ANALYZING INTER-REGIONAL TRAVEL MODE CHOICE BEHAVIOR WITH MULTI NESTED GENERALIZED EXTREME VALUE MODEL

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Abstract: Travelers inevitably make multi-modal route choices – a combination of modes making a trip. It is particularly important in the analysis of inter-regional travels, including access modes, trunk modes, egress modes etc. The paper focuses on the mode choice behavior in the entire trip covering each part of the trip. This paper also aims to give contributions to the evaluation of the policies aiming to more efficient and smooth transfer between travel modes. An advanced discrete choice model called "Multi-Nested GEV (MN-GEV) Model" is formulated to capture the correlations among the elements of the inter-modal travel behaviors. The stability of MN-GEV model parameters is also examined to show the capability of the model. It is applied for the inter-regional travel survey data of Japan and the estimation results are compared with other types of discrete choice models.

Key Words: *Multi-modal travel, Inter-regional trips, Multi-nested GEV model*

1. INTRODUCTION

1.1 Background

Since the construction of HSR started in Japan-the country has the most advanced HSR network- from last 60's, HSR and airplanes have always maintained a conflict relationship. HSR were able to compete with planes on destinations which were formerly only served by airlines. They were ascendant in a way that having a more positive impact on the environment and by using less fuel. Once it became clear that HSR could provide comparable trip times on middle- distance travel more efficiently than air, indifference gave way to action and the competition between them became real.

1.2 Objective

Evaluation of proposal to improve the competitiveness of HSR in the middle-distance trips requires the use of forecasting and policy analysis tools, for example, route choice model.

However, passengers more often tend to use a combination of modes in interregional trip. To carry on a study on an inter-regional trip, it is also necessary to consider the preceding/subsequent modes (access/egress modes) in the total trip.

A recent study by Coldren and Koppelman (2005) firstly employs "Multi-Nested Generalized Extreme-value Model (MN-GEV model)". This is called "Weighted Nested Logit Model" in other words as a tool evaluating the competition among air-travel itinerary shares of all East West markets in the United States and Canada in their paper. Bovy and Hoogendoorn-Lanser (2005) also chooses MN-GEV model as the tool to estimate the result of intercity train service within the Rotterdam-Dordrecht region in The Netherlands.

Contrary to these previous works, this paper aims to give contributions to the evaluation of the policies which aiming to the "seamless" between travel modes by using MN-GEV model. Here, "Seamless" means more efficient and smooth in the transfer between access and trunk modes, or trunk and egress modes. This paper intends to apply an advanced MN-GEV model to a new area, and make a comparison of the estimation results with other GEV-type models.

1.3 Structure of the paper

This paper first makes review of travel mode choice models for inter-regional trips, and extended discrete choice models in the GEV family and the adopted MN-GEV model. Chapter 2 presents a brief literature review and shows the adopted modeling methodology. A stability analysis is executed to test the performance and the capability of MN-GEV model in Chapter 3. Adopted data from National Corridor Trips Survey of Japan in 2000 and the format of alternatives and choice sets in the model will be talked in Chapter 4. Finally, Chapter 5 briefly discusses the model estimations and their results.

2. ADOPTED MODELLING METHODOLOGY

2.1 Travel Mode Choice Models for Inter-Regional Trips

Passengers more often tend to use a combination of modes in an inter-regional trip, which can be also called an inter-modal trip. It could be roughly divided into 3 parts: home-end part (access mode), main part (trunk mode), and activity-end part (egress mode).

For many years' studies, route choice models could be described into two categories with regard to whether they comes from Generalized Extreme Value (GEV) theory or not.

GEV model has been derived from the random utility model pioneered by McFadden (1978). It constitutes a large class of models that show a variety of substitution patterns, including Multinomial Logit (MNL), Nested Logit (NL), Cross-Nested Logit (CNL), Paired Combinatorial Logit (PCL), General Nested Logit (GNL), Network GEV, C-Logit, Path- Size Logit (PS-Logit) models etc. Ben-Akiva and Bierlarie (1999) and Bierlaire (2006) present the detailed review of these models.

The most distinct advantage of GEV models is that the choice probabilities usually take a closed form so that they can be estimated without resorting to simulation. But as well, they have the limitations in other aspects: they cannot represent random taste variation; they cannot be used with panel data when unobserved factors are correlated over time for each decision maker. On the other hand, the representatives of Non-GEV model are Probit model and Mixed model (e.g. Train 2003).

2.2 Outline of the MN-GEV Model

MN-GEV model is a special case of GNL model. And, it is an extension of usual 2-level nested logit models (Figure 1).

