Location Choice Model for Logistic Firms with Consideration of Spatial Effects

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ABSTRACT

This paper presents an overview of a location choice model for logistic firms; this model takes into account spatial effects. A modeling framework is developed to analyze decisions regarding location choice for logistic firms using mixed logit models. In this framework, spatial effects such as the correlation among firms in deterministic terms and the spatial correlation among zones in the error term are captured by mixed logit models. In addition, the dynamics of the consumption of commodities between consumers and suppliers is considered.

In a case study, the developed framework is applied to the Tokyo metropolitan area. The model is tested for retailers, wholesalers, and other manufacturers. The results of the study indicate that for choosing a location, the number of employees is a more important determinant for manufacturers than it is for retailers and product wholesalers. Additionally, the results indicate that the spatial effects and the land prices in a given zone strongly affect the decision-making process of all the firms in the metropolitan area.

Keywords: Mixed Logit, Spatial Choice Model, Logistic Firm Location Choice

1. INTRODUCTION

Understanding the factors that play a key role in the decisions that businesses make on where to locate is very important in order to determine the most effective mechanisms to attract business, and thereby maintain a healthy economy. Numerous studies have examined the relative significance of various factors in the process of selecting a business location by developing theoretical models to explain the different facets of the process (Ozmen-Ertekin et al., 2007). In practice, the choice of location is determined by a logistic firm, which follows a complex process to evaluate the trade-offs among different locations. The choice of location is generally influenced by factors such as the characteristics of the firm, the attributes of the zones being considered, and transportation accessibility. In addition, the interplay among logistic firms can be view as interactions in a space. In urban economics, related firms that gather together will gain benefits such as lower cost of production and a greater market share that one firm can achieve. A firm, while making a location choice decision, does not act in isolation; in contrast, firms are influenced by others who located nearby. Therefore, how the spatial effect on the firm location choice behavior should be considered carefully in the research process.

In recent years, there has been enormous progress in the field of disaggregate choice modeling. This development has also influenced research in the area of urban and regional science. It has been increasingly realized that many decisions made by consumers, firms, public agencies, and other similar entities involve complex choices based on a finite set of discrete spatial alternatives such as modes of transport, traffic routes, jobs, educational facilities, residential and work locations, recreation, industrial plant locations, etc. However, the use of mixed logit models for such location decisions by logistic firms in metropolitan areas has received less attention, and very few studies have been conducted in this field. In this study, the quantitative analysis aims to contribute to our understanding of the processes that influence location decisions.

The rest of this paper is organized as follows. The next section introduces the theories upon which models of firm location choice are based, and provides a basis for discrete choice models with structuralized spatial effects. It also describes the approach taken in this study, which uses a mixed logit model framework for location choice behavior in which the error term reflects the spatial correlation among zones and the deterministic term reflects the correlation among firms, given the fraction of consumption between firm and suppliers. Section 3 presents a simulation process that employs a maximum likelihood calibration procedure. Section 4 presents a case study based on data from the Tokyo Metropolitan Goods Movement Survey, the Establishment and Enterprise Census, and the Road Traffic Census. Discussion of the results is presented in Section 5, and Section 6 presents the conclusions and offers some recommendations.

2. LITERATURE REVIEW

2.1. Firm Location Choice Models

Stated preference experiments were introduced and conducted to investigate the impact of road transport and other factors in an ex ante process decision-making for the location of industries (Leitham, 1999). Kawamura (2001) argued that firms seek to locate close to freeway ramps and are moving further away from the central business district. He tested a series of regression models to assess firms' location patterns with respect to transportation facilities. His findings suggest that, controlling for exogenous factors, firms have moved closer to freeway ramps. This signals a decrease in the significance of other patterns upon which location prediction has been based, such as industry type, local economic activity, and the size of the establishment. Sridhar (2003), using an anecdotal survey of firms in India, indicated that infrastructure is an important determinant of firm location in the growth centers of India.

De Bok (2004) attempted to explain the location decisions of logistic firms by examining their mobility profiles and the accessibility of locations. His model is based on random utility theory and features systematic choice sets to account for the choice context at the highest level of spatial detail (address level). Firms are categorized according to their mobility profiles, which represent homogeneous groups of firms with similar mobility characteristics that are a priori assumed. The location attributes of alternative sites are allocated in relation to the type of business environment and the rental level.

Chin (2005) investigated the location decisions of foreign logistic firms with the aid of a multinomial logit model and identified factors that are crucial for attracting these firms to China. His results suggest that the location decisions of logistic firms depend on transport infrastructure, market size, labor quality and cost, agglomeration economies, communication cost, degree of economic privatization, and government incentives. Moreover, Clifton et al. (2006) specified and empirically tested a firm level model. The model indicated that the relationship between the propensity of a particular firm to relocate from its current business location as a function of local and regional accessibility, agglomeration economies, firm-specific characteristics, business attributes, attitudes towards regional considerations, and factors that influenced the firm's initial location decision. The findings of his research suggest a positive association between access to primary highway facilities and the level of economic activity. His results also confirm our expectation that roads with higher functional form and capacity are likely to more positively influence a firm's location decision.

Sridhar and Wan (2007) used a multinomial logit model to estimate whether capital cities in India, China, and Brazil are attractive for firms seeking to locate their operations. Their research found that labor regulations deter firms from locating in the larger cities in India and China, but not in Brazil. Exporters prefer to locate in large cities in India and China, but this was not true in the case of Brazil. Moreover, they found that in China, the size of a firm has no impact on its location decision, while in India, large firms prefer to locate in large cities, but not in mid-sized cities.

To measure the accessibility and economies of agglomeration, an individual firm's characteristics and business attributes are key determinants. In particular, a firm's characteristics such as number of employees, area occupied, and years in operation need to be specified in the conceptual structure of the model to be tested along with other activity attributes such as supply chains, industry classification, suppliers and worker types, customer bases, labor market environment, and the mode, route taken, and frequency of travel of customers. Additional determinants of a firms relocation decisions that cannot be factored into observed accessibility and agglomeration effects or firm-level attributes concern attitudes related to regional considerations.

In the research process, however, less attention has been given to the use of a mixed logit model in particular, and discrete choice models in general, in the analysis of spatial effects for the location choices of logistic companies.

2.2. Discrete Choice Models with Structuralized Spatial Effects

In the long history of the application of discrete choice models, enormous progress has been made in the field of disaggregate choice modeling with spatial effects. Boots and Kanaroglou (1988) incorporated the effect of spatial structure in discrete choice models of migration. Dubin (1995) developed a spatial binary logit model to predict the diffusion of a technological innovation. In Dubin's model, the probability of the adoption of a new technology varies depending upon a firm's own characteristics and its interactions with those who have previously adopted its technology. Paez and Suzuki (2001) tested the application of a spatial binary logit model to a land use problem related to the effects of transportation on changes in land use. Mohammadian and Kanaroglou (2003) expanded the binary choice model into a more general form to derive a spatial multinomial logit model, and tested it on a problem related to the choice of housing type.

Bhat (2004) proposed a mixed spatially correlated logit (MSCL) model for location-related choices. The MSCL model is a powerful approach that can capture both random variations in taste and spatial correlation in location choice analysis. The empirical results underscore the need to account for these variations and this spatial correlation, both to obtain an improved data fit and to realistically assess the effect of socio-demographic, transportation system, and land use changes on residential location choices. In addition, Miyamoto (2004) presented a discrete choice model with a systematic specification of the spatial influences upon the choice process. The utility function of this model is specified with autoregressive expressions for the deterministic and error component, and the model is evaluated with reference to three alternative models: the standard logit model, a logit model with an autoregressive deterministic term, and a mixed logit model with autoregressive error terms. Furthermore, Mohammadian and Kanaroglou (2005) attempted to incorporate spatial dependencies in random parameter discrete choice models. They formulated a mixed spatial multinomial logit model that incorporates spatial dependencies to predict the choice of type for new housing projects. Their results suggest that the choices in a housing project are influenced by factors related to other projects in adjacent zones, resulting in correlated choice behavior over space.

As described above, in previous research efforts, the debate focused on a model for residential location choice in urban areas. Very little research, however, has been conducted regarding a model for location choice for logistic firms using a discrete choice model with spatial effects. Therefore, the objective of this paper is to present a mixed logit model for the analysis of location choice behavior in order to better understand the key factors that influence the decisions made by logistic firms as to where they locate in metropolitan areas. Moreover, this model incorporates not just the correlation among zones in the error term, but also the correlation among firms in deterministic terms.

3. STUDY METHODOLOGY

3.1. Mixed Logit Model Framework for Behavior when Making Location Choice Decisions

Mixed logit is a highly flexible model which can approximate any random utility model (McFadden and Train, 2000). It obviates the three limitations of the standard logit model by allowing for random variations in taste, unrestricted substitution patterns, and the correlation of unobserved factors over time. Unlike probit, it is not restricted to normal distributions. Its derivation is straightforward, and the simulation of its choice probabilities is computationally simple. Based on Ben-Akiva et al. (2001), the utility of alternative *i* for a firm *n* takes a general form in the mixed logit model as follows.

The firm location choice is decided by a firm in nature. For a given individual firm *n*, *n* = 1, …., *N*, where *N* is the total number of firms, and an alternative *i*, *i* = 1,…., J_n, where J_n is the total number of alternatives in the choice set C_n of firm *n*. As usual, the utility function U_{ni} can be written as two terms: a deterministic term V_{ni} and a random term ε_{ni}.

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (1)$$

V_{ni} = the observed portion of the utility, which depends on the parameters β_n . If utility is linear in β_n, then $V_{ni}(\beta) = X_{ni}\beta_n$, in this case the equation (1) can be rewritten as follows:

$$U_{ni} = X_{ni}\beta_n + \varepsilon_{ni} \quad (2)$$

where

X_{ni} = a (1x *K*) vector of observed explanatory variables describing the characteristics of an individual firm *n* and alternative *i*, which could be size of firm, number of employees, attributes of the zones, socio-economic characteristics of the respondent, etc.;

β_n = a ($K \times 1$) vector of firm *n*'s tastes over the attributes of alternative *i*;

ε_{ni} = a random disturbance capturing firm *n*'s idiosyncratic and unobserved taste for alternative *i*;

where *j* indexes all possible alternatives in the individual firm's *n* choice set. Conditional on the utility parameters β_n, the probability that an individual firm *n* chooses an alternative *i* is computed by the standard logit formula:

$$L_{ni}(\beta_n) = \frac{\exp(X_{ni}\beta_n + \varepsilon_{ni})}{\sum_{j=1}^{J_n}\exp(X_{nj}\beta_n + \varepsilon_{nj})} \quad (3)$$

Since β_n is not given, the unconditional choice probability of the individual firm *n* choosing alternative *i* is obtained by integrating β_n over its population distribution, as shown below:

$$P_{ni}(\theta) = \int L_{ni}(\beta) f(\beta/\theta) d(\beta) \quad (4)$$

where

$f(\beta/\theta)$ = density of the distribution of β_n over the population;

θ = refers collectively to the parameters of the distribution (such as the mean and covariance of β).

3.2. Spatial Correlation among Zones in the Error Term

Autocorrelation refers to the similarity or dissimilarity of the values of the same variable associated in different intervals. Although this notion is better known in the field of time series analysis, the intervals (lags) may be of a temporal or spatial nature. It is quite natural for data observed in space to have similar values for adjacent spatial units (Cliff and Ord, 1973).

There are two important reasons to incorporate spatial dependence in a discrete choice model of firm location choice. First, in any case in which there is a large number of zones, it seems clear that individuals partition the choice set into clusters of zones. It is usually easier to identify clusters of zones in a spatial choice. Second, the availability of data on different spatial scales and in different spatial distributions may also create this kind of correlation across zones. If the data for different variables are not measured within the same boundary, then there will be a cross-zone correlation.

The spatial autoregressive term inserted into the disturbance term of the probit model has been successfully applied to housing choice behavior in the model of McMillen (1992). Moreover, Ben-Akiva et al. (2001) suggested the addition of a generalized autoregressive term to the disturbance term of mixed logit. The ε_{ni} random utility term is made up of two components: a probit-like component with a multivariate distribution and an i.i.d Gumbel random variable. This paper, therefore, utilizes the generalized autoregressive term to explain the spatial correlation among zones. The disturbance vector ε_{ni} can be expressed as:

$$\varepsilon_{ni} = F_{ni}\xi_{ni} + v_{ni} \tag{5}$$

where
ξ_{ni} = a $(M \times 1)$ vector of M multivariate distributed latent factors;
F_{ni} = a $(J_n \times M)$ matrix of the factor loadings that map the factors to the error vector;
v_{ni} = a $(J_n \times 1)$ vector of i.i.d Gumbel random variable.

It is desirable to specify these factors so that they are independent, so we therefore decompose ξ_{ni} as follows:

$$\xi_{ni} = T\varsigma_{ni} \tag{6}$$

where
ς_{ni} = a set of standard independent factors (often normally distributed);
T = the Cholesky factorization.

The number of factors, *M*, can be less than, equal to, or greater than the number of zones. To simplify the estimation, in this paper, we assume that the factors have a standard normal distribution. In fact, however, these factors can follow any number of different distributions such as lognormal, uniform, etc.

$$\varepsilon_{ni} = \rho W\varepsilon_{ni} + T\varsigma_{ni} \tag{7}$$

$$\varepsilon_{ni} - \rho W\varepsilon_{ni} = T\varsigma_{ni} \tag{8}$$

$$\varepsilon_{ni} = (I - \rho W)^{-1}T\varsigma_{ni} \tag{9}$$

$$\varepsilon_{ni} = F_{ni}T\varsigma_{ni} \quad \text{with} \quad F_{ni} = (I - \rho W)^{-1} \tag{10}$$

where
ε_{ni} = a disturbance term of mixed logit;
ρ = a scalar unknown parameter;
I = an $[J_n, J_n]$ identity matrix;
W = a $[J_n, J_n]$ weight matrix identifying the correlation among zones;
T = a lower triangular matrix of unknown parameters σ;

$TT' = Cov(\xi_{ni} = T\varsigma_{ni})$;

$$U_{ni} = X_{ni}\beta + F_{ni}T\varsigma_{ni} + v_{ni} \tag{11}$$

where
U_{ni} = a $[J_n \times 1]$ vector of utilities;
X_{ni} = a $[J_n \times K]$ matrix of explanatory variables;
β = a $[K \times 1]$ vector of unknown parameters;
F_{ni} = a $[J_n \times M]$ matrix of factor loadings, including fixed and/or unknown parameters;
T = a $[M \times M]$ lower triangular matrix of unknown parameters, where
$TT' = Cov(\xi_{ni} = T\varsigma_{ni})$;
ς_{ni} = a $[M \times 1]$ vector of i.i.d random variables with zero mean and unit variance;

v_{ni} = a $[J_n \times 1]$ vector of i.i.d. Gumbel random variables with zero zone parameter and scale equal to $(\mu > 0)$.

Many distance-based weighting functions have been proposed for use in the weights matrix. It is always assumed that the distance (or more precisely, the inter-centroid distance) from site *i* to site *j*, d_{ij}, is the same as the distance from site *j* to site *i*, d_{ij} [see Miaou and Sui (2004) for several specifications of the spatial weight matrix]. The inverse distance weighting function is utilized in this research.

$$w_{ij} = \frac{1}{d^{\gamma}{}_{ij}} \tag{12}$$

where

w_{ij} = an element of weight matrix *W*;

d_{ij} = a distance between zones *i* and *j*;

γ = an unknown parameter.

The probability of the choice of alternative *i* in the proposed model may be written as follows:

$$P_{ni} = \int_{\varsigma} \left[\frac{\exp[X_{ni}\beta + (I - \rho W)^{-1}{}_i T\varsigma_{ni}]}{\sum_{j \in J_n} \exp[X_{nj}\beta + (I - \rho W)^{-1}{}_j T\varsigma_{nj}]} \right] * f(\varsigma / I_{J_n}) d(\varsigma) \tag{13}$$

3.3. Correlations among Firms in Deterministic Terms

Mohammadian et al. (2005) incorporated spatial dependences in a mixed logit model to predict type choice for new housing projects. It was assumed that the systematic component of utility function (V_{ni}) consists of two terms. The first term is a linear parameter function that captures the observed attributes of decision-maker *n* and alternative *i*, while the second term captures spatial dependencies across decision-makers. The utility of alternative *i* for decision-maker *n* is given as follows:

$$U_{ni} = V_{ni} + \varepsilon_{ni} = (\sum \beta_i X_{ni} + \sum_{s=1}^{S} \rho_{nsi} y_{si}) + \varepsilon_{in} \tag{14}$$

where the parameters β_i make up a vector of parameters (to be estimated) corresponding to X_{ni}, the vector of observed characteristics of alternative *i*, and decision-maker *n*. Parameters ρ make up a matrix of coefficients that represent the influence that the choice of decision-maker *s* has on decision-maker *n* when choosing alternative *i*. *S* is the number of decision-makers who have an influence on *n*. This research, therefore, applies this concept in order to explain the interaction among firms. After adding the interactions, the systematic utility function of alternative *i* for firm *n* is given as follows:

$$V_{ni} = \sum_{k=1}^{K} \beta_{ik} x_{nik} + \lambda \sum_{s=1}^{S} y_{is} \frac{1}{d^{\delta}{}_{ns}} \tag{15}$$

where

β_{ik} = a parameter corresponding to the observed characteristics x_{nik} of alternative *i* and firm *n*;

λ = a scalar unknown parameter;

δ = a scalar unknown parameter;

d_{ns} = a distance between firm *n* and another firm *s*;
S = a total number of firms.

A firm is defined as a shipper when it generates commodities and as a customer when it receives them. Each logistic firm is assumed to choose its location according to the attractiveness of each zone. The sum of the fraction across all production zones for each customer's firm must equal one, and the fraction should satisfy the following constraints:

$$\sum y_{si} = 1 \text{ and } 0 \leq y_{si} \leq 1 \tag{16}$$

where
y_{si} = a fraction of commodity consumed by firm *s* from suppliers.

3.4. Simulation

A mixed logit model allows the use of simulation methods for estimation. θ is denoted as the vector of joint parameters of all the parameters that need to be estimated. The probability is approximated through the simulation of any given value of $\varsigma^r{}_n$. The average value of these probabilities yields the following simulated probability:

$$\hat{P}_{ni}(\theta) = \frac{1}{R}\sum_{r=1}^{R} L_{ni}(\beta^r) \tag{17}$$

where
R = a total number of draws;
$\hat{P}_{ni}$ = an unbiased estimator of P_{ni} by construction.

This simulated probability is an unbiased estimator whose variance decreases as the number of draws R increases. It is strictly positive so that $\ln \hat{P}_{ni}$ is defined, which is useful for approximating the log-likelihood function below. $\hat{P}_{ni}$ is smooth (twice differentiable) in the parameters θ and in the variables *x*, which facilitates numerical research for the maximum likelihood function and the calculation of elasticity (Train, 2003).

The simulated probabilities of a model that incorporates spatial correlation among firms in the deterministic term, and incorporates spatial correlation among zones in the error term, can be expressed as follows:

$$\hat{P}_{ni} = \frac{1}{R}\sum_{r=1}^{R} \frac{\exp[X_{ni}\beta + \phi_{ni} + (I-\rho W)^{-1}{}_i T\varsigma_{ni}]}{\sum_{j \in J_n} \exp[X_{nj}\beta + \phi_{nj} + (I-\rho W)^{-1}{}_j T\varsigma_{nj}]} \tag{18}$$

The parameters can be estimated by the maximum likelihood method. Because the true log likelihood cannot be calculated, the simulated maximum likelihood technique is used with the following formula:

$$SML(\theta) = \sum_{n=1}^{N} \sum_{i=1}^{J_n} y_{ni} \log \hat{P}_{ni}(\theta) \tag{19}$$

All estimations in this research were implemented using the GAUSS programming language. Bhat's Gauss code for a scrambled Halton sequence was modified and integrated into our maximum simulated likelihood estimation code.

4. DATA COLLECTION FOR CASE STUDY

The data set used in this case study was compiled from numerous sources such as the Establishment and Enterprise Census (EEC), the Road Traffic Census (RTC) survey, and the Tokyo Metropolitan Goods Movement Survey (TMGMS). These surveys are summarized as follows.

The Establishment and Enterprise Census (EEC) data provides information on all enterprises that operate in Japan, except for small firms with less than five employees and some particular types of industry. The survey is conducted by the Statistics Bureau in the Ministry of Public Management, Home Affairs, Posts and Telecommunications of the Japanese government. The survey is conducted every five years, and the data utilized in this study is from the year 2004. General information about firms is obtained from the EEC: type of industry, location, number of employees, head or branch office, capital, and other related factors. The total number of establishments for each industry type in each zone is collected from this data. In this research, the first variable (X_1) is the total population of each zone, and the second variable (X_2) is the total number of employees in each zone for each kind of industry.

The Road Traffic Census (RTC) survey is conducted for all of Japan by the Road Bureau of the Ministry of Land, Infrastructure and Transport of the Japanese government. The survey aims to characterize the usage of automobiles and quantify the volumes of traffic in Japan. The survey is usually conducted every five years, and the survey data utilized in this research is from 2005. The data consists of two parts: the link traffic volume and OD survey data. The OD survey data includes vehicle trips OD (passenger cars, buses, and trucks), commodity OD by commodity type, and other related criteria. In this research, the average distance among zones and firms was obtained from empirical data. Another source of data is from the basic land price survey which was conducted 2004. Hence, the third variable (X_3) is represents land prices in the Tokyo metropolitan area.

The Tokyo Metropolitan Goods Movement Survey (TMGMS) surveys were conducted in 2004 by the City and Regional Development Bureau of the Ministry of Land, Infrastructure and Transport of the Japanese government to measure the movement of goods and trucks in the Tokyo metropolitan area. TMGMS includes four surveys: Survey A on Firms' Characteristics, Survey B on Truck Behavior, Survey C on Goods Carried in and out, and Survey D on Firms' Locations. The characteristics of firms are, therefore, used in this paper. These characteristics include type of industry, location, number of employees, weight of shipments, and other related information. In this paper, the fourth variable (X_4) is the number of employees in each individual firm and the fifth variable (X_5) is the floor area of each individual firm.

5. RESULTS AND DISCUSSIONS

The study is based upon retailers, product wholesalers, and other manufacturers. The estimation of the model was performed using the Gauss programming language. The results of the estimated location choice models for logistic companies are presented in Table 1 and Table 2 (where some statistically insignificant variables are omitted). On the one hand, the models presented in Table 2 with the higher Log-likelihood at convergence than that in Table

1 is likely to be considered the better models. On the other hand, it can be seen clearly from the estimated results that the obtained Rho-square values between 0.20 and 0.40 in both Table 1 and Table 2 suggest a very good fit of these two models.

Moreover, these tables show the estimated coefficients and the associated robust t-statistics. The preference structure of each location choice behavior for each type of logistic firms can be derived from the estimated coefficients.

A zone's population size and number of employees have a statistically significant and positive effect on that zone being selected as a firm's location for other manufacturing firms from Table 1. This means that other manufacturing firms are more likely to locate in zones that have a high population density and a large employee pool. The reason for this is that the companies can reduce the cost of recruitment that is important cost for other manufacturers. Furthermore, the number of population of zones also is an important factor for retailers based on the statistically significant and reasonable sign of coefficients in Table 2. This is likely to be important to get close to the consumers of retailers.

From these results, it is clear that the land price coefficients have statistically significant and negative signs for all firms which belong to all type of industries in this research. This means that the land price has a significantly negative effect on a firm's decision to select a particular location in the case of other manufacturers, retailers and product wholesalers. The reason for this is that logistic firms like to locate in zones that have a lower land price in order to realize maximum profit. In addition, the land price variables are statistically significant for all firms in this model. Land price factor, therefore, is an important factor that keeps a key role in the location choice decision of all logistics firm.

A firm's number of employees maintains an important role in the location choice decision for other manufacturers. The reason for this is that the number of employees is one of the most important input factors for manufacturers. Manufacturers usually require many employees, and their salaries represent a large part of their total expenses. The role of this characteristic, however, is less important for retailers.

The spatial parameters are statistically significant in terms of the t-statistics with reasonable signs for all type of firms in Table 1 and Table 2. This means that the significant role of spatial interaction and spatial autocorrelation in the location choice decision behavior of logistic firms in the Tokyo Metropolitan area. The values of the correlation coefficients indicate the effectiveness of the firm location choice model when it incorporates the correlation among zones in the error term, and when it incorporates the correlation among firms in deterministic terms, given the distribution of consumption between firms and suppliers.

In order to get a better perspective on the results obtained in this research and our methodological approach, it is useful to compare them with those of some similar studies. For this purpose, we first considered the published paper by De Bok et al. (2004). In this study, we have focused more on the influences of the characteristics of firms, the attributes of zones, and the spatial effects on the logistic firm location choice behavior. The study of De Bok et al. (2004), however, focused mostly on the mobility profile, so no firm specific characteristics were added in the model. In addition, firm location choice in cities in paper by Sridhar et al. (2007), focused on the factors as the characteristics of firms, the attributes of cities and no consideration related with spatial effects are mentioned in his model.

Second, we can compare some of our results to the findings obtained in Ozmen-Ertekin et al. (2007) and Holguin-Veras et al. (2005). The results of our study and these studies concluded that the average land price has negative relationship with the likelihood of business location decisions. This means that the attractiveness of a given zone decreases with land price factor. In addition, Miyamoto et al. (2004) also concluded that spatial effects can be substantially accommodated by the structuralized specification of the utility function in the discrete choice model. The autoregressive expression used has been known and used in the econometrics for a long time, but so far has rarely been explored and employed for discrete choice modeling, in particular in the context of analyzing location choices.

6. CONCLUSIONS AND RECOMMENDATIONS

This study has highlighted the influence of spatial effects on the decision behavior of logistic firms for location choice. A mixed logit model was applied to a case study, whose results indicate that the location choice decision of logistic firms depends on the number of employees in a particular firm and the attributes of the zone such as the size of the population and the number of employees in the zone. The results suggest that logistic firms prefer to locate in zones that have a higher population and a higher number of employees.

Nonetheless, the main contribution of this study is its analysis of the processes that influence logistic firms' behavior for location choice. This clarifies the factors that play a key role in the decisions made by logistic companies in selecting a location. Our findings confirm the important role of structuralized spatial effects and zone attributes in the decision-making process of logistic firms. In addition, the statistically significant results obtained from this research suggest that, given sufficient data, the research methodology developed in this study can be successfully applied to cities other than Tokyo in order to gain insight into the determinants of the location patterns of logistic firms in particular, and businesses in general. Our results can also be applied to predictions of the effects of public policies on these location patterns. The results, therefore, should also be of interest to freight transportation and urban planners. Furthermore, it is understood that it is important to determine the effect of a spatial planning policy on a firm location.

In fact, the supply chain structure has emerged as a core component in the models of many logistic firms. Therefore, the influence of modern inventory controls and supply chain structures on the behavior governing location choice decisions is a related subject that merits future research. In addition, the present results can be valuable for further research into simulation modules for the location decisions for firms in an integrated land use and freight-transport modeling environment.

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LIST OF TABLES

TABLE1 Estimation Results for Other Manufacturer, Retailer and Product Wholesaler

Variables	**Other Manufacturer**		**Retailer**		**Product Wholesaler**	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Number of population of zones (in 10,000 persons) X_1	0.0145	4.78	0.0163	1.81	0.0056	1.25
Number of employee of zones (in 10,000 persons) X_2	0.0621	5.13	0.0079	4.83	0.062	3.74
Land price (1,000 yen/ m^2) X_3	-0.0063	-2.15	-0.0049	-4.29	-0.0071	-5.12
Number of employee of firms (in 10,000 persons) X_4	0.0440	3.82	0.0058	0.72	0.003	2.73
Floor area of firms (km^2) X_5	-0.0048	-2.33	-0.0013	-0.98	-0.0029	-0.51
Correlation among zones						
σ	2.438	4.95	1.415	6.65	1.252	2.48
ρ	3.265	5.28	1.39	4.53	2.94	4.57
γ	2.563	3.64	2.02	3.09	1.14	3.36
Correlation among firms						
λ	0.6571	5.97	0.42	6.90	0.37	4.86
δ	2.339	3.26	2.51	4.55	2.88	3.40
Log-likelihood at convergence	-2755.79		-2827.07		-2795.39	
Log-likelihood at zero	-3959.48		-3959.48		-3959.48	
Rho square	0.304		0.286		0.294	
Number of samples	1500		1500		1500	

Source: calculated by the authors.

TABLE 2 Estimation Results only with the Significant Variables

Variables	**Other Manufacturer**		**Retailer**		**Product Wholesaler**	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Number of population of zones (in 10,000 persons) X_1	0.0145	4.78	0.0542	3.04	Omitted*	
Number of employee of zones (in 10,000 persons) X_2	0.0621	5.13	0.0862	6.33	0.0890	5.94
Land price (1,000 yen/ m^2) X_3	-0.0063	-2.15	-0.0093	-4.96	-0.0085	-7.71
Number of employee of firms (in 10,000 persons) X_4	0.0440	3.82	Omitted*		0.0102	4.73
Floor area of firms (km^2) X_5	-0.0048	-2.33	Omitted*		Omitted*	
Correlation among zones						
σ	2.438	4.95	2.331	7.96	1.461	4.42
ρ	3.265	5.28	2.644	5.31	3.129	5.03
γ	2.563	3.34	2.834	4.39	1.375	2.31
Correlation among firms						
λ	0.6571	5.97	0.55	7.78	0.72	3.53
δ	2.3390	3.26	4.13	6.63	2.12	3.64
Log-likelihood at convergence	-2755.79		-2502.39		-2648.89	
Log-likelihood at zero	-3959.48		-3959.48		-3959.48	
Rho square	0.304		0.368		0.331	
Number of samples	1500		1500		1500	

Note: Omitted* is denoted as the case of omitting variable with its statistically insignificant coefficient.

Source: calculated by the authors.