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Comparative Analysis on Heuristic Methods of Generating a Choice Set in Urban Rail Route Choice: Evidence from the Tokyo Metropolitan Area

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Abstract: This paper examines the characteristics of the choice behavior of urban rail users in the Tokyo Metropolitan Area and proposes heuristic rules for generating an individual's choice set by eliminating the options by his/her aspects. Then, this paper empirically applies the proposed rules to the simultaneous choice analysis of the access travel mode, rail station of origin, and rail route using multinomial logit models. The results show that the choice set generation rule with two-step elimination according to the access distance to the rail station of origin and the total travel time, including access travel time and rail-ride travel time, exhibits the best fitness in the parameter estimation.

Key Words: *choice set generation, discrete choice model, urban rail route choice*

1. INTRODUCTION

Traditionally, travelers' choice behaviors are modeled through specifications such as multinomial logit (MNL), nested MNL, and probit models (Ben-Akiva and Lerman, 1985; Train, 2003). In such discrete choice models, it is often assumed that the traveler's choice set is provided *a priori* on the basis of the analyst's technical experience and/or knowledge. This is simply because it is occasionally difficult to define the traveler's choice set empirically. In particular, a large-scale transit network makes it difficult to define the choice set. This can be partly attributed to the fact that transit users have to choose not only the transit routes, but also the origin stations/stops and the access/egress travel mode and routes. This paper examines a heuristic method of generating a choice set in the case of an urban rail commuter's travel behavior in a large transit network. It employs a combination of compensatory and non-compensatory models in a simultaneous discrete choice analysis of the rail route, origin station, and access travel mode of rail users.

The paper is organized as follows. Section 1 presents the research background and the goals of this paper. Section 2 explains the basic approach for the analysis of the urban rail commuter's behavior. Section 3 describes the empirical data and analyzes the characteristics of the urban rail commuter's travel choice in the Tokyo Metropolitan Area. Section 4 analyzes the commuter's choice with discrete choice models under the rules of generating the choice set and compares the results. Finally, Section 5 discusses the implications of transit demand analysis.

2. APPROACH

Psychological and consumer behavior research supports the view that decision makers are information processors with limited capabilities and resources, who attempt to make the best possible decisions within operational constraints (Swait, 2001). Beach and Potter (1992) presented that these decisions occur in steps: the first step generates the choice set that includes several options, whereas the second step chooses the best option from the given choice set. Manski (1977) formulated the paradigm of this two-stage approach as

$$P_i = \sum_{C \subseteq \Gamma} P(i|C)Q(C), \tag{1}$$

where P_i is the probability of choosing alternative i, $P(i|C)$ is the conditional probability of choice of i, given the choice set is $C \subseteq \Gamma$, Γ is the set of possible choice sets, and $Q(C)$ is the probability of choosing a choice set C. Numerous studies such as Swait and Ben-Akiva (1987a, b), Roberts and Lattin (1991), Andrews and Srinivasan (1995), and Ben-Akiva and Bocca (1995) analyze the consumer's behavior with discrete choice models on the basis of Equation (1). Moreover, we assume that there are two steps in the discrete choice analysis of urban rail-use travel behavior under the condition that their origins and destinations are given.

It is assumed that the individuals identify their choice set in the first step by considering the nested model structure, whereas they choose the best one by considering the non-nested model structure in the second step. In the first step, the individuals' choices are grouped into the following three sub-choices: the rail-station-of-origin choice, access travel mode choice, and rail route choice. The rail-station-of-origin choice refers to choosing the rail station that rail-using individuals approach from their residences to use the urban rail service. The access travel mode choice refers to choosing the transportation mode for traveling from their residence to the rail station of origin, for example, by walking, or by riding a bicycle, bus, or automobile. The rail route choice refers to choosing the rail route from the origin station to the destination station. We do not consider the rail-station-of-destination choice and egress travel mode choice simply because it is expected that the commuters use the nearest station to their final destination and that they reach there by walking.

Furthermore, it is assumed that the first step follows the non-compensatory choice rule, whereas the second step follows the compensatory choice rule. This reflects the results of psychological and behavioral research. For example, Van Zee et al. (1992) shows that the first step comprises screening out unacceptable options and the second step involves choosing the best option from among the options remaining after screening. Compensatory models of choice assume that the individual utilizes all available information for selecting the optimal option, while non-compensatory models do not assume this. Compensatory models include traditional discrete choice models such as MNL, nested MNL, and Probit models. Non-compensatory models include Simon (1955) with the satisfying decision rule as well as Dawes (1964) and Einhorn (1970, 1971), which proposed and tested the conjunctive decision rule respectively. Furthermore, such models include Dawes (1964) with the disjunctive rule of choice and Tversky (1972) with elimination-by-aspects (EBA). We employ EBA for the choice set identification, whereas we use MNL for choosing from the choice set.