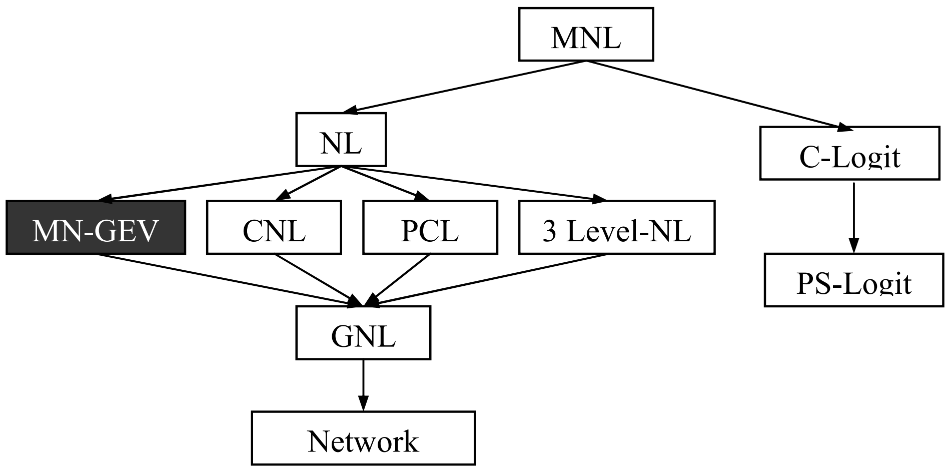

Figure 1 Relationships among GEV-type Discrete Choice Models

As MN-GEV Model is also called "Weighted nested-logit model (Coldren and Koppelman 2005)", its representation is a weighted sum of multiple NL models in which each NL model represents a distinct choice dimension. For a model with two dimensions the mixing distribution can therefore be written as:

$$P_i = \alpha_1 P_{i,d1} + \alpha_2 P_{i,d2} \tag{1}$$

where P_i : probability of the alternative i being chosen,

$P_{i,dn}$: probability of the alternative i being chosen along dimension n (takes the same form as the choice probability functions of Nested Logit models), and

α_d : weight for dimension d, which can be fixed, estimated or defined as a function of the logsum parameters. ($\sum \alpha_d = 1$ and $0 \le \alpha_d \le 1$).

One of the advantages of the MN-GEV model is that the network representation allows to intuitively capturing complex correlation structures of actual modeling situations (Daly and Bierlaire 2006).

Figure 2 shows a simple example of MN-GEV model structure. It also allows differences in correlation along multiple choice dimensions. In many cases, it's necessary to allocate same factors in the nest trees, causing complex correlation which could not be captured properly by other GEV models. MN-GEV models will provide a more proper estimation result in those situations.

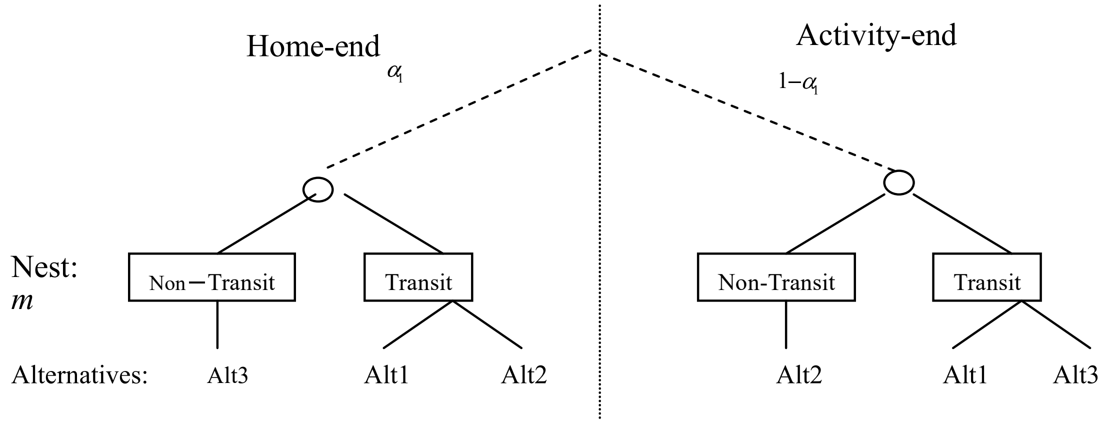

Figure 2 A simple MN-GEV model with 2-dimensional structure
(Source: Bovy and Hoogendoorn-Lanser 2005)

3. STABILITY ANALYSIS OF THE MN-GEV MODEL

3.1 Analytical Strategy

Before applying MN-GEV model into practical study, it's necessary to confirm whether the model will work well. Stability of the model is one of the important indices in the criteria. To check the stability of MN-GEV model is one key to judge the performance of the model. However, there's no previous study for the stability analysis of MN-GEV model. This chapter will simply talk about a primary analysis of the stability of MN-GEV model. As shown in Figure 3, a simple structure with 2-dimension and 2-level is tested here.

