Proceedings of the Eastern Asia Society for Transportation Studies, Vol.7, 2009

Development of Microsimulation Model for Land Use Analysis on a Hypothetical City

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Abstract: Impacts on land use distribution of a metropolitan area by a policy measure such as development of a road network or a railway system are increasingly complicated and more detailed analysis is required. A micro simulation system is a very effective tool to analyze these impacts in detail. The current paper develops a microsimulation model for representing demographic distribution on a hypothetical metropolitan area by using parameters estimated by the real data of the Person Trip Survey and its accompanied survey in 2006 which investigate individual location choice behavior. This model shows that the microsimulation model is able to forecast various possible demographic distributions as well as the most likelihood one. Therefore, this tool is useful in managing various risks which will occur there by foreknowing what will happen from the results of this model.

Key Words: *Microsimulation, Land Use Model, City Planning*

1. INTRODUCTION

The importance of the feedback of a transportation project on land use has been recognized in federal policy in U.S.A. since the passage of the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991. This point of view is also important not only in European area but also in Asian area where many transportation projects cause dramatic change of land use pattern. Furthermore, impacts on land use in a metropolitan area by a transportation policy measure such as development or renewal of a road network or a railway system are increasingly complicated and more detailed analysis is required.

A microsimulation system is a very effective tool to analyze these impacts in detail. This system used in economics is able to tackle nonlinear, complex, stochastic and period-oriented problems which can not be solved analytically but have to be simulated numerically. Therefore, this should be applied in theory development and decision support in the transportation study field.

However, in Asian area, few microscopic integrated land use and transportation model which is able to analyze these issues has been developed even though many such models are developed and applied to real cities in E.U. and U.S.A. (see Wegener 2003; Wegener *et al.* 2005) Therefore, now, a new type of microscopic integrated land use and transportation model is required in Asia area.

The aim of this paper is to try to develop a microsimulation model for representing demographic changes and location choice behaviors based on household types on a hypothetical metropolitan area. It is because demographic distribution, especially from the point of view of household types, throughout a metropolitan area should be forecasted to make a good plan of infrastructure and public facilities as well as transportation networks.

After this introduction in Chapter 1, literatures about the microsimulation in integrated land use and transportation model field as well as in demographic, financial and social security fields are reviewed in Chapter 2. Methodology of parameter estimation and simulation is described in Chapter 3. The simulation model consists of two parts. One is a demographic model and the other is a location choice one of residents. Households are divided into seven types according to patterns of location choice. These two models consider features of these household types consistently. Results of the simulation are shown and implications are discussed in Chapter 4. At last, concluding remarks are summarized in Chapter 5.

2. LITERATURE REVIEW

Orucott *et al.* (1986) firstly introduced a microsimulation method in the social and financial fields. This work has been conceptually affecting the later microscopic method. However, the analysis was based on poorer capacity of computers and lower technique of database management at that time.

Troitzsch *et al.* (1996) summarized the state of the arts of microsimulation models in various approaches to simulation on the individual level in the social science field at that time. There were many microanalytical simulation models designed for policy implementation and evaluation, multilevel simulation methods designed for detecting emergent phenomena, dynamical game theory applications, cellular automata to explain the structure in social systems, and multi-agent models using the experience from distributed artificial intelligence. This means that various analytic methods have high potentiality to be investigated from the point of microscopic view.

Mitton *et al.* (2000) have suggested that microsimulation models use micro-data on persons (or households, or other micro-units) and simulate the effects of changes in policy on each of these units. Current policy issues require researchers to understand the interactions between policy and the complexities of economic and social life. Microsimulation is a technique that is employed to analyze these issues. At the same time, developments in computing power and analytical technique allowed a greater sophistication to analyze more complicated social issues. The land use and transportation and related policy measures also have complexities of economic and social affairs. Microsimulation is one of the useful techniques that are employed to analyze these issues.

However, these literalities have been focusing the only demographic, financial and social security issues. They never pay their attention to the issues of city planning, therefore spatial land use pattern and effective distribution of infrastructure or public facilities are not able to be discussed in their schemes.

UrbanSim is the most famous microscopic integrated land use and transportation model which has a lot of application cities, for example, Eugene-Springfield in Oregon, Salt Lake City in Utah etc. Waddle (2002) and Waddle *et al.* (2007) introduced UrbanSim as a software-based simulation model for integrated planning and analysis of urban development, incorporating the interactions between land use, transportation, and public policy. This is intended for use by Metropolitan Planning Organizations and others needing to interface existing travel models with new land use forecasting and analysis capabilities. Many applications for various policy measures are carried out and very precious examples are collected. Therefore, applicability of microscopic models to real policy measures should be reconsidered by using of the fruitful results.

ILUTE (Integrated Land Use, Transportation, and Environment) modeling system is also microsimulation model which is applied to the Greater Toronto area. Salvini *et al.* (2005) explains that this model is an integrated urban modeling system that consists of four inter-related components such as land development, location choice, activity/travel and auto ownership. But this model is not a fully operational model according to the developer. The fully operational model will be highly expected.

The residential location choice part of the IRPUD model (the Institute of Spatial Planning of the University of Dortmund) is based on a microsimulation method. Wegener *et al.* (1985) shows that the IRPUD model is a simulation model of mobility decisions in a metropolitan area. It receives its spatial dimension by the subdivision of the study area into zones connected with each other by transport networks containing the most important links of the public transport and road networks coded as an integrated, multimodal network including all past and future network changes. However, other part than residential location choice is not based on a microsimulation method. The consistency as a total model should be discussed from the point of view of applicability for real policy measures including whether on not the microscopic view point should be applied to other parts.

However, in Asian area, few microscopic integrated land use and transportation model has been developed according to Wegener (2003). Miyamoto *et al.* (1987) developed a disaggregate land use model but not a microscopic model. Hayashi *et al.* (1988) developed a forecasting method of population attributes by zone in a metropolitan area using random utility models. However, several decades have passed ever since these works, so that the issues to be treated have much changed. Yoshida *et al.* (2002), Igarashi *et al.* (2005) and Sugiki *et al.* (2005) respectively discussed an individual issue to be discussed about the microscopic model, but do not reach to the total system. This does not mean that there is no land use model in Asian areas. But, now, a new type of microscopic integrated land use and transportation model is required.

For the new type of microscopic model, relationship between features of a microscopic model and needs of real policy measures should be firstly discussed. The current paper focuses our attentions on its features for the applicability to real policy measures.

3. METHODOLOGY AND DATA

3.1 Flow of Simulation

Figure 1 shows a flow of simulation of this model. The system consists of 2 components. One is a demographic component and the other is a location choice one. The model is simulated on a hypothetical metropolitan area described later. The total population is the only 1 thousand for simplicity and shortening in calculation time. Each person belongs to a household. Households are divided into seven types according to each location choice pattern. The data of person, household and land condition are hypothetically determined but arranged similar to the real metropolitan area.

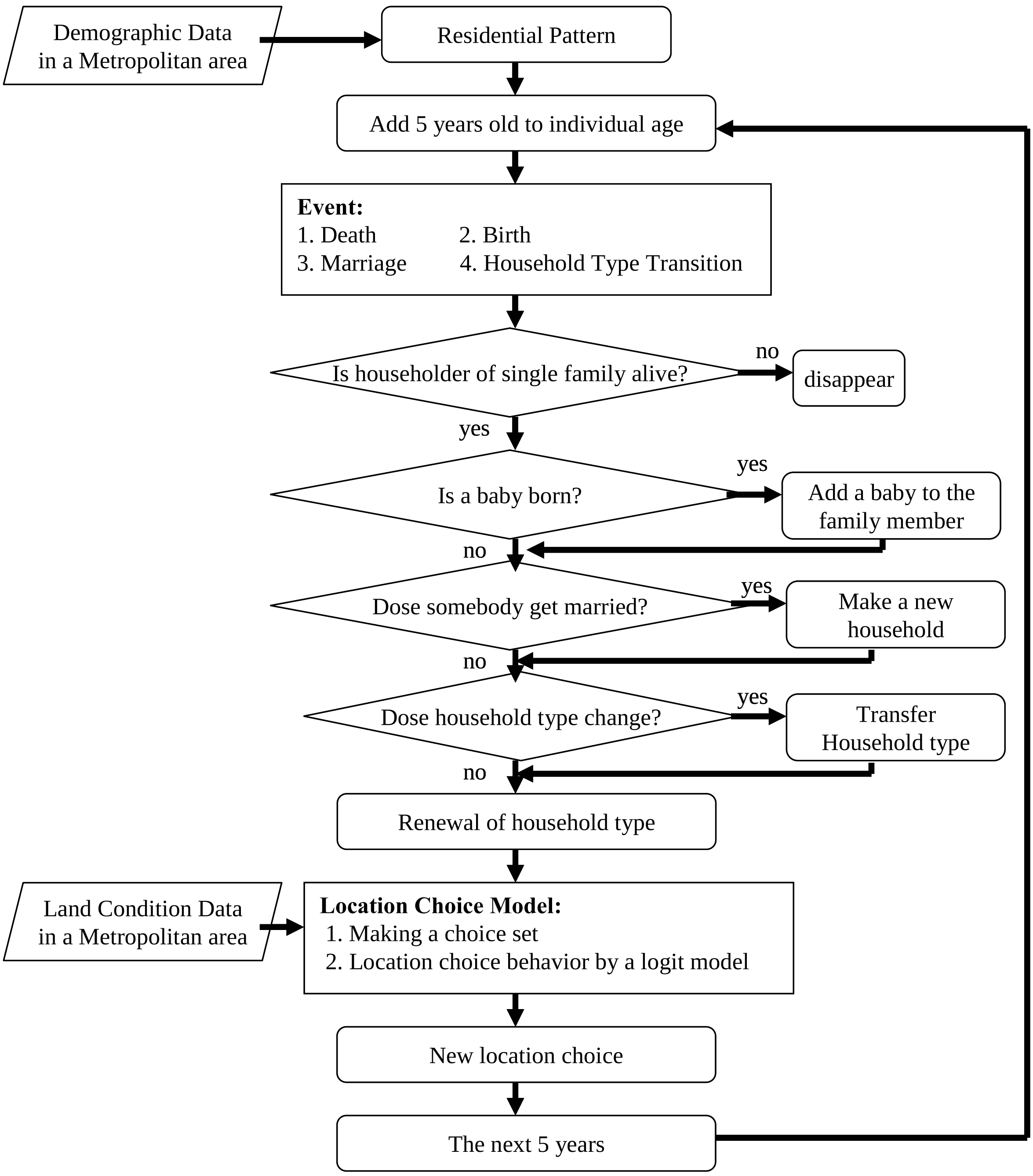

Figure 1 Flow chart of simulation

This research refers the Sapporo Metropolitan Area. Therefore, the share of gender and age of people and of types oh household and structure of metropolitan area similar to there. The referred data is the 4th Person Trip Survey and the accompanied location choice survey etc. held in 2006. Parameters of location choice model are estimated by using these data. Therefore, location choice behavior in this model represents real choice pattern.

3.2 Demographic Component

Interval of simulation is 5 years, and demographic components are calculated every 5 years.

At first, the system adds 5 years to age of each person. After that, this considers 4 events for person and household as follows;

- death
- birth
- marriage
- household type transition

Data of the crude death rates is given by cohort of 5 ages from the National Institute of Population and Social Security Research which reports the most reliable projected population and therefore provides the most reliable demographic data in Japan (see Appendix 1). Each person is forecasted alive or death each 5 years later according to these rates by the Monte-Carlo simulation method. If a householder is dead, the household will disappear in the case of single family and his/her partner, brother/sister or the eldest child will be a new householder in the other cases. Women from 15 to 49 years old can give birth to a child. Age-specific fertility rates are also given from the Institute and multiplied by each age-specific female population. If a household has a baby, the system adds a baby to the family after multiplied by gender rates. Marriage is also considered. A person from 15 to 60 years old who is not yet marred is target. Crude marriage rates per 1,000 populations are also given from the Institute by ages of groom or bride and multiplied by each age-specific male or female population respectively (see Appendix 2). A new family is separated from the existed households and makes a new household. Remarriage and divorce are not considered in this system. The system has 7 types of households for a location choice model (see Table 1). Time passing of 5 years makes transfer some households to a new type. This system forecast a certain type of household to each household each 5 years.

Table 1 Type of households

No.	Structure of Family
1	Single, young person (under 65 years old)
2	Single, elderly person (older than and equal to 65 years old)
3	Two, young persons
4	Two, one of them is elderly person
5	Two, both of them are elderly persons
6	More than two, all of them are young persons
7	More than two, at least one is an elderly person

3.3 Location Choice Component

After the renewal of household types, residential location choice by individual household is simulated. The model is based on equations (1) and (2). V_{in} is a utility function when n is located on grid i among the all grids A_I. The utility is a linear function of various variables

$\mathbf{X}_{in}$ including transportation and other land conditions. The choice behavior model is a simple MNL type. The probability when *n* is located on grid *i* is calculated by equation (2).

$$V_{in} = \boldsymbol{\beta}'\mathbf{X}_{in} = \sum_{k=1}^{K} \beta_k X_{ink}, \quad (i \in A_I) \tag{1}$$

$$P_{in} = \frac{exp(\lambda V_{in})}{\sum_{j \in A_I} exp(\lambda V_{jn})}, \quad (i, j \in A_I) \tag{2}$$

where,

V_{in} : *Utility Function when n is located on grid i*
β : *Parameter,* $\boldsymbol{\beta}$: *Vector of parameter*
X : *variable,* k : *number,* $\mathbf{X}$: *Vector of Variable*
A_I : *Grids*
P_{in} : *Probability when n is located on grid i*

The choice set is always composed of 25 grids described in section 3.4. The parameters are estimated by using real data of the 4th Person Trip Survey and the accompanied location choice survey etc. held in 2006. Table 2 shows the estimated results. In this table, railway 1, 2, 3 respectively mean individual railway line operated by the Hokkaido Railway Company, a private one since location choice behavior along each line is differently observed. There is one more railway service that is a subway network system and location choice behavior along this line is also differently observed. The road network consists of a toll road and non-toll road networks which are including an inner loop road and an outer one. The data of householder's working place are collected by the PT survey and land price data are collected the data base of the National Government Institutes.

Table 2 Estimated parameters for residential location choice

Variables	Type 1		Type 2		Type 3		Type 4	
	parameter	t-Value	parameter	t-Value	parameter	t-Value	parameter	t-Value
Dummy of CBD (=0)	4.328	10.331	11.175	7.319	2.993	8.442	34.566	5.617
Dummy of Center City (=0)	3.643	7.114	11.858	7.120	-6.892	-6.979	33.802	5.661
Dummy of Railway 1			-0.391	-2.417	0.174	2.663		
Dummy of Railway 2	0.144	2.568						
Dummy of Railway 3					0.355	3.871		
Dummy of Subway			-1.011	-2.306				
Dummy of Toll road			0.558	2.129	0.287	4.706		
Dummy of Inner Loop road			1.727	5.138				
Dummy of Outer Loop road			-0.631	-3.812	0.345	5.931		
Householder's Working Place	3.233	69.899			3.312	86.641	5.336	8.831
Average Land Price	-2.121E-04	-9.174	-2.545E-05	-2.986	1.170E-05	5.980	2.996E-06	0.346

Variables	Type 5		Type 6		Type 7	
	parameter	t-Value	parameter	t-Value	parameter	t-Value
Dummy of CBD (=0)	2.140	2.782	4.293	10.653	2.810	2.122
Dummy of Center City (=0)			3.963	8.787	3.053	2.113
Dummy of Railway 1			0.264	4.834	0.348	2.231
Dummy of Railway 2					-0.388	-2.888
Dummy of Railway 3			0.266	3.915		
Dummy of Subway					0.730	2.103
Dummy of Toll road	0.424	4.139	0.309	5.842	0.856	4.653
Dummy of Inner Loop road	0.394	2.678	-0.391	-5.100		
Dummy of Outer Loop road	0.352	3.968	0.425	9.320	0.825	4.977
Householder's Working Place			2.917	86.848	4.260	46.184
Average Land Price	1.391E-05	3.175	1.737E-05	7.620	8.015E-06	1.095

Almost of all parameters for variables are significantly estimated. These variables must significantly affect the choice behaviors and consequently present the processes and results of model simulations. In this paper, the model is applied to a hypothetical metropolitan city. The performances or effects by each variable are important but the goodness of fit of the model is relatively not focal point. The t-value of each variable is relatively important.

However, some t-values for average land price of zones are small. In this model, land price is such an important variable that it plays role of protecting over-demand to each grid. At each simulation step, demand in each grid is calculated and respond land price is also estimated. High demand leads to high land price which stabilize the concentration of residential demand. Therefore, each parameter of land price is used even though some t-values are low.

3.4 A Hypothetical City

Even though parameters are estimated from sample data of a real city, the Sapporo Metropolitan Area, simulation is carried out on a hypothetical metropolitan area. Because the simulation requires all of the data including family type, history of household etc. of each agent which may reach more than one million people.

The hypothetical city consists of 5 x 5 grids; each is assumed 10 km x 10 km. The system assumes that the center grid is the CBD, surrounding 8 grids are city area, for example the center city, and other outside 16 grids are satellite cities. Total population is 1 thousand for simplicity and distributed into each grid in proportion to the share of real residents. Transportation network is also hypothesized. Two loop roads are located around the center grid respectively and two rail way lines are located, one is from the north to the south part of the metropolitan area and the other extends to the east direction. Along these road and rail way network, more residents are located because of the high accessibility, so that populations there are more than other grids. As a result, population of the center grid is 85, one of each around grid is from 100 to 110, and one of each suburban grid is from 2 to 5 respectively. Figure 2 shows the basic residential pattern. This city is closed. Therefore, no one will be migrated from outside nor inside.

The base year is 2005. The system simulates 30 times from base year to 2025 during 20 years and calculates every 5 years. It takes longer than 2 hours to simulate 1 time by using a high end class personal computer.

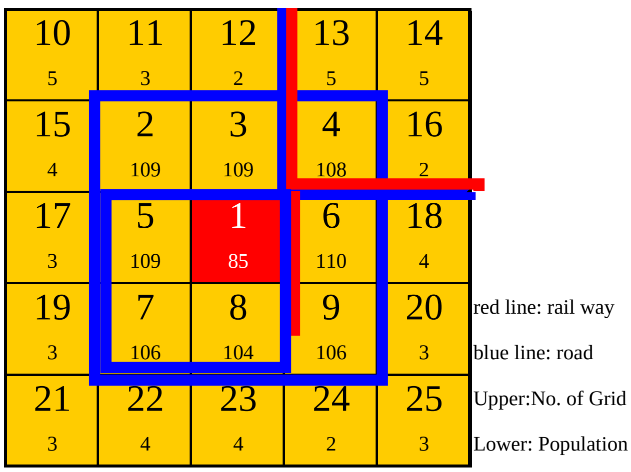

Figure 2 A basic residential pattern

4. RESULTS OF SIMULATIONS

Table 3 shows total population of the metropolitan area. Total population in the base year (2005) is 1 thousand and will increase to 1,021 at a peak in 2015 followed by decreasing after that. This trend of a total population from the macro point of view is similarly simulated each calculation time, but the value of standard increases as year passes.

Table 3 Results of simulation (total population)

	2005	2010	2015	2020	2025
Average	1,000	1,015	1,021	1,016	1,005
Standard	0.00	1.16	1.35	1.95	2.23
Max	1,000	1,017	1,023	1,020	1,008
Min	1,000	1,013	1,018	1,012	999

note: 2005 is the base year.

Figure 3 shows one of the results simulated which gives the average case. Figure 4 shows the result of the extreme case which gives the minimum total population.

Household type 3 and 6 which are consists of the only young persons move to CBD or the surrounding areas with high accessibility to railway networks, for example grid from No. 1 to 6, in 2010. On the other hand, in 2025, other types that consist of more than 2 persons move to the surrounding areas. The thing that should be mentioned, household type 5 that consists of two elderly persons will be located in CBD in 2025. This means that these elderly persons may tend to receive the health care service in urbanized area in future. More important thing is that household type 2 which consists of the only one elderly person dose never move to urbanized areas. The government will be required to care these elderly single persons. Household type 1 which is a single young person tends to move to areas with low land price both in 2010 and 2025.

The extreme case shows that the concentration to CBD will be severer even though the total population will be smaller than the average case. This means that the probability of severer congestion in CBD will be expected. The local government may be faced with the risk of lack of infrastructure. It should be required to monitor the balance between demand and supply of infrastructure more carefully.

2010

H	N	R	C	N	R	C	N	R	C	N	R	C	N	R	C
1	10	5	0.0	11	1	1.0	12	0	0.0	13	0	0.0	14	10	0.0
2	10	3	0.0	11	0	0.0	12	0	0.0	13	2	0.0	14	3	3.0
3	10	0	0.0	11	0	0.0	12	0	0.0	13	0	0.0	14	0	0.0
4	10	2	0.0	11	4	2.0	12	2	0.0	13	0	0.0	14	0	0.0
5	10	0	0.0	11	0	0.0	12	0	0.0	13	0	0.0	14	0	0.0
6	10	0	0.0	11	4	0.0	12	12	0.0	13	7	1.4	14	3	0.0
7	10	0	0.0	11	6	0.0	12	3	0.0	13	4	0.0	14	0	0.0
1	15	12	0.0	2	0	0.0	3	0	0.0	4	0	0.0	16	6	0.0
2	15	4	0.0	2	0	0.0	3	0	0.0	4	0	0.0	16	3	0.0
3	15	0	0.0	2	32	1.2	3	54	1.9	4	24	0.9	16	0	0.0
4	15	2	0.0	2	8	1.3	3	2	0.5	4	8	2.0	16	0	0.0
5	15	0	0.0	2	10	2.5	3	18	3.0	4	8	2.0	16	2	0.0
6	15	8	2.0	2	59	1.2	3	63	1.3	4	42	0.9	16	9	0.0
7	15	0	0.0	2	23	2.6	3	10	1.0	4	11	1.4	16	3	0.0
1	17	6	0.0	5	0	0.0	1	0	0.0	6	0	0.0	18	7	0.0
2	17	1	0.0	5	0	0.0	1	0	0.0	6	0	0.0	18	4	0.0
3	17	0	0.0	5	26	0.9	1	22	0.9	6	22	0.8	18	0	0.0
4	17	4	0.0	5	2	0.5	1	2	0.5	6	2	0.3	18	4	0.0
5	17	0	0.0	5	2	0.5	1	0	0.0	6	6	1.0	18	0	0.0
6	17	6	2.0	5	42	0.9	1	24	0.8	6	55	1.1	18	3	0.8
7	17	3	0.0	5	0	0.0	1	3	0.8	6	10	1.1	18	0	0.0
1	19	8	8.0	7	0	0.0	8	0	0.0	9	7	0.6	20	6	0.0
2	19	5	0.0	7	0	0.0	8	1	0.3	9	0	0.0	20	2	0.0
3	19	0	0.0	7	18	0.6	8	12	0.5	9	2	0.1	20	0	0.0
4	19	2	0.0	7	10	2.5	8	4	0.7	9	0	0.0	20	2	0.0
5	19	0	0.0	7	2	0.3	8	8	2.0	9	6	1.0	20	0	0.0
6	19	0	0.0	7	5	0.1	8	15	0.3	9	18	0.4	20	3	1.0
7	19	6	0.0	7	10	1.7	8	7	1.0	9	0	0.0	20	0	0.0
1	21	9	0.0	22	12	0.0	23	9	0.0	24	20	0.0	25	17	0.0
2	21	4	4.0	22	8	0.0	23	4	0.0	24	1	0.0	25	1	0.0
3	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
4	21	2	0.0	22	2	0.0	23	0	0.0	24	4	0.0	25	2	0.0
5	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
6	21	0	0.0	22	0	0.0	23	0	0.0	24	4	0.0	25	0	0.0
7	21	0	0.0	22	0	0.0	23	3	0.8	24	3	0.0	25	3	0.0

Total: 1,015

2025

H	N	R	C	N	R	C	N	R	C	N	R	C	N	R	C
1	10	7	0.7	11	1	0.5	12	0	0.0	13	1	1.0	14	13	1.2
2	10	2	1.0	11	4	4.0	12	0	0.0	13	2	1.0	14	8	1.6
3	10	0	0.0	11	0	0.0	12	0	0.0	13	0	0.0	14	0	0.0
4	10	2	1.0	11	0	0.0	12	0	0.0	13	0	0.0	14	2	0.5
5	10	0	0.0	11	0	0.0	12	0	0.0	13	0	0.0	14	2	0.0
6	10	4	1.0	11	4	0.5	12	0	0.0	13	8	1.3	14	3	0.6
7	10	5	0.3	11	13	0.6	12	12	0.9	13	0	0.0	14	6	0.0
1	15	10	1.3	2	1	0.0	3	0	0.0	4	0	0.0	16	7	0.6
2	15	6	2.0	2	0	0.0	3	0	0.0	4	4	0.0	16	10	5.0
3	15	0	0.0	2	18	0.9	3	28	1.1	4	12	0.8	16	0	0.0
4	15	2	0.0	2	10	1.0	3	10	0.8	4	14	0.0	16	0	0.0
5	15	2	0.0	2	16	1.6	3	24	0.9	4	16	0.7	16	2	1.0
6	15	0	0.0	2	20	0.4	3	31	0.7	4	16	1.1	16	0	0.0
7	15	7	1.8	2	31	3.9	3	53	1.8	4	39	6.5	16	5	1.0
1	17	11	0.8	5	0	0.0	1	0	0.0	6	0	0.0	18	11	2.2
2	17	9	1.8	5	1	0.0	1	0	0.0	6	1	0.0	18	10	1.3
3	17	0	0.0	5	22	1.4	1	14	0.9	6	18	0.6	18	0	0.0
4	17	2	1.0	5	4	0.7	1	4	0.0	6	2	0.3	18	0	0.0
5	17	2	0.0	5	14	1.4	1	10	0.8	6	14	1.4	18	2	1.0
6	17	0	0.0	5	16	1.1	1	0	0.0	6	0	0.0	18	0	0.0
7	17	0	0.0	5	9	0.6	1	11	1.6	6	0	0.0	18	0	0.0
1	19	13	1.2	7	0	0.0	8	0	0.0	9	8	1.3	20	7	0.9
2	19	6	0.7	7	2	0.0	8	1	1.0	9	2	0.0	20	6	1.0
3	19	0	0.0	7	2	0.1	8	6	0.5	9	6	3.0	20	0	0.0
4	19	0	0.0	7	10	2.5	8	2	0.3	9	0	0.0	20	2	0.0
5	19	0	0.0	7	10	0.8	8	4	0.3	9	8	2.0	20	4	0.0
6	19	0	0.0	7	13	0.0	8	0	0.0	9	11	0.0	20	0	0.0
7	19	7	0.0	7	21	3.5	8	6	0.5	9	0	0.0	20	7	2.3
1	21	6	0.4	22	13	0.9	23	12	0.9	24	25	1.1	25	11	1.0
2	21	11	0.6	22	17	1.9	23	15	1.7	24	2	2.0	25	2	1.0
3	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
4	21	0	0.0	22	2	1.0	23	2	0.0	24	8	1.3	25	2	0.5
5	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
6	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
7	21	6	0.6	22	3	0.0	23	0	0.0	24	23	2.3	25	0	0.0

Total: 1,005

Note: H: Number of household type, (see Table 1)
N: Grid number,
R: Number of residents,
C: Ratio of change

Figure 3 Results of simulation (average case)

2025

H	N	R	C	N	R	C	N	R	C	N	R	C	N	R	C
1	10	9	0.6	11	0	0.0	12	0	0.0	13	0	0.0	14	7	0.8
2	10	0	0.0	11	3	1.5	12	4	0.0	13	1	0.3	14	11	1.2
3	10	0	0.0	11	0	0.0	12	0	0.0	13	0	0.0	14	0	0.0
4	10	2	0.0	11	6	3.0	12	2	1.0	13	2	1.0	14	0	0.0
5	10	0	0.0	11	2	1.0	12	2	0.0	13	0	0.0	14	0	0.0
6	10	0	0.0	11	5	0.4	12	20	2.2	13	0	0.0	14	7	0.0
7	10	5	1.7	11	14	4.7	12	0	0.0	13	7	0.3	14	3	0.2
1	15	8	1.6	2	0	0.0	3	0	0.0	4	0	0.0	16	14	2.0
2	15	8	1.0	2	0	0.0	3	1	0.0	4	1	0.3	16	4	0.6
3	15	0	0.0	2	24	0.7	3	20	0.8	4	12	0.8	16	0	0.0
4	15	0	0.0	2	10	1.3	3	12	2.0	4	6	0.4	16	0	0.0
5	15	4	0.0	2	8	0.3	3	28	2.0	4	12	1.2	16	0	0.0
6	15	0	0.0	2	18	1.2	3	30	1.0	4	6	0.2	16	0	0.0
7	15	3	0.0	2	14	1.2	3	19	1.3	4	40	1.1	16	3	0.2
1	17	11	0.9	5	0	0.0	1	0	0.0	6	0	0.0	18	10	1.1
2	17	7	2.3	5	0	0.0	1	0	0.0	6	4	0.0	18	7	1.2
3	17	0	0.0	5	10	0.5	1	18	0.8	6	6	0.5	18	0	0.0
4	17	0	0.0	5	10	2.5	1	4	1.0	6	8	2.0	18	0	0.0
5	17	0	0.0	5	24	1.7	1	18	0.9	6	30	2.1	18	0	0.0
6	17	4	0.0	5	14	0.5	1	3	1.0	6	3	0.1	18	0	0.0
7	17	6	0.0	5	27	1.3	1	5	0.0	6	24	3.0	18	9	3.0
1	19	8	1.1	7	0	0.0	8	0	0.0	9	12	1.7	20	11	1.6
2	19	8	1.6	7	2	1.0	8	3	3.0	9	1	0.5	20	11	1.8
3	19	0	0.0	7	8	1.3	8	8	1.0	9	4	0.0	20	0	0.0
4	19	0	0.0	7	8	0.7	8	4	0.3	9	2	0.0	20	0	0.0
5	19	2	0.0	7	4	0.5	8	6	0.8	9	6	0.8	20	2	0.0
6	19	3	0.0	7	6	0.0	8	0	0.0	9	6	1.0	20	3	0.0
7	19	0	0.0	7	17	5.7	8	29	2.9	9	0	0.0	20	0	0.0
1	21	12	0.8	22	12	0.8	23	16	1.2	24	17	0.8	25	16	1.0
2	21	13	1.3	22	18	3.0	23	5	0.7	24	0	0.0	25	3	0.0
3	21	0	0.0	22	0	0.0	23	0	0.0	24	0	0.0	25	0	0.0
4	21	0	0.0	22	2	1.0	23	2	1.0	24	0	0.0	25	2	1.0
5	21	0	0.0	22	0	0.0	23	4	0.0	24	0	0.0	25	0	0.0
6	21	0	0.0	22	0	0.0	23	0	0.0	24	6	1.0	25	0	0.0
7	21	0	0.0	22	0	0.0	23	0	0.0	24	10	1.3	25	8	0.8

Total: 999

Note: H: Number of household type, (see Table 1)
N: Grid number,
R: Number of residents,
C: Ratio of change

Figure 4 Results of simulation (extreme case)

5. CONCLUDING REMARKS

The current paper develops a microscopic land use model on a hypothetical metropolitan area. The model consists of demographic and location choice components. Demographic components are developed from the point of microscopic view based on the change of individual person's attribute. Location choice components are developed based on the household types.

There are three important viewpoints. The first is a risk management as a policy measure. Microsimulation provides some possible land use patterns as well as the average land use pattern in a certain year. The impact of a policy measure will be estimated not only from the average point of view but also from the possible one. In this model, many different cases are simulated. The variety is the most important point of this research rather than the discussion about each case. Some extreme cases, for example concentration of regional demand on a grid, few demand along the railway system because of motorization and lack of health care services for elderly people inhabited outside of metropolitan area, give us caution. This is expected to contribute good risk management for urban planning.

The second is the discussion about the process of land use change. The many processes of land use changes are presented and they are very useful to discuss action plans of policy measure. The most possible land use patters in a certain future year may follow a process which is not based on available land use patterns. A good action plan is required to realize the possible land use pattern.

The last is visibility of land use patterns. Public involvement is currently popular when some of policy measures are discussed. The visibility is very useful for people to understand effects of policy measures, and therefore, is much required in the future. People can select the best policy among visible alternatives.

As a further study, validation and verification by asking the feedback opinions of the decision-makers of the technology firms should be investigated. We will carry out to collect the opinions when this model will be revised at the more realistic level.

ACKNOWLEDGMENT

This research has been funded by the Grant-in-Aid for Scientific Research (B) (No. 20360232) of the Ministry of Education, Culture, Sports, Science and Technology of Japan. The authors acknowledge this grant with deep gratitude.

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Appendix 1 Death rates

	male				Female			
Hokkaido Prefecture	2005-2010	2010-2015	2015-2020	2020-2025	2005-2010	2010-2015	2015-2020	2020-2025
Birth -> 0- 4	0.312%	0.284%	0.263%	0.245%	0.255%	0.231%	0.213%	0.199%
0- 4 -> 5- 9	0.134%	0.121%	0.111%	0.102%	0.103%	0.094%	0.085%	0.078%
5- 9 -> 10-14	0.070%	0.064%	0.059%	0.055%	0.053%	0.048%	0.044%	0.041%
10-14 -> 15-19	0.143%	0.134%	0.126%	0.119%	0.072%	0.067%	0.063%	0.059%
15-19 -> 20-24	0.313%	0.295%	0.279%	0.265%	0.132%	0.123%	0.115%	0.108%
20-24 -> 25-29	0.393%	0.371%	0.351%	0.333%	0.152%	0.142%	0.133%	0.126%
25-29 -> 30-34	0.439%	0.415%	0.394%	0.375%	0.174%	0.164%	0.154%	0.146%
30-34 -> 35-39	0.525%	0.499%	0.476%	0.455%	0.242%	0.227%	0.214%	0.204%
35-39 -> 40-44	0.722%	0.686%	0.655%	0.628%	0.365%	0.343%	0.325%	0.309%
40-44 -> 45-49	1.156%	1.103%	1.057%	1.016%	0.598%	0.563%	0.533%	0.506%
45-49 -> 50-54	1.875%	1.802%	1.739%	1.684%	0.937%	0.884%	0.838%	0.798%
50-54 -> 55-59	2.915%	2.807%	2.714%	2.634%	1.297%	1.222%	1.158%	1.103%
55-59 -> 60-64	4.323%	4.150%	4.003%	3.875%	1.803%	1.687%	1.589%	1.506%
60-64 -> 65-69	6.761%	6.482%	6.246%	6.043%	2.652%	2.469%	2.319%	2.193%
65-69 -> 70-74	10.379%	9.935%	9.562%	9.244%	4.281%	3.962%	3.699%	3.480%
70-74 -> 75-79	15.872%	15.194%	14.628%	14.151%	7.443%	6.873%	6.403%	6.010%
75-79 -> 80-84	25.203%	24.253%	23.462%	22.799%	13.455%	12.496%	11.706%	11.049%
80-84 -> 85-89	38.470%	37.374%	36.470%	35.722%	23.570%	22.171%	21.018%	20.061%
85- -> 90-	60.766%	60.168%	59.719%	59.392%	48.625%	47.591%	46.779%	46.149%

Source: the National Institute of Population and Social Security Research

Appendix 2 Marriage rates

(‰)

	Groom	Bride
Total	30.26	39.73
-19	2.01	4.86
20-24	22.60	37.35
25-29	69.30	98.80
30-34	61.54	74.50
35-39	36.29	37.71
40-44	17.23	13.00
45-49	8.83	5.37
50-54	4.62	2.05
55-59	2.54	1.24
60-64	1.53	0.88
65-69	0.71	0.41
70-	0.42	0.15

Source: the National Institute of Population
and Social Security Research