MODELING LOGISTIC ENTERPRISE RE-LOCATION DECISION BY A NESTED LOGIT MODEL

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Abstract

This paper develops a model to analyze decisions regarding the relocation process for logistics enterprise by using nested logit model. In this framework, two decision points in the relocation process are assumed and maintained in the micro-simulation modeling. The first decision, move or non move and the second decision, choosing the destination location. This study applied the relocation decision structure of each logistics enterprise by nested logit model to find out the best model.

In case study, the logistics enterprise relocation decision model has acceptable performance by the nested logit model. However, the nested logit model has to follow the IID Gumbel distribution holds within each nest. Therefore, nested logit model cannot take into account the various tastes among alternatives in the random part of utility function to improve the implementation of the model.

The results indicate that big logistics enterprises have a lower probability of relocating and the migrating enterprises are more attractive in the zone which has a high accessibility. Finally, the population density, number of employees and the average land prices of zone strongly affect on the relocation decision making process of individual logistics enterprises.

Keywords: Logistics Enterprise, Re-location Decision Model, Nested Logit Model

JEL classification:

1. Introduction

Most logistics enterprises must constantly adjust themselves to new and changing circumstances to survive in a competitive business environment. Relocation of an individual logistics enterprise can be considered as a form of the adaptation (Brouwer et al. 2004). Pellenbarg *et al.* (2002) defined enterprise relocation as a change of address of an individual enterprise from this location to the other location. The factors influencing a logistics enterprise's propensity for moving are internal factors such as number of employee, floor area, transportation costs, and so on; external factors including the number of companies in market, population density..; and location factors such as average land price of location, distance between location and the IC highway. (see more, e.g. Van Dijk and Pellenbarg, 2000; Brouwer et al. 2002). This research, therefore, analyzes the influence of these factors on relocation decision behavior of logistics enterprise in order to better understand the key factors.

There have been a number of studies concerning the issue of relocation decision making behaviors of an individual firm or household, which is also discussed in these papers (see, e.g. Charles, 1979; Van Dijk et al. 2000; Leitham et al. 2000; Wissen, 2000; Brouwer et al. 2004; Holguín-Veras et al. 2005; Clifton et al. 2006; Ozmen-Ertekin et al. 2007; Xiang Cai. 2018; Alexiadis, S. 2020). However, very little research has been done concerning a model for individual logistics enterprise' relocation decision by means of a nested logit model. Therefore, the objective of this paper is to present a nested logit model to analyze logistics enterprise's relocation decision making behaviors in order to better understand the key factors that influence the decisions made by logistics enterprises as to where they relocate in metropolitan areas.

2. Literature review in Nested Logit Models

Waddell (1996) considered the interaction of workplace, residential mobility, tenure and location choices. In his research, the model is on the basis of the description of a household's location choice as a bundle of choices which consist of the decision to move, and the subsequent selection of a housing tenure and location. One motivation for the treatment of mobility and location choice as separate but linked choices is that he intends to model marginal changes in residential location as a function of changes over time in household characteristics and location characteristics, including such policy-relevant factors as accessibility and housing prices. His model is conceived as a dynamic adjustment to changing conditions, rather than as a cross-sectional static or equilibrium solution.

Zondag *et al.* (2005) analyzed the importance of accessibility in explaining residential relocation choice. They proposed the detailed structure of the housing market module which illustrated the various steps at the demand side of the housing market. First, a household makes a decision to move or to stay. Once, a household has a decision to move this household to enter the residential location choice module. The residential location choice module consists of a nested structure which includes the first level is a household chooses a region and the second level is a specific zone within a region. Their research results suggested that the significant role of accessibility but rather small compared to the effect of demographic factors, neighborhood amenities and dwelling attributes, in explaining residential location choices.

Holguín-Veras *et al.* (2005) placed their concentration on studying the problem of the business relocation and applied both the aggregate and disaggregate approaches taking account of the fundamental geographic models of business relocations, and an econometric investigation of the role of the transportation accessibility in the process of the business relocation. The disaggregate approach applied in their study is involved in the development of the multinomial logit (MNL) models representing the decision to choose an alternative among a set of the aggregated alternatives.

In the research process, however, less attention has been given to the use of a Nested logit model. 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 relocation choice for logistic firms using a Nested logit model. Therefore, the objective of this paper is to present a Nested logit model for the analysis of relocation choice behavior in order to better understand the key factors that influence the decisions made by logistic firms as to where they relocate in metropolitan areas.

3. Study Methodology

3.1. Conceptual Framework of Re-location Choice Models

In reality, the logistic enterprise or household relocation behavior decision process is very complex. This process has been separated into many steps from one more step up to seven steps in the many previous researches. Nevertheless, the most common relocation choice process has been chosen for this research. Therefore, the logistic enterprise relocation model of the proposed model is assumed to include two steps such as move/stay decision and location choice decision in this research.

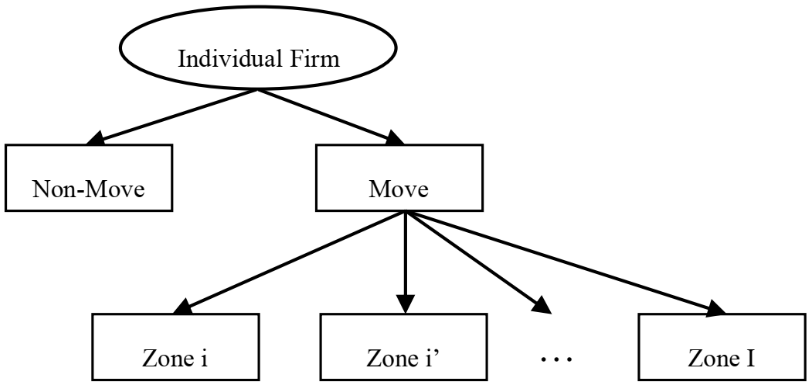
The relocation decision process is considered by the nested logit model. Firstly, the individual logistic enterprise makes a decision to move or to stay. One, an individual logistic enterprise has a decision to move this individual logistic enterprise to enter the zone choice decision.

3.2. Proposed Re-location Models Structure

This paper proposes the logistic enterprise process that consists of two levels, namely, (1) moving probability, and (2) location choice probability.

The proposed model structure can be drawn as the following chart which shows clearly in Figure 1.1. For each individual firm *n*, the relocation process is assumed to consist of two levels, namely (1) move/stay, and (2) zone choice decision.

Figure 1.1 Re-location Models Structure



The joint decision of firm n to move and to relocate to zone i is assumed to the product of the probability firm n that will move and the conditional probability that firm n chooses location i. The probability of relocation decision of individual firm can be expressed as follows:

$$P_n(i) = P_n(m) \times P_n(i/m)$$

Where,

$P_n(i)$ = probability firm n will relocate and choose zone i;

$P_n(m)$ = probability firm n will move;

$P_n(i/m)$ = probability that firm n chooses zone i after deciding to move;

n =1,…, N with N= the total number of firms.

3.3. Re-location Models by Nested Logit Model

In this study, the moving decision of each individual logistic enterprise and location choice are assumed to be two related steps of the individual firm relocation choice process that can be modeled jointly by using a nested logit (NL) structure. The two-tier nested structure of (Lee et al. 2010) for residential mobility and location choice has been utilized to explain the relocation decision of an individual logistic enterprise. Some notes are utilized in the structure of logistic enterprise relocation model by nested logit model.

The mathematical formulation of this model follows the utility maximizing NL model developed by McFadden (1974), as described by Koppelman and Wen (1998), but with an additional sampling correction procedure added to ensure consistent estimation of the model parameters using a subset of alternatives. The probability of an individual firm choosing zone i is defined as follows:

$$P^n{}_z = P^n{}_{z/m} P^n{}_m$$

Where,

$P^n{}_z$ = the probability of firm n will relocate and choose zone z;

$P^n{}_m$ = the marginal probability of an individual firm n choosing move;

$P^n{}_{z/m}$ = the conditional probability that firm n chooses zone z after decided to move;

n = 1,…, N with N= the total number of firms.

First level: the bottom level conditional choice probability is equivalent to the standard multinomial logit (MNL) equation (Lee et al. 2010) and has the form as follows:

$$P^n{}_{(z/m)} = \frac{\exp(\mu_z V^n{}_{z,m})}{\sum_{k=1}^{I} \exp(\mu_z V^n{}_{k,m})}$$

Where,

$V^{n}{}_{z,m}$ = the observable components of the utility function for each elemental alternative z;

μ_z = the associated scale parameter.

There is no correction that is needed here as it has been shown that the standard MNL form produces consistent estimates of the model parameters due to the IIA property when the simple random sampling strategy is used to draw a subset of zones (McFadden, 1978). In addition, the other researches also mentioned other sampling strategies which include independent importance sampling or stratified importance, different additional adjustment terms as described in Ben-Akiva and Lerman (1985) are needed to correct for sampling bias. The marginal choice probability of an individual firm for choosing move decision can be expressed as follows:

$$P^{n}{}_{m} = \frac{\exp(\mu_m V'_m)}{\sum_{m'}^{M} \exp(\mu_{m'} V'_{m'})}$$

Where,

V'_m = the logsum (or inclusive value) associated with moving nest m and μ_m is the top level scale parameter.

The logsum represents the expected value of the maximum of the random utilities of all zones in moving nest m (Lee et al. 2010*)*. In addition, the logsum equals the log of the denominator of the conditional probability multiplied by $1/\mu_z$ in a standard NL formulation with full enumeration of all variable zones. The logsum can be written as following formula.

$$V'_m = (1/\mu_z)\left\lfloor \sum_{z' \in Z_m} \exp(V_{z'}\mu_z) \right\rfloor$$

In this case where a subset of elemental alternatives at the bottom level was sampled from the universal choice set, the denominator of the conditional probability must be adjusted in the calculation of the logsum. The Slutsky theorem (Ben-Akiva and Lerman, 1985) which states that a continuous function of consistent estimates is also consistent, an expanded logsum may be used as a consistent estimate of the logsum derived from the full set of alternatives. The expanded logsum for a simple random sampling can be written as follows:

$$V'_m = (1/\mu_z)\left\lfloor \sum_{z' \in Z_m} \{(1/R)\exp(V_{z'}\mu_z)\} \right\rfloor$$

Where,

R = the sampling rate, $0 < R < 1$, which only applied to the sampled non-chosen alternatives.

Regarding with the two unknown parameters, μ_z, or μ_m, only one of them or the ratio between the two can be identified in the model estimation. It is a common practice to normalize one of the parameters to equal one and estimate the other (Ben-Akiva and Lerman 1985). Following the approach described in Koppelman and Wen (1998), μ_z is set to one here. In this case, μ_m must be between 0 and 1 as a condition of consistency. As the coefficient of the logsum, the parameter μ_m can be interpreted as an indicator of the hierarchical nature of the nesting structure. If the estimation of this parameter approaches 0, the decision process is considered to be strictly hierarchical. Whereas, if μ_m equals one, then the two choices are considered independent and the NL model decreases to a single-stage MNL model. In the case where there is only a single alternative in a nest, that nest is considered degenerate and μ_m equals one Lee et al. (2010). If there is only a single alternative in every nest of the individual firm relocation process structure, then the NL model of this structure also collapses to the MNL model of zone choice decision. In addition, the meaning of log-sum coefficients can be expressed as follows: (See more Ortuzar and Willumsen, 1994). If the value of log-sum coefficient is less than 0, an increase in the utility of an alternative in the nest, which should increase the value of expected maximum utility, would actually diminish the probability of selecting the nest. If the value of log-sum coefficient is equal to 0, such an increase would not affect the nest's probability of being selected, as an expected maximum utility would not affect the choice between move decision and non-move decision. If the value of log-sum coefficient is higher than 1, an increase in the utility function of an alternative in the nest would tend to increase not only its selection probability but also those of the rest of the option in the nest. Finally, if the value of log-sum coefficient is equal to 1, the hierarchical logit model becomes mathematically equivalent to the MNL. In such cases, it is more efficient to recalibrate the model as an MNL, as the latter has fewer parameters (Ortuzar and Willumsen, 1994).

4. Data Collection for Case Study

The input, output, and data source in each of the models are summarized in Table 1.1 in the case study of the proposed model. With regard to the data source of the move/stay decision, the distance from the current location of individual firm to the nearest IC highway and the average land price of current location were collected from the survey A and D of TMGMS. The number of employees of the firm and the floor area also was collected from the survey D of TMGMS. For the data source of the zone choice decision, the number of employees of the firm was collected from the survey D of TMGMS. The number of the population of a zone was collected from the population census of Japan. The number of firms of zone and the number of employees of the zone was collected from the establishment and the enterprise census (EEC). In addition, the accessibility of each zone was calculated based on the accessibility formula of Allen *et al*. based on the average travel distance of each zone which can get from the RTC. The average land price of a zone can be computed from the land price survey of Japan. The average distance between zones obtained from the empirical data is used as the zonal impedance variables in this research.

Table 1.1 Input, Output, and Data Source in Logistics Enterprise's Relocation Model

Model		*Input*	*Data source*	*Output*
Re-location Model	**Move/stay Probability**	- The number of employees of each firm. - The floor area of each firm - The land price of the current location of each firm. - The distance from the current location of each firm to the nearest IC Highway	Survey A and D of TMGMS	Probability of moving decision.
		- Dummy variables of destination characteristics	Survey D of TMGMS	
		- The weight of commodity per day and the travel distance from firm to customers - Transportation cost	Survey B of TMGMS	
	Zone Choice Probability	- Average land price of zone	Land price survey	Probability of a zone being selected.
		- Number of firms of zone	EEC	
		- Population number of a zone	PCJ	
		- Total area of zone	GIS	
		- Employees number of firm - Floor area of each firm	TMGMS	
		- Accessibility of each zone - Distance	RTC	

5. Results and Discussions

Table 1.2 shows the results of individual firm relocation decision by nested logit model. The nested logit model of individual firm mobility and location choice has a relatively parsimonious specification but it, nevertheless, includes the important exploratory variables that are expected to be an integral part of the individual firm relocation decision process. The model has an acceptable good fit based on the value of log-likelihood ratio and AIC test, which are shown at the end of Table 1.2 are 0.267, 0.176 and 0.149 for chemical manufacturers, machinery manufacturers and retailers, respectively. In addition, the model gives the same sign of the estimated parameters, each of which is as expected. For example, the average land price of each zone has a negative effect on the individual firm location choice decision as it's intuitive that an individual firm tends to locate in the zone with lower land price. Next, as we expected that the number of employees of each individual firm has negative sign. This means that the large firms or big firms have a lower mobility of re-locating.

Regarding with the logsum of nested logit model, the logsum value can be considered as the links between the two levels of the nested logit model by bringing information from the bottom level into the upper level. Therefore, the logsum coefficient reflects the degree of independence among the unobserved portions of utility for alternatives the moving nest. Note that the probability of choosing moving nest in the first level depends on the expected utility that the individual firm receives from choosing that nest. This expected utility is made up to the utility that an individual firm receives no matter which zone an individual firm chooses in the moving nest. The expected extra utility that an individual firm receives from being able to choose the best zone in the moving nest, which is the multiple between logsum value and logsum coefficient (see more, Wen, Chieh-Hua & Frank S. Koppelman.2001, Vovsha, Peter.1997, and Heiss, F. 2002, Matt Golder).

In this research, the log-sum coefficient showing a degree of independence in the unobserved parts of utility for alternatives in a nest, and the estimated logsum parameters of the move nest are 0.0455, 0.2592 and 0.3664 for chemical manufacturers, machinery manufacturers and retailers, respectively. Therefore, the low values of the log-sum coefficients mean that an increase would affect slightly on the probability of the move nest of being selected, as the expected maximum utility would affect slightly on the choice between move decision and non move decision.

Table 1.2 The Estimation Results of Logistics Enterprise Re-location Decision by Nested Logit Model

Variables	Chemical Manu	Machinery Manu	Retailers
	Coefficients (*t-value*)	Coefficients (*t-value*)	Coefficients (*t-value*)
Zone choice			
Average land price of zones (1,000 yen/ m^2)	-0.0042(-3.37)	-0.0085(-3.23)	-0.0029(-4.94)
Population density of zones (in 1,000 persons/ km^2)	0.0079 (2.30)	0.0023 (1.52)	0.0016 (1.28)
Number of employee of zones (in 1,000 persons)	0.0731 (2.01)	0.0402 (3.12)	0.0230 (0.76)
Distance (1,000 m)	-0.0006 (-1.72)	-0.0002 (-1.11)	-0.0017 (-1.15)
Number of employee of firms (in 1,000 persons)	-0.0734 (-0.85)	-0.0212 (-0.47)	Omitted*
Distance from firm to IC Highway (1,000 m)	0.0111 (2.40)	0.0047 (1.43)	0.0012 (0.69)
Move/stay choice			
ASC_move	-0.0793 (-3.62)	-0.2704 (-1.71)	-0.3119 (-1.42)
Land price of current location of firm (1,000 yen/m^2)	0.0016 (0.96)	0.0022 (1.45)	0.0036 (0.98)
Transportation Cost (10,000 yen)	0.0015 (1.37)	0.0013 (1.35)	0.0004 (0.82)
Firms need for large land (Yes =1, No =0)	0.0378 (0.83)	0.0118 (0.69)	0.0148 (0.41)
Firms need to be near to major customers (Yes =1, No =0)	0.0455 (1.07)	0.0816 (1.21)	0.0211 (0.97)
Firms need to be convenient for employees to commute (Yes=1, No = 0)	-0.0109 (-2.35)	-0.0106 (-1.24)	Omitted*
Firms need to be available for land to expand area (Yes =1, No =0)	0.5854 (0.89)	0.7054 (1.86)	0.0499 (1.31)
Firms have problems about loading and/or unloading (Yes =1, No =0)	0.1714 (1.59)	0.0943 (0.78)	0.0116 (0.47)
Firms have problems of parking space (Yes =1, No =0)	-0.6417 (-0.65)	-0.8595 (-1.23)	-0.0710 (-1.45)
Move nest logsum μ_m	0.0455 (3.62)	0.2592 (3.91)	0.3664 (2.06)
Number of observation	571	659	519
Log-likelihood at convergence	-1652.5	-2144.2	-1743.7
Log-likelihood at zero	-2256.1	-2603.8	-2050.6
Log likelihood ratio	0.267	0.176	0.149
AIC test	5.85	6.55	6.77

The estimation results of the nested logit model arrange in a line with those found in previous empirical studies (Lee et.al 2010). Number of employee, floor area, distance between the current location to the nearest IC highway, transportation cost and land price of current location of each individual firm, the demand to get a large land, need to be near to customers or major customers, need to be near IC highway, and need to be convenient for employees to commute, the pressures of many problems such as loading and unloading at road in front of firms, parking space were determined to be important individual firms' characteristics which helped to explain the individual firm's mobility and zone choice decision making process with the important attractiveness of zones. In general, large firms or big companies are less likely to move and change location than the small firms with high land price of current location and transportation cost.

Even though, the individual firm relocation decision model has acceptable performance by the nested logit model. However, the nested logit model has to follow the IID Gumbel distribution holds within each nest (Ben-Akiva et al. 1985). Therefore, nested logit model cannot take into account or considering the various tastes among alternatives (zones) in the random part of utility function to improve the implementation of the model. It means that the nested logit model has some disadvantages to deal with the incorporating spatial interactions among zones in the error part of utility function in the individual firm zone choice decision model.

6. Conclusions and Recommendations

This research has analyzed the relocation decision structure by using nested logit model. In this results, the t statistic values of most variables are acceptable in the nested logit model. However, the nested logit model has to follow the IID Gumbel holds within each nest (Ben-Akiva et al. 1985). Therefore, nested logit model cannot take into account the correlation among alternatives (zones) in the random part of utility function.

The future research must overcome the limitation of survey data which include a little information of the characteristics of individual firm, firm current location, previous location and attributes of zones, such as the age of firm, the age of building, the distance building to the nearest station, IC highway or previous location, land price of firm in building,… In addition, the present results can be valuable for further research into simulation modules for the relocation decisions for firms in an integrated land use and freight-transport modeling environment.

The firm relocation model consists of two decisions is very popular in the literature review. In fact, there are some structures of firm relocation models and each this structure corresponds with each different purpose of each individual firm. For example, the individual firm relocation structure consists of two decisions, three decisions, four decisions or five decisions. Therefore, the results of this research still open for the future researches which want to study on the individual firm relocation models. The obtained results still leave ample room for improvement because the present study is limited to a small data set for the estimation and common structures. It is expected that the better model performance will be achieved with an improved, larger set of data and specific structures. In addition, the influence of spatial effect on the location choice decisions by incorporating spatial effect on the deterministic part of utility function by nested logit model is a related subject in the future research.

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