3. DATA USED

The data used in the empirical analysis was collected through a paper-based questionnaire survey organized by the Japan Rail Construction, Transport and Technology Agency. The survey was conducted in November 2001. It includes the revealed preference travel data in addition to socio-demographic data of 321 urban-rail-use commuters who reside in areas along the Saitama Railway (SR) Line. The travel data covers the residence address, rail stations, access and egress travel modes, rail route, and final destination, whereas the socio-demographic data includes the age, gender, occupation, and available transportation mode. We screened the data set and finally considered 238 sample individuals for the empirical analysis.

The SR Line is owned and operated by Saitama Railway Co. Operations of the SR Line commenced in March 2001. The SR Line is 14.6 km long, running from north to south in Saitama Prefecture, which is a suburban location in the Tokyo Metropolitan Area. The SR Line is directly connected to one of the subway lines, Nanboku Line, operated by Tokyo Metro Co. The subway trains run into the SR Line directly. This means that the SR Line was constructed mainly for commuters who travel from the southern Saitama area to the central business district (CBD). There are two alternative urban rail services for the individuals living along the SR Line who travel to CBD. The first alternative is the JR Keihin-Tohoku Line, which runs along the western side of the SR Line and is operated by East Japan Railway Co. The second alternative is the Tobu Isesaki Line, which runs along the eastern side of the SR Line and is operated by Tobu Railway Co. As the JR Musashino Line intersects the three lines, individuals living along the SR Line can also choose the stations of this line. The map of the SR Line along with the other lines is depicted in Figure 1. Moreover, this figure includes the location of a sample individual's residence and the chosen rail station of origin.

Next, in order to prepare the level-of-service data, we hypothetically consider the maximum choice set for each observed individual. We assume that an individual can choose from, at most, six available rail stations of origin, five available access travel modes, and four available rail routes. The stations that are located at the place with the first- to fifth-shortest distances from the individual's residence are selected as the available rail stations of origin.

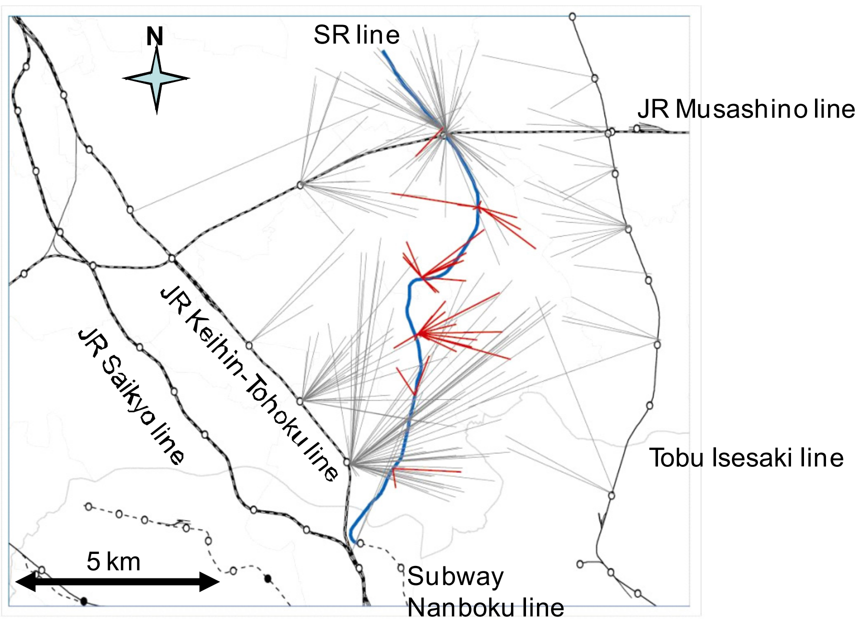

Figure 1 Map of Saitama Railway Line along with other lines

Notes: Straight lines in the map connect the residences of respondents with the chosen rail stations of origin. Red-colored straight lines mean the ones of SR users while blue-colored straight lines mean the ones of non-SR users.

The available access travel modes include walking, bicycle, bus, motorbike, and automobile. The rail routes that have the first- to fourth-shortest travel times are selected as the available rail routes. The above process leads to a maximum of 120 options in an individual choice set.

4. DATA ANALYSIS

Data regarding the level-of-service of rail station of origin, access travel mode, and rail route chosen by the observed commuters will be analyzed here. The transportