A STUDY OF MODELING HOUSEHOLD RESIDENTIAL LOCATION CHOICE BEHAVIOR FOCUSING ON AGGLOMERATION*

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1. Introduction

Understanding the factors influencing household location choice is critical for the development of integrated land-use transportation plans. However, the agglomerations resulting from social composition effects are difficult to fully characterize. Moreover, the effects of residents originating from locations either outside or within the same city may also be different. Therefore, this paper focuses on the design, specification, and empirical results of a discrete choice residential location model for the city of Kyoto with special emphasis on relocation within the city and the composition of neighborhoods.

Pioneering dynamic analyses of neighborhoods include Kasarda (1985), Wilson (1987), Massey (1990), Clark (1992), Waddell and Ulfarsson (2003), and Waddell (2005a, 2005b). Of these, Kasarda (1985) mentioned the decline of economic restructuring in manufacturing and other predominantly blue-collar industries while growth occurred in occupations associated with knowledge-intensive service-sector industries. Wilson (1987) attempted to examine the growing black underclass in America's inner cities. Massey (1990) argued that segregation and disassociation from other cultures and other ways of life is at the root of many problems facing African-Americans. Clark (1992) showed strong desires for own-race combinations in the ethnicity of neighborhoods. Waddell and Ulfarsson (2003) examined complex patterns of agglomeration and clustering of employment. Finally, Waddell (2005a, 2005b) developed an approach to facilitate the analysis of individual choices and the resulting neighborhood dynamics.

Although there is no racial segregation problem in Japan, the literature reviewed above provides an analytical perspective on neighborhood composition. The present research follows Waddell's pioneering works (2003, 2005a, 2005b) by focusing on intra-city relocation and neighborhood composition such as the agglomeration seen in Kyoto. The remainder of this paper is structured as follows. The discrete choice residential location model is described in the next section. Subsequently, the estimation data and the choice set are summarized. Model specification and empirical results appear in the following section. The final section offers conclusions and potential future research directions.

2. Review of the Discrete Choice Model

As the final step of spatial choice behavior, the residential location choice model generally simulates location choices for households predicted to move by the residential mobility model and the housing tenure choice model. All households that are moving are faced with a choice set of alternative locations. The probability of each alternative being chosen is calculated using a multinomial logit model drawing on discrete choice theory and the random utility maximizing models introduced by McFadden (1973, 1981, and 1984). Each location, denoted by *i*, is associated with some utility, U_i, for a household and the location with the highest utility is chosen. It is assumed that the utility of alternative *i* for a household can be separated into a systematic part and a random part:

$$U_i = u_i + \varepsilon_i \quad (1)$$

where $u_i=\beta_i x$ is a linear-in-parameters function, β_i is a vector of *k* estimable coefficients, *x* is a vector of *k* observed, exogenous, independent variables, and ε_i is an unobserved random error. The explanatory variables used in this study

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are summarized in Table 1.

The systematic component of the utility of location *i* is specified as a function of an array of characteristics of the following: individual (I_i), including age group, marital status, annual income of the head of household, and vehicle ownership; characteristics of type and tenure in the dwelling (H_i); multi-modal accessibility to the nearest station and workplace (A_i); and characteristics of mobility and number of children in the immediate neighborhood surrounding the location (N_i):

$$u_i = \alpha + \beta I_i + \delta H_i + \lambda A_i + \gamma N_i \tag{2}$$

Assuming the errors in Equation (1) are distributed with a Gumbel distribution (Type I extreme value distribution) leads to the familiar multinomial logit model:

$$P_i = \frac{e^{\beta_i \cdot x}}{\sum_{\forall i'} e^{\beta_i \cdot x}} \tag{3}$$

where P_i denotes the probability of the household choosing location alternative *i* for its next dwelling. The coefficients β_i are estimated using the maximum likelihood method.

Assuming that each household's choice is independent of other households, the probability of each household choosing the alternative it was actually observed to choose is expressed by Equation (4).

$$L(\beta) = \prod_{n=1}^{N} \prod_{i} (P_i)^{\delta_i} \tag{4}$$

where δ_i is 1 if the *i*th alternative (location) is chosen and 0 otherwise. The total number of households with no location is *N*. The log-likelihood function is then expressed by Equation (5).

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i} \delta_i \ln(P_i) \tag{5}$$

and the estimator is the value of β that maximizes this function (Train, 2003).

3. Data

The estimation data used in this study are derived from a survey conducted in Kyoto in 2007 to analyze household dwelling choice behaviors. The sample used in this analysis is comprised of 554 individuals for all explanatory variables. Each household is represented with the characteristics of individual, including age, marital status, annual income of householder, number of children, vehicle ownership, and movement profiles. Each dwelling occupied by households is represented with the characteristics, including housing type, ownership, and accessibility. Locations are represented based on the original school districts, which are basic statistic units in the city of Kyoto.

Seven districts are determined as the choice set of alternative locations as shown in Figure 1. That is: the Second Shugakuin original school district, Downtown including seven original school districts, the Second Saiin original school district, Katsurazaka original school district, Azuma Kawaoka original school district, Close to Highway including four original school districts, and Mukoujima area including three original school districts. There are three reasons for the formation of choice set. First, the survey used in this study only covers eighteen original school districts in city of Kyoto. Second, geographical considerations are incorporated, e.g., the seven original school districts included within Downtown area are aggregated as one choice, etc. Third, characteristics of each original school district are also considered as the factor for the formation of choice set.

4. Model Specification and Empirical Analysis

Given the estimation data, multinomial logit models were calculated for household residential location behavior

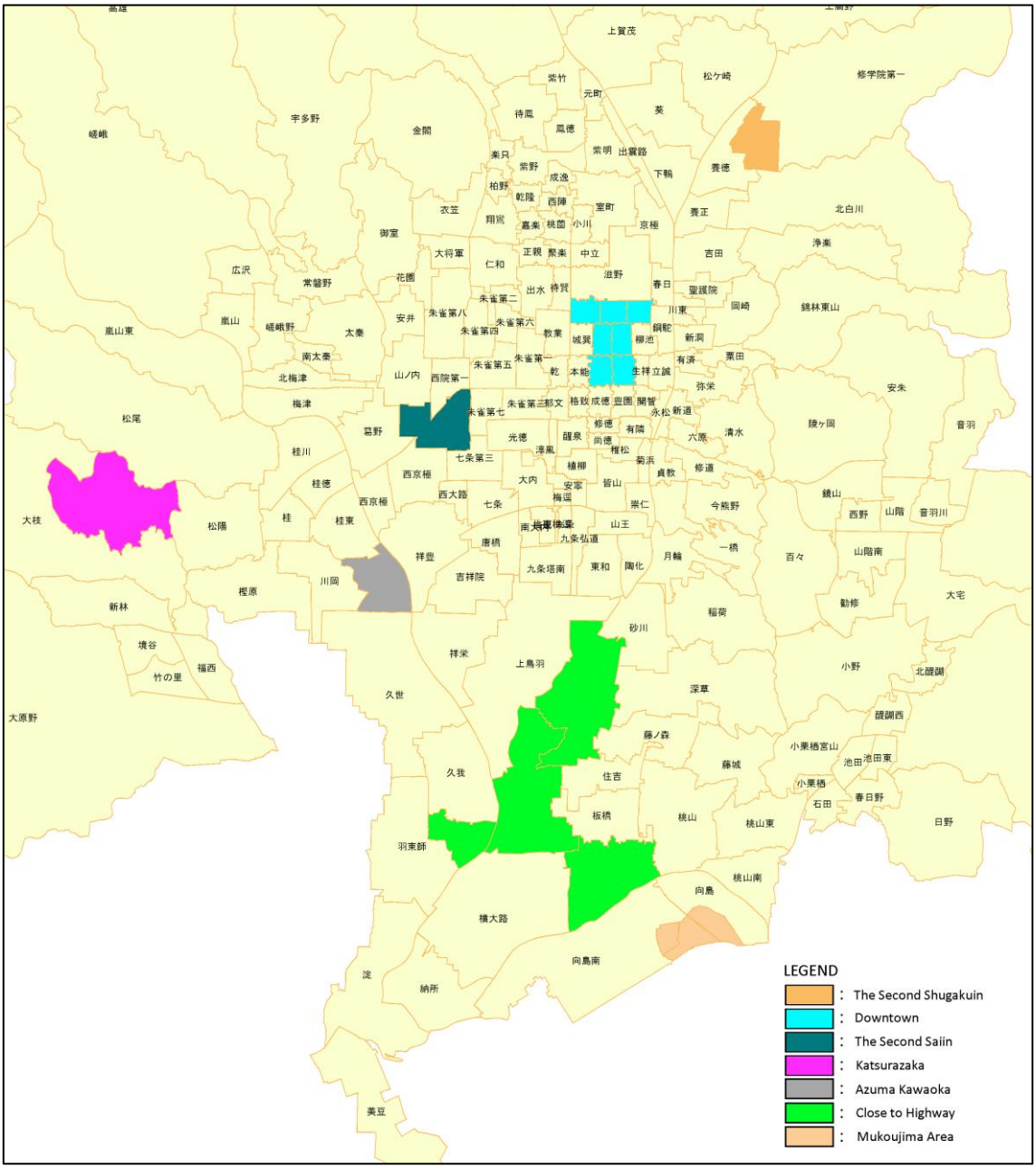

Figure 1: Choice set

with six alternative locations in addition to the chosen location. The statistical package R (version 2.9.2) was used to perform all of the analyses in this study. Model estimation results for the sample of 554 households that moved between 1936 and 2007 are given in Table 1. The coefficients are interpretable in terms of the direction of influence of a variable on the utility of a move and the probability of a location choice. Furthermore, the coefficients can be compared because the same specification was used for all alternatives, except for insignificant variables, which were restricted to zero.

Beginning with individual characteristics, it should be noted that the parameter *age between 18 and 22* shows a positive and significant effect for the representative utility of the Downtown. This result suggests that movers who are between 18 and 22 years old have a higher probability of choosing the downtown area than others. In addition, *marital status* is a positive and significant parameter in the utility function for the four original school districts Close to Highway. This result indicates that individuals with a spouse are more likely to choose locations close to the highway district. Turning to effects from annual income of the head of household, the parameter *300-700 million yen*, representing middle-class incomes, has a significant positive effect for the Azuma Kawaoka school district, which

Table 1: Estimation results for the household location choice model for the city of Kyoto

Models: 1. the Second Shugakuin 2. Downtown 3. the Second Saiin 4. Katsurazaka 5. Azuma Kawaoka 6. Close to Highway 7. Mukoujima area

Explanatory variable (Variable enters models in parentheses and is zero in other modes.)	Coefficient	t-statistic
Age between 18 and 22 dummy (2)	1.95	3.32
Marital status (6)	0.74	3.01
Annual income of head of household		
300-700 million yen (5)	0.81	2.06
>700 million yen (4)	1.29	3.65
Vehicle ownership		
0 auto (2)	0.81	2.80
2 autos (4)	1.52	4.07
Housing type		
3DK/LDK (7)	1.45	4.43
Housing tenure		
owner-occupied detached house (4)	1.44	3.10
owner-occupied condo (2)	0.63	2.12
renter-occupied dwelling (7)	1.98	5.57
Utility of travel to the nearest station		
<=5 minutes (2)	1.56	5.33
<=5 minutes (6)	0.62	2.69
Utility of travel to work		
<=15 minutes (5)	0.94	2.21
Mobility within the same ward dummy (1)	1.25	3.97
Mobility within the same ward dummy (6)	1.27	5.49
Has children dummy * Pct has children within the same school district		
>0.75 (4)	2.68	7.29
>0.75 (5)	2.96	7.03
>0.75 (7)	3.28	8.78
Likelihood ratio index		0.2989
Log likelihood at convergence		-755.8
Number of observations		554

implies that households with a middle-class income have a higher settlement rate in that district. In contrast, the pattern of coefficients for the variable *more than 700 million yen* indicates that individuals with high incomes are more likely to choose the Katsurazaka school district. The variable *0 auto* has a significant positive coefficient for the representative utility of the Downtown district, suggesting that individuals in households without a vehicle have higher settlement rates in the downtown area. This result may be because the downtown area has a convenient public transit system that makes private vehicle ownership less necessary. By contrast, the pattern of coefficients for the variable *2 autos* has a significant and positive association with the utility function for the Katsurazaka school district, indicating that individuals in a household with two vehicles have a higher probability of moving to this district.

Dwelling characteristics include housing type and ownership. The *3DK/LDK* parameter shows a positive and significant effect for the representative utility of the three original school districts within the Mukoujima area. This result suggests that individuals who hope to choose a 3DK/LDK swelling have a higher probability of moving to the Mukoujima area. When evaluating the effects on housing ownership, one can see the pattern of coefficients for the variable *owner-occupied detached house* has a significant positive association with the representative utility of the Katsurazaka school district, which indicates that households hoping to purchase an owner-occupied detached house prefer this district. Moreover, the variable *owner-occupied condo* has a significant and positive coefficient for the representative utility of the seven original school districts within the Downtown area. This result implies that households purchasing a condominium have a higher probability of moving to the downtown area. Furthermore, the pattern of coefficients for the variable *renter-occupied dwelling* shows a significant positive effect in the representative utility of the three original school districts in the Mukoujima area, suggesting that households that want

to rent a dwelling have a higher probability of considering the Mukoujima area.

Accessibility characteristics include utility of travel to the nearest station and work. The variable *less than 5 minutes* has significant and positive effects on the utility functions for both the downtown and the near-highway districts. This result suggests that households preferring better accessibility to the public transit system have higher entry rates for these two alternatives with the former having a greater magnitude for this effect. Recall that the pattern of coefficients for the variable *0 auto* shows a significant positive coefficient for the representative utility of the Downtown area. Therefore, it can be concluded that the seven original school districts in the Downtown area have high accessibility to the public transit system. Households generally prefer to reduce commuting costs to work with either private vehicles or mass transit. These preferences are operationalized in this study by employing a utility of travel to work. As shown in Table 1, the variable *less than 15 minutes* has a positive and significant coefficient for the representative utility of the Azuma Kawaoka school district.

Turning to the effects of prior residence locations, the pattern of coefficients for the variable *mobility within the same ward dummy* shows a significant positive effect for the representative utilities of the Second Shugakuin school district and the four school districts Close to Highway. This result implies that households living in the Sakyo ward, which includes the Second Shugakuin district, have a higher probability of re-locating to the Second Shugakuin school district. Similarly, households occupying a residence in the Fushima ward have a higher entry rate to the four original school districts close to the highway.

The interaction of a dummy for households with children and the percentage of households with children in the same original school district measures the degree to which neighborhood composition influences individual choice of residential location. The variable *more than 0.75* has a positive and significant coefficient for the representative utilities of the Katsurazaka, Azuma Kawaoka, and Mukoujima areas, suggesting that there are agglomeration effects for household with children among the original school districts of these three alternative locations.

5. Conclusions

This paper reports on the design, specification, and empirical results from a discrete choice residential location model for the city of Kyoto with a special emphasis on mobility within the city and the composition of neighborhoods. The household residential location choice model is a component of the proposed comprehensive residential household behavior system for implementation within a land use transport model (Li et al., 2009a, 2009b). Seven districts, based on existing school districts, were employed as the choice set of alternative locations. Estimation results confirm the significance of individual characteristics such as age, marital status, annual income, and vehicle ownership, as well as housing characteristics such as type and tenure, and accessibility characteristics such as travel to the nearest station and the workplace.

The estimation results presented in this paper have the following implications for land development choices in Kyoto regarding type and location of construction projects. Developers who tend to construct rental dwellings for college students should consider choosing the downtown area. In addition, developers who hope to construct dwellings for middle and high-income residents should choose the Azuma Kawaoka school district or the Katsurazaka school district, respectively. Dwelling developments in the downtown area could place unnecessary demands on parking spaces and garages. By contrast, developments in the Katsurazaka school district should consider constructing dwellings with space for parking garages. Furthermore, dwelling developers who tend to construct 3DK/LDK housing should consider choosing the Mukoujima area, which encompasses three school districts. Turning to housing ownership, detached house developers should choose the Katsurazaka school district; condo developers should choose the downtown area; and dwellings for renters should be considered in the Mukoujima area. Lastly, land developers who work in the Katsurazaka, Azuma Kawaoka, and Mukoujima areas should consider constructing facilities for children such as kindergartens.

This paper presented the agglomeration effects of households with children in city of Kyoto. Further development of the approach adopted in this study will explore other social neighborhood composition effects such as household incomes and dwelling prices.

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