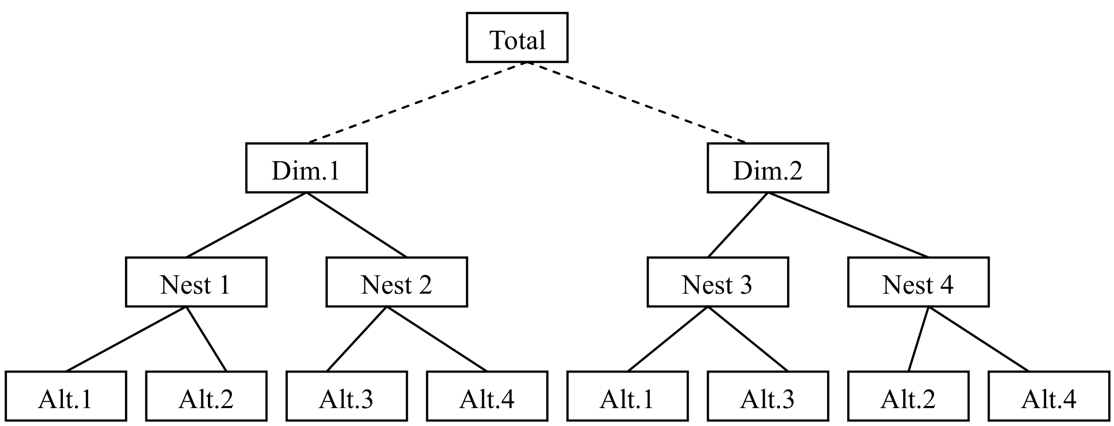

Figure 3 A simple structure for 2-dimension, 2-level MN-GEV model

As we already know, the utility function for models in GEV family can be written as:

$$U_{ni} = V_{ni} + \varepsilon_{ni} + \ln G_i \tag{2}$$

where G_i is the first derivative of GEV function, V_{ni} is the systematic component of the utility function such that $V_{ni} = a_i + bx_i$, a_i and b are the unknown parameters, and x_i is a single explanatory variable.

It is easy to get the GEV function for MN-GEV model because we already know that for GNL model structures (Wen and Koppelman 2001). As MN-GEV model is a special case of GNL model, we can generate the GEV function for MN-GEV model as:

$$G = \sum_{d \in D} [\alpha_d \sum_{k \in d} (\sum_{j \in B_k} Y_j^{1/\lambda_k})^{\lambda_k}] \tag{3}$$

where α_d is the weight parameter of the dimension, and λ_k is the nest parameter.

There are two important kinds of parameters in this model: nest parameter (logsum parameter) and weight parameter. Therefore, the strategy set to conduct the stability study is mainly considering about these two parameters.

3.2 Procedure of the Simulation Study

The steps for the analysis according to the strategy are set to 5 phases:

1) Set the coefficient of allocation parameter α and nest parameter λ
2) Generate set of x, which is distributed with normal standard distribution
3) Generate set of ε, which is distributed with Gumbel standard distribution
4) Calculate U's and find the choice results
5) Estimate α or λ through the choice result, and compare with the original value to make the sum-up.

A dataset with 500 observations is set in the Monte Carlo study. 20 simulation runs are carried out for checking the estimation results, which means that the step2-5 will be repeated for 20 times with one setting of α or λ.

The artificial data set here include $a_i = 5$ (the constants specific to the alternative i), x_i (variable), $b = 1$ (the coefficient of these variables) and ε_i (error term within each alternative i respectively). Where x_i is content with normal standard distribution and ε_i is standard Gumbel distributed. And another error term can be expressed as:

$$\ln G_i = \ln \sum_{d \in D} [\alpha_d \sum_{k \in d} (\sum_{j \in B_k} Y_j^{1/\lambda_k})^{\lambda_k - 1} \cdot Y_i^{1/\lambda_k - 1}] \tag{4}$$

The setting of logsum parameters and weight parameters will be talked in next section.

Also, the true values of the systematic component of utility functions are set as follows:

$$\begin{cases} a_1 = 1 \\ a_2 = 2 \\ a_3 = 3 \\ b = 1 \end{cases} \tag{5}$$

Finally, for the settings, the choice probability is given by the following formula:

$$P_i = \frac{\exp\left(V_i + \ln G_i\right)}{\sum\left[\exp\left(V_j + \ln G_j\right)\right]} \tag{6}$$

3.3 Simulation Results

Firstly, the logsum parameters are randomly fixed as different four patterns of correlation structures. They are: (1) $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.5$, (2) $\lambda_1 = 0.1, \lambda_2 = 0.9, \lambda_3 = 0.2, \lambda_4 = 0.8$ (3) $\lambda_1 = 0.8, \lambda_2 = 0.9, \lambda_3 = 0.1, \lambda_4 = 0.2$, and (4) $\lambda_1 = 0.1, \lambda_2 = 0.2, \lambda_3 = 0.8, \lambda_4 = 0.9$. The 16 combinations of these four nest patterns and the four patterns of the weight parameter α (0.05, 0.1, 0.3, 0.5) are examined. The estimation results of all these sixteen settings are conducted with 20 trials for each. All estimation were carried out using the software "BIOGEME (Bierlaire, 2003)". The average of each parameter estimate is shown in Table 1.

Table 1 Averages of Estimated Parameters for 16 Settings

(a) Same level of independence in each nest of both dimension				
True value	$\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.5$			
	$\alpha_1 = 0.05$	$\alpha_1 = 0.1$	$\alpha_1 = 0.3$	$\alpha_1 = 0.5$
α_1	0.284	0.323	0.47	0.617
λ_1	0.782	0.705	0.639	0.648
λ_2	0.81	0.723	0.634	0.586
λ_3	0.479	0.454	0.497	0.515
λ_4	0.154	0.173	0.22	0.18
a_1	2.112	2.121	2.184	2.109
a_2	4.078	4.068	4.187	4.164
a_3	5.988	5.974	6.12	6.104
b	1.96	1.952	1.982	1.998
(b) High independence and low independence in each dimension respectively				
True value	$\lambda_1 = 0.1, \lambda_2 = 0.9, \lambda_3 = 0.2, \lambda_4 = 0.8$			
	$\alpha_1 = 0.05$	$\alpha_1 = 0.1$	$\alpha_1 = 0.3$	$\alpha_1 = 0.5$
α_1	0.311	0.262	0.382	0.578
λ_1	0.437	0.411	0.214	0.13
λ_2	0.797	0.78	0.732	0.83
λ_3	0.317	0.291	0.228	0.216
λ_4	0.383	0.399	0.353	0.324
a_1	1.875	1.823	1.846	1.871
a_2	4.031	3.944	3.903	3.875
a_3	5.955	5.868	5.817	5.79
b	1.988	1.979	1.966	1.957
(c) High independence in the 1st dimension and low independence in the 2nd dimension				
True value	$\lambda_1 = 0.8, \lambda_2 = 0.9, \lambda_3 = 0.1, \lambda_4 = 0.2$			
	$\alpha_1 = 0.05$	$\alpha_1 = 0.1$	$\alpha_1 = 0.3$	$\alpha_1 = 0.5$
α_1	0.054	0.091	0.235	0.311
λ_1	0.376	0.415	0.734	0.757
λ_2	0.503	0.512	0.584	0.788
λ_3	0.15	0.161	0.212	0.366
λ_4	0.169	0.203	0.213	0.201
a_1	2.386	2.786	2.031	2.038
a_2	4.417	4.778	3.986	3.939
a_3	6.358	6.716	5.893	5.85
b	1.985	1.973	1.939	1.928
(d) Low independence in the 1st dimension and high independence in the 2nd dimension				
True value	$\lambda_1 = 0.1, \lambda_2 = 0.2, \lambda_3 = 0.8, \lambda_4 = 0.9$			
	$\alpha_1 = 0.05$	$\alpha_1 = 0.1$	$\alpha_1 = 0.3$	$\alpha_1 = 0.5$
α_1	0.574	0.566	0.703	0.796
λ_1	0.777	0.75	0.662	0.525
λ_2	0.808	0.808	0.713	0.704
λ_3	0.613	0.637	0.585	0.528
λ_4	0.25	0.262	0.215	0.116
a_1	1.922	1.897	2.027	2.175
a_2	3.812	3.786	3.959	4.142
a_3	5.671	5.651	5.84	6.056
b	1.902	1.907	1.932	1.962

Weight parameters

Almost all the estimated weight parameter is greater than the setting value of it. As the exception, in Table 1 (c), relatively great logsum parameters are set in the first dimension and small ones in the other. It indicates a high independence of the nests in the first dimension and a low independence of the nests in the second dimension. In this case, the estimated weight parameters turn to be most close to the true value and the standard deviation is the least among all estimations.

While in Table 1 (a), (b) and (d), small logsum parameters are set in the first dimension and great ones in the other. In this case, the estimated results most deviate form the true value and the estimated weight parameters in the first dimension are all greater than half. It might be concluded from these two cases that the group of nests, which have higher independence, will be lower weighted than the groups of nests with low independence.

Logsum parameters

As the estimated logsum parameters, the results are always totally different from the true values. Since the standard deviations of each estimate are always in the same grade as the means, the estimations must be strongly deviate from the average and not be stable.

Utility Parameters

From the estimation results, the estimated constants and parameter of explanatory variables turn to be around twice of true values, but all numerically similar. As the standard deviation of these estimation results are much smaller than the average, the constant and the parameter of explanatory variables could be regarded as stable estimation results.

3.4 Summary

In the estimation results, we can find very different values of weight parameters and logsum parameters in each estimation setting with choice results from same parameters' setting. They are not necessarily estimated as the true value. However, the results of the constants and parameter of explanatory variables are always stable through the all trials. They are able to show off the true value.

This examination provides the properties of estimations results in MN-GEV model, especially the relationships between weight parameters and nest parameters. It proves that the weight parameter or the nest parameter is sensitive to the change of the other. And small weight parameter might be allocated to the dimension composed of nests with high independent unobserved utilities.

4. DATA DESCRIPTION FOR EMPIRICAL ANALYSIS

4.1 Target Area

All data used in the estimation are empirical data from National Corridor Trips Survey of Japan. This survey was carried by Ministry of Land Infrastructure and Transportation of Japan in 2000, which made a detailed summary of yearly national travel description.

Tokyo-Osaka corridor is chosen as the target area in this study, not only due to its proper distance around 500km, but also because it is a typical corridor in Japan for inter-regional travelers.

4.2 Data Specification

Because HSR and air have a 95% market share in Tokyo-Osaka corridor, the analysis here only treats these two transport modes as trunk modes in travels. Therefore, 4444 observations are selected from the survey (Figure 4). But there are still lots of unknown alternatives in the dataset, which makes it unable to judge the access/egress modes. And as well, some alternatives such as "chartered bus" and "trip in non-business purposes" only take a tiny occupancy in the choice sets. To have a more advantaged dataset and make it easier to carry on the analysis, the unknown and minority alternatives are all deleted. Finally, the new set of data decreases to 2588 individual trips.

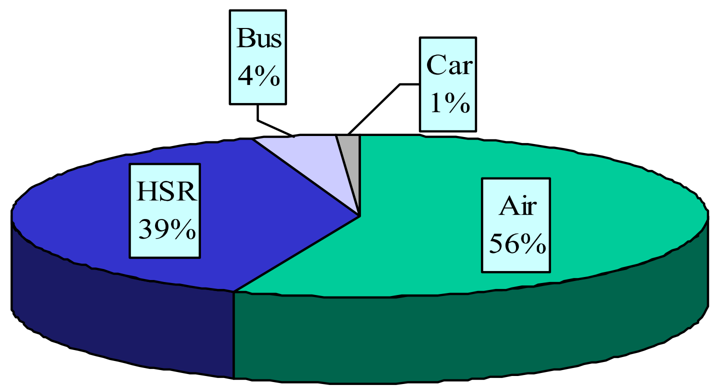

Figure 4 Share of Trunk Modes in Tokyo-Osaka trips

In the original data, there are 4444 observations taking HSR or air as trunk mode in Tokyo-Osaka trips. If we list them categorized by access or egress mode, we can find that the conventional train plays a main role in it (Figure 5 and Figure 6). While train, bus, car, and taxi are mostly used as access or egress modes. Hence, the data with access or egress mode of these four modes are adapted in the analysis.

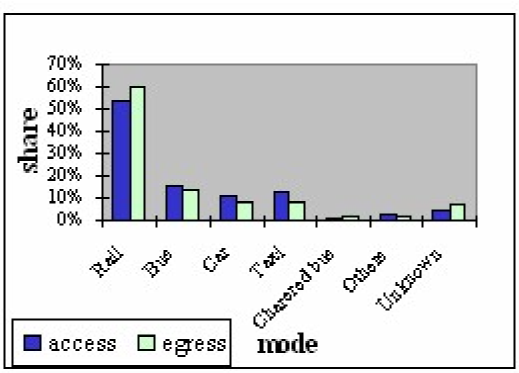

Figure 5 Share of access and egress modes in AIR travel

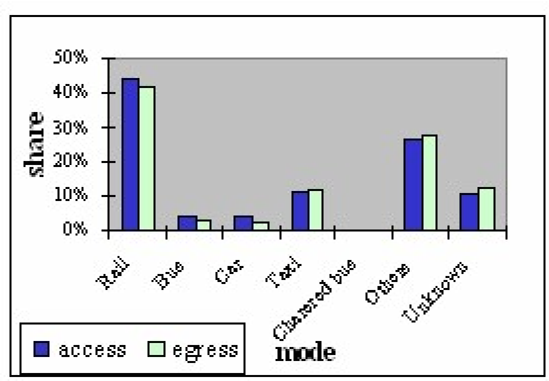

Figure 6 Share of access and egress modes in HSR travel

In order to execute model analysis to find the preference pattern of travelers in inter-regional areas, all possible Level-of-Service variables should be listed in the dataset, including time and cost for each mode. It is easy to find the necessary data for main modes through ticket center. However, data for access or egress modes are hard to be calculated since there are varieties of routes to be chosen as the access or egress modes in one OD pair. Thus, software named “NITAS (National Integrated Transportation Analysis System)” is used to calculate the variables of the best route (i.e. the route with the lowest generalized cost) for the access or egress modes respectively. As a result, 2542 observations are adapted after deleting some useless data, and LOS data including travel time and travel cost of each mode in the total trip are calculated as variables in the utility function.

5. MODEL ESTIMATION

5.1 Alternative Definition and Utility Specification

Firstly, let be reminded that each alternative is defined as a combination of three parts: access, trunk, and egress mode. Since there are 4 access choices, 2 trunk choices and 4 egress choices, totally there will be 32 possible combinations and these can be the alternatives (Figure 7).

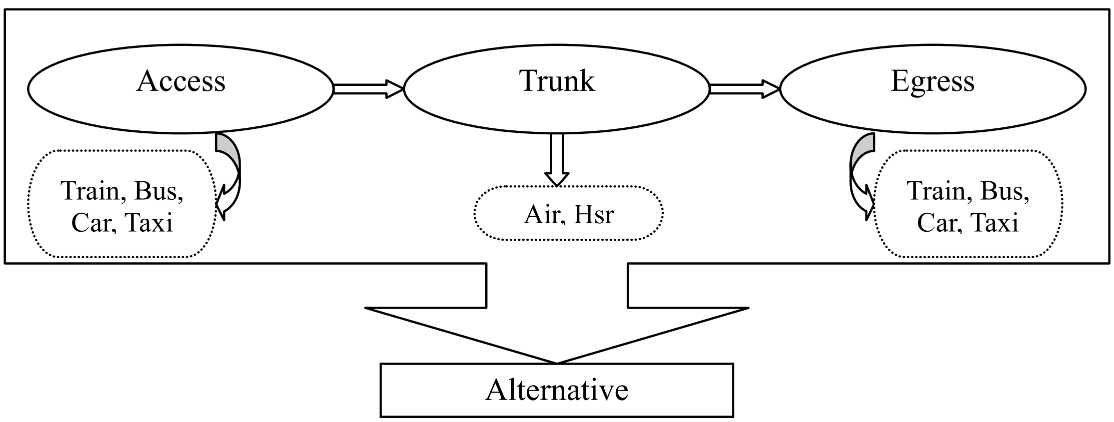

Figure 7 Definition of Alternatives in the Case

Now, it is easy to define the explanatory variables and constants in each utility function. Travel time, cost for access or egress mode and only travel time for trunk mode, because the cost for HSR and air are very close. Every mode in each part of the total trip has its specified constant. Hence, there are totally 10 alternative specific constants specified. In the estimation, however, we set constants of train as access mode, air as trunk mode, train as egress mode as base, which means these three constants were set to zero for identification.

5.2 Definition of the Multi Nest Structures

The nest structure should be defined before NL model estimation. As we know, there are 3 parts of the total trips. We can set each nest and estimate it respectively.

And according to the definition of MN-GEV model, the structure of it can be described as a weighted combination of these 3 NL models as shown in Figures 8-10.

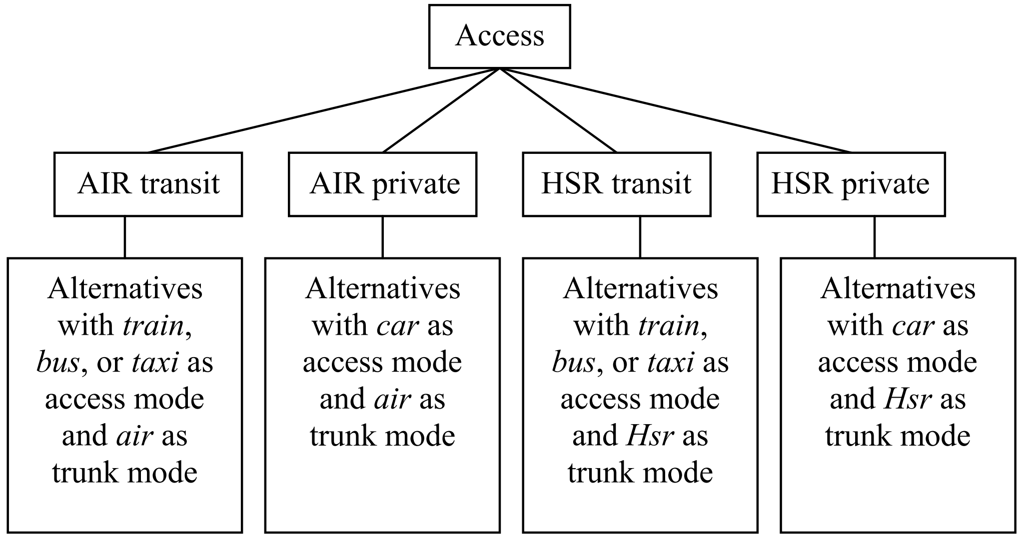

Figure 8 Nested Logit Structure of Access Mode Choice

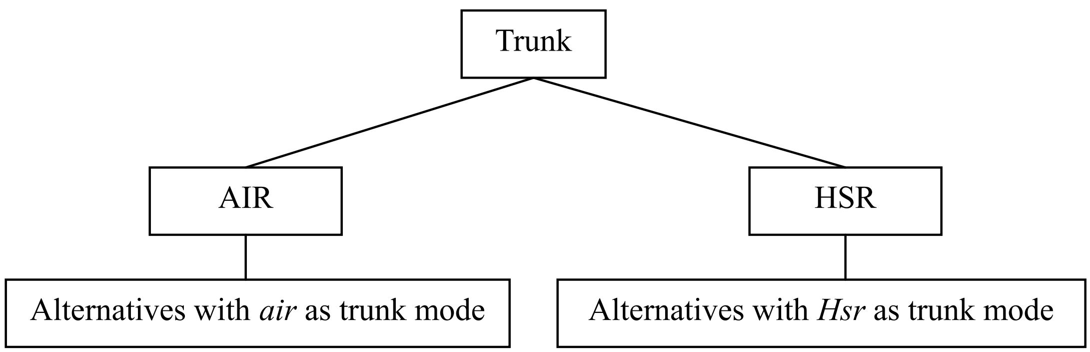

Figure 9 Nested Logit Structure of Trunk Mode Choice

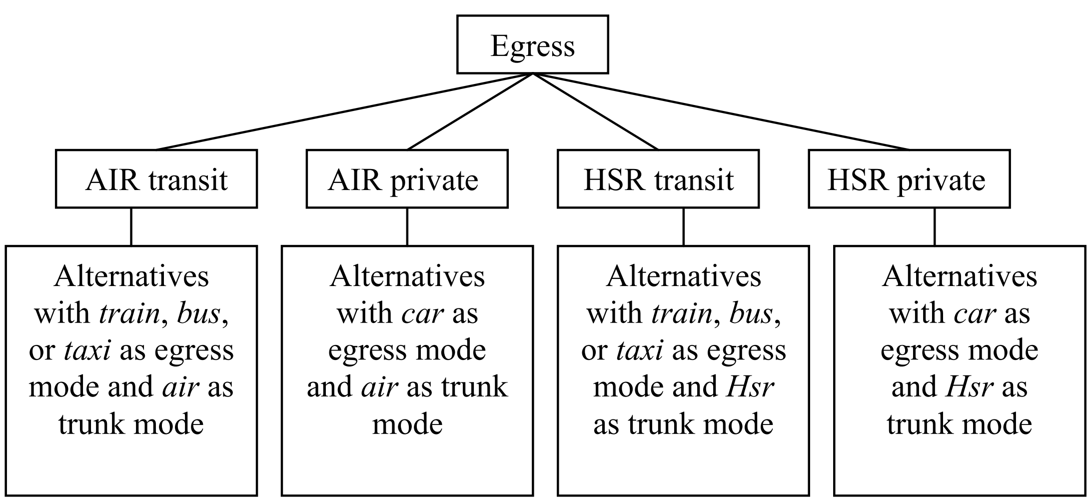

Figure 10 Nest Structure of Egress Mode

Finally, according to the definition of MN-GEV model, the structure of it can be seen in Figure 11.

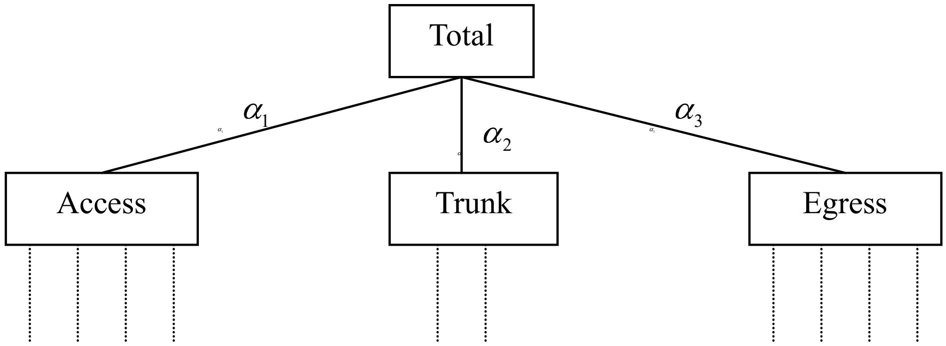

Figure 11 Structure of MN-GEV Model with Three Dimensions

5.3 Estimation Results

Estimation efficiency of the models

BIOGEME (Bierlaire, 2003) is also employed in the empirical estimation, which is a free package software developed specially for the estimation of GEV model. The computational time is relatively quick for MNL or NL models, while it takes a very long time for MN-GEV model estimations. With the help from super-computer in Tokyo Institute of Technology, it still cost around 120 hours for the overall calculation.

The advantages of MN-GEV model in the estimation of multi-modal choices show it is unique in the capture of the correlations of unobserved portions of utility across every part of the trip. We can estimate the extent to which an alternative is allocated to a home-end, trunk, and activity-end nest only through MN-GEV model. Because of this flexibility, MN-GEV model may give the best representation of choice behavior of multi-modal choices, despite of its complicated calculation. These are summarized in Table 2.

Table 2 Comparison of Advantages and Disadvantages among three GEV Type Models

Model	*Advantages*	*Disadvantages*
MNL	- Very simple calculation.	- Cannot capture the correlation of unobserved portions of utility.
NL	- Simple nest structure to capture the correlations in unobserved parts of utility. - Relatively simple calculation	- The alternatives can only be allocated in one nest. - It only captures the sources of correlations of unobserved portions of utility in one part of trip, such as home-end part.
MN-GEV	- Be flexible in the allocation of the alternatives. - Able to capture the sources of correlations of unobserved portions of utility along multiple choice dimensions	- Very complicated calculation

Estimation Results and Model Comparison

For MN-GEV model estimation, there are varieties of the combinations of estimation results. With different nest parameter settings, the estimated results are totally different. From the estimation result, as expected, MN-GEV model is the best model in the terms of the goodness of fit (see Table 3). NL provides the second best fit followed by MNL model. The result of MNL, NL and MN-GEV estimation using the same database is listed in Table 4.

Table 3 Adjusted Rho-Squared Statistics of MNL, NL and MN-GEV models

	MNL	NL-access	NL-egress	MN-GEV
Adjusted rho-squared	0.289	0.295	0.296	0.305

The results of MNL and NL models are estimated appropriately through the first estimation. In contrast, when estimating MN-GEV model, the results of t-test turn to be inappropriate without pre-setting of nest parameters.

In the NL model estimations, there are two settings. As for the first setting, classification of nests is based on the access modes, with which the commonness in the access transit and private modes are considered. While in the second setting, commonness in egress modes is regarded as the criteria in the nest classification.

Note that in MN-GEV model, the model structure is a combination of NL-access, NL-trunk, and NL-egress, and gives them each an allocation parameter. According to the estimation result (Table 4), the egress part shows its most importance in the decision making in inter-modal trips, while in the previous study it is assumed that access part should be more important. And also, the weight parameters of access and trunk dimensions are too small. As what has been explained for the stability of MN-GEV model in Chapter 3, when weight parameter is too small, it might not be properly estimated. In this case, after checking many estimation results, it can be noticed that the value of weigh parameters always change a lot in different estimations with varieties of setting of nest parameters.

Table 4 Estimation Results of Multi-modal Travel Choice Models

Model type	MNL		NL-access		NL-egress	
	value	*t-test*	*value*	*t-test*	*value*	*t-test*
constants						
access						
train	0	-	0	-	0	-
bus	-1.19	-19.667	-0.567	-9.235	-0.77	-8.482
car	-2.239	-29.788	-2.703	-18.802	-1.564	-9.789
taxi	-1.107	-10.827	-0.567	-7.401	-0.737	-7.589
trunk						
air	0	-	0	-	0	-
hsr	0.721	1.543	1.383	3.013	0.0598	0.117
egress						
train	0	-	0	-	0	-
bus	-1.294	-21.135	-0.628	-9.339	-0.802	-8.588
car	-2.64	-31.551	-1.483	-10.591	-2.46	-25.102
taxi	-1.145	-9.981	-0.631	-7.401	-0.669	-7.672
parameters						
access time	-0.0307	-16.385	-0.0191	-9.852	-0.0239	-10.288
access cost	-0.000155	-7.778	-0.000086	-6.809	-0.000132	-7.567
trunk time	-0.0426	-7.63	-0.0442	-8.17	-0.0326	-4.962
egress time	-0.0318	-15.358	-0.0223	-10.836	-0.0251	-13.215
egress cost	-0.000233	-9.346	-0.000134	-7.536	-0.0002	-7.94
logsum parameters						
air transit			0.477	10.432	0.587	9.785
air private			0.907	6.61	0.776	8.995
hsr transit			0.531	10.262	0.728	11.04
hsr private			0.946	6.94	0.678	6.016

MN-GEV	*value*	*t-test*
constants		
access		
train	0	-
bus	-0.294	-8.583
car	-1.041	-6.920
taxi	-0.315	-6.612
trunk		
air	0	-
hsr	1.558	3.436
egress		
train	0	-
bus	-0.339	-9.168
car	-3.218	-32.258
taxi	-0.359	-6.735
parameters		
access time	-0.0149	-8.895
access cost	-0.0000879	-7.533
trunk time	-0.0437	-8.129
egress time	-0.0206	-11.008
egress cost	-0.000151	-9.083
logsum parameters		
Access		
air private	1(fixed)	-
air transit	0.175	1.322
hsr private	1(fixed)	-
hsr transit	1(fixed)	-
egress		
air private	1(fixed)	-
air transit	0.197	7.022
hsr private	0.696	5.150
hsr transit	0.145	6.435

				trunk		
				air	1(fixed)	-
				hsr	0.253	0
				alpha		
				access	0.103	4.137
				egress	0.828	23.066
				trunk	0.069	4.797
init log-likelihood	-8809.9	-8814.04	-8814.65	***init log-likelihood***	-8812.49	
final log-likelihood	-6252.38	-6191.38	-6184.64	***final log-likelihood***	-6105.41	
likelihood ratio test	5115.05	5237.05	5250.51	***likelihood ratio test***	5397.21	
adjusted rho-test	0.2889	0.2954	0.2962	***adjusted rho-test***	0.3047	
number of individuals	2542	2542	2542	***number of individuals***	2542	

However, some conclusion could be drawn from the estimation results:

- Constants: Rail, Hsr, rail modes appear to be the preferred mode in three parts of trips respectively. Car turns out to be the least preferred mode both in access and egress mode maybe because of its inconvenience in the transfer station.
- Utility Parameters: Travel time has more significant affect on the decision making rather than cost. Maybe because we only employed travel data in business purpose, travel time is much higher important for business men.
- Logsum Parameters: Lower logsum parameter means less independence of the nest, or greater correlations in the nest. In another word, it means larger similarity in the nest. We can conclude from the results for logsum parameters that the nests in access dimension are more independent than the nests in egress dimensions. Or the nests in egress dimension have a larger similarity.
- According to the value of alpha, the egress part in the travel is most weighted in all three dimensions.

6. CONCLUSIONS

HSR and air are considered as the trunk mode in the total trip in this case, and the access and egress modes in the trips are also taken into account to catch their affect on the final decision making. MN-GEV model has been used as a tool in the analysis of inter-regional multi-modal route choice behavior. Despite of its computational complex, this model shows its advantage in the estimation compared with MNL and NL models in the situation of an inter-modal travel. And this model may be regarded as a useful tool in the prediction of policy affects. In the future, some political analysis could be evaluated by the result of the estimation, or by re-estimating by other variables with this tool.

There will be several HSR lines to be completed in these years in China, and it can be predicted more in the future. A conventional high-speed line based on Inter-city Express technology between Beijing and Tianjin is expected to open in 2007. As the model presented in this paper provides a more precise estimation of mode choice behavior by considering the effect of access and egress modes on the trunk mode choice, it might be an effective tool even for China's case. For example, until now in China, bus is considered to be the most useful mode in the inner-city travel. As the boom of subway construction from now on, policy deciders should consider the transfers between subways and HSR in the plan to provide a convenient transfer to improve the rider ship of HSR. In this situation, the proposed model could help them with a more predict estimation in the total trip.

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