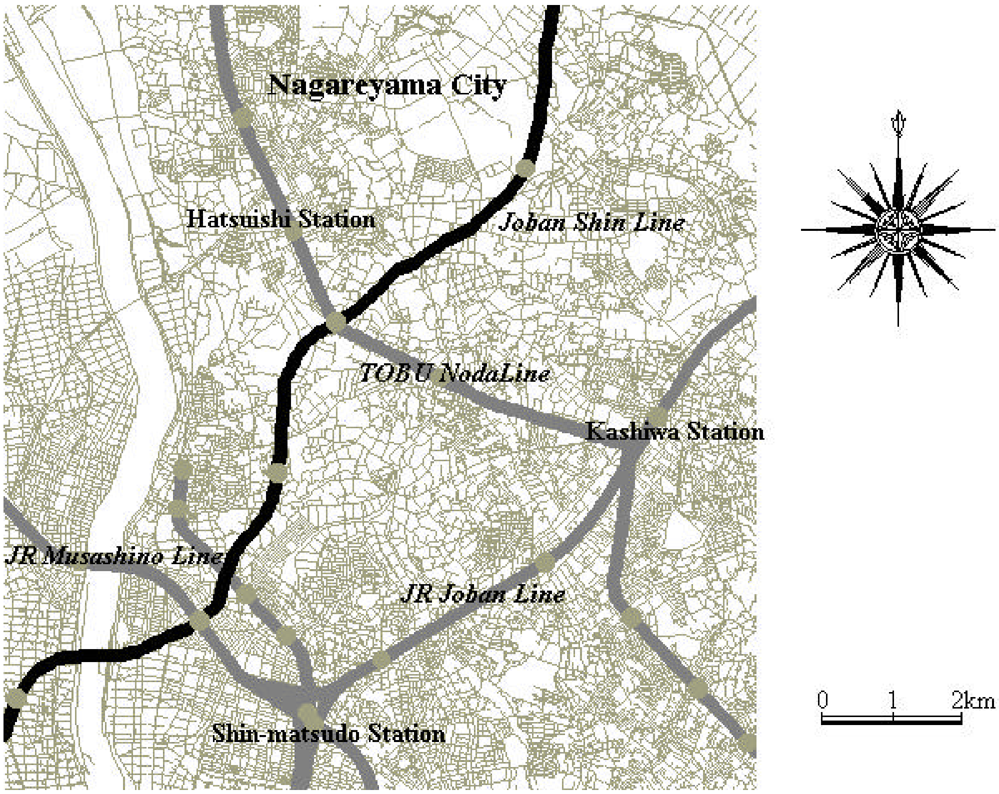


Figure 12. Case Study Area

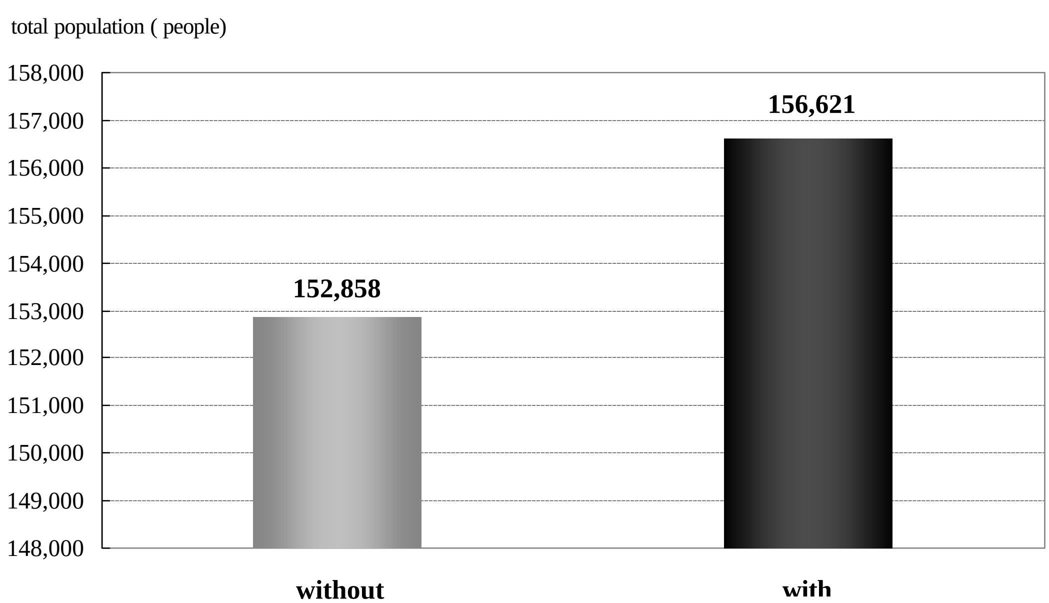


Figure 13. Comparison of Total Population

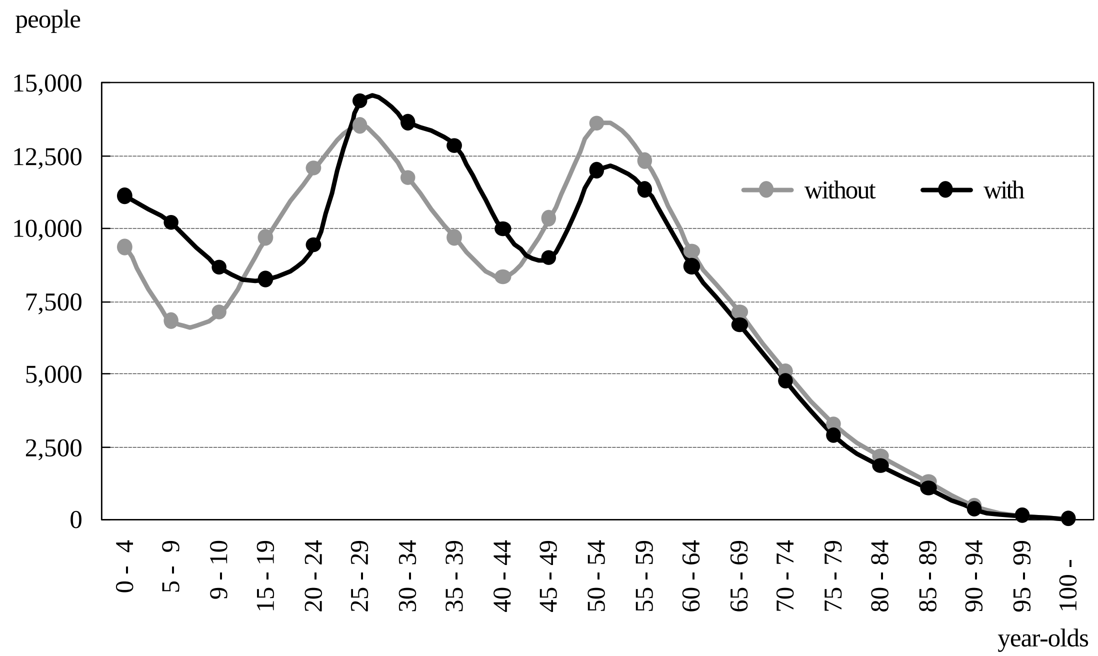


Figure 14. Estimated Population by Age

6. CONCLUSIONS

This study is an important analysis to achieve a better balanced distribution of household locations in the whole Tokyo Metropolitan Area. From the estimated results of Inzai city, it can be proven that the models proposed in this study are able to predict changes in population with a high degree of precision. In other words, the study has grasped the factors that influence population flows. One of the important points in the study is to find out the factors of not only flow-in but also flow-out. It is concluded that access time to business places and land prices have great effects on population flows, as well as the composition of employee and annual expenditure of local government.

This study is able to show the difference between the rail-project alternatives by controlling the several explanatory variables (i.e., political factors). The comparison shown in the case study is necessary for the success of new railway projects. It is quite important, hence, to figure out the structure of household relocation and to forecast future population for railway planning as well. In conclusion, this paper has made it clear the direction toward the planning of new railway and of relocation of households, on situation without population growth like the Tokyo Metropolitan Area.

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