Evaluation of Residential Guided Area Setting Using Urban Household Micro-Simulation Model

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1. Introduction

In recent years Japan's declining birth rate, ageing population and population decrease has become serious problem. It's consequences on urban infrastructure is resulting in a degradation of urban functionalities and also an increased number of abandoned houses[1]. Under such circumstances, predicting the changes of future population distribution in scale of cities and regions to a detailed degree has become important task for evaluating urban policies. Therefore, in this study Urban Micro-Simulation model will be developed as a tool to forecast future population using only open data. In addition, urban policy evaluation measures will be taken for Toyohashi city by changing guided area of Location Optimization Plan of the city.

2. Basic Structure of Household Micro-Simulation

Household Micro-Simulation model is shown in Figure 1. This model consists of Initial Household Micro Data Estimation that generates household micro-data for initial year of simulation, followed by Urban Structure Prediction model which will be utilized as a forecasting model.

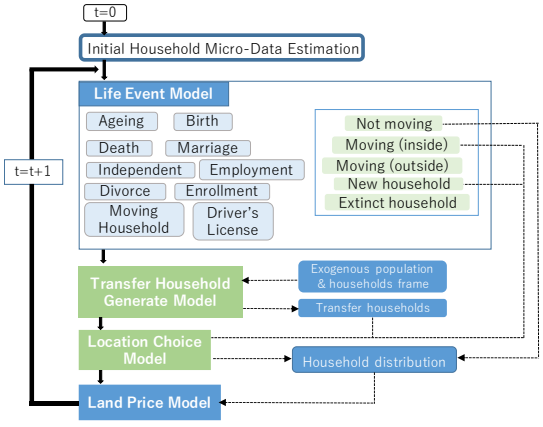

Figure 1. Urban Micro-Simulation Model

3. Study Area and Use Data

In this study, target study area will be Toyohashi city. For open data, Japan's National Census Data and National Land Numerical Information's open data from 2015 is used.

4. Urban structure prediction model

(1) Life Event Model

In this model, events that occur in people's life that have impact on how their transition will behave are considered. We have considered following event in our model: *Ageing, Mortality, Fertility, Marriage, Divorce, Driver's License Status, Employment and Enrolment, Relocating Households, Independence*. Additionally, individual's transition from their household due to marriage, divorce, independence, employment, enrolment events are also considered in this model.

(2) Transfer Household Generate Model

In this model, transferred households from outside the target area is generated. The population by gender and age and household number are calculated based on household size. On the other hand, the population and the household number in the period t+1 are given as exogenous frame data. The difference between the regional aggregation and exogenous frame is taken as the number of transferred people and household.

(3) Land Price Model

In this model, land price of each zone at the simulation time step t+1 is determined. Land price will be calculated using hedonic regression model (1).

$$LP_i = \sum_k \gamma_k X_{ki} + \delta D_i + c \qquad (1)$$

where: X_{ki} is the zone condition such as distance to the central station, D_i is population density.

(4) Location Choice Model

This model is divided into two section, namely house type choice model and zone choice model, determining how individuals and households relocating are going to choose their house type and zone at their destination.

a) House Type Choice Model

In this model we will consider choice set $H_n$contains 4 types of house to choose from which are $H_n = \{h = 1(own/detached),\ h = 2(own/apartment),\ h = 3(rent/detached),\ h = 4(rent/apartment)\}$. The choice probability (2) and utility function (3) are based on Multinomial Logit Model.

$$P_{hn} = \frac{e^{V_{hn}}}{\sum_{h \in H_n} e^{V_{hn}}} \quad , \quad (h \in H_n) \qquad (2)$$

$$V_{hn} = \sum_k \theta_{hk} x_{nk} + c \ , \qquad (3)$$

where: x_{nk} Household attribute (Household size, dummy variable for having child or not, household owner's age) and θ_{hk}, c: Model parameters. Parameter result is shown in Table 1.

Table 1. House Type Choice model parameter result

Variables	own/detached		own/apartment	
	parameter	t-value	parameter	t-value
Household size	0.351	6.99 **	-	-
Household head's age	0.011	6.10 **	-0.028	-5.86 **
Child existence	-	-	-	-
Choice characteristic dummy value	-0.675	-4.55 **	-0.718	-2.81 **

Variables	rent/detached		rent/apartment	
	parameter	t-value	parameter	t-value
Household size	-	-	-0.083	-1.45
Household head's age	-0.047	-8.42 **	-	-
Child existence	-	-	0.4948	4.86 **
Choice characteristic dummy value	-0.081	-0.31	-	-

** 1% significant

Keyword Household micro-simulation model, Residential guided area, Open data
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b) Zone Choice Model

In this model, individual's relocation residency zone will be determined. Zone choice probability (4) of each 4 house types and utility function (5) are calculated by Multinomial logit model. Parameter results are shown in Table 2.

$$P_{ihn} = \frac{e^{V_{ihn}}}{\Sigma_{i' \in Z_n} e^{V_{i'hn}}} \ , \tag{4}$$

$$V_{ihn} = \sum \alpha_{hk} X_{ik} + \gamma_h LP_i + c \ , \tag{5}$$

Table 2. Zone choice model parameter result

Variables	own/detached h=1		own/apartment h=2	
	parameter	t value	parameter	t value
Land Price	-0.162	-2.436 *	0.174	0.642
Distance from Toyohashi sta.	0.037	0.934	-0.516	-1.689
Land-use zone (medium-to-high-rise exclusive residential districts)	-		-	
Number of house type *h*	0.002	3.849 **	0.100	1.637
Residence guided zone	3.018	13.954 **	1.578	1.971 *
Likelihood ratio	0.555		0.989	

Variables	rent/detached h=3		rent/apartment h=4	
	parameter	t value	parameter	t value
Land Price	-0.084	-1.010	-0.076	-1.086
Distance from Toyohashi sta.	-0.091	-1.656	-0.112	-2.353 *
Land-use zone (medium-to-high-rise exclusive residential districts)	-		0.497	2.689 **
Number of house type *h*	0.052	6.559 **	0.000	0.599
Residence guided zone	1.610	6.363 **	2.440	11.652 **
Likelihood ratio	0.799		0.755	

**1% significant, *5% significant

5. Result of Urban Structure Prediction Model

Table 3 shows simulation result of each event's population rise and decrease for the first year of Urban Structure Prediction Model.

Table 3. Result of population change from Urban structure prediction model

Life Events	Population	Simulation result	
		Population rise	Population decrease
Ageing	374997	0	0
Mortality	371648	0	3349
Divorce	371279	0	369
Marriage	370792	186	673
Fertility	374158	3366	0
Employment & Enrolment	372628	0	1530
Driver's license	372628	0	0
Independence	371999	0	629
Relocation household	366520	0	5479
Relocation before transfer household	366193	0	327
Transfer household generate	373958	7765	0
Total *Fertility and Mortality is not considered		7951	9007

Table 4. Aichi prefecture population migration survey – Toyohashi city

Mortality	3407
Fertility	3272
Transfer inside	12051
Transfer outside	12081

Table 4 shows migration survey data of Toyohashi city. It can be seen that mortality event and fertility event simulation results are accurate, whereas transfer household number is bit off in number. Therefore, improvement of transfer household model is needed in future studies.

6. Policy Evaluation Measure

In order to plan sustainable urban development, Toyohashi city formulated location optimization plan. Zoning for urban policy in Toyohashi city is shown in Figure 2. For evaluation of urban policy, we will reduce the number of houses per mesh by 20% for grid cells outside of residential guided area. In our study, residential guided area is assumed as 1km distance from railway station inside the real residential guided area. Figure 3 shows the relocating population's difference between case 1 and case 2. Case 1 is taken as relocating population before implementing evaluation measure, case 2 is after implementing evaluation measure. It can be seen that, after implementing evaluation measure, relocating households and individuals are more inclined to move to central area of the city.

7. Conclusion

In this study, Household Micro-Simulation is developed utilizing models that predict future population and transitive behaviour of household or individuals. Simulation result of each event's in Urban structure prediction model is calculated and the population rise and decrease for the first year is shown. In addition, urban policy evaluation measure is taken by changing the number of households outside of residential guided area which formulated in location optimization plan of Toyohashi city.

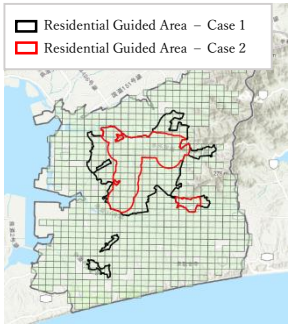

Figure 2. Zoning for urban policy in Toyohashi city

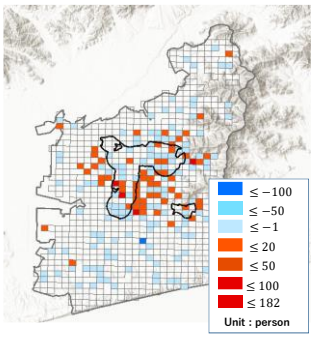

Figure 3. Relocating population difference between 2 cases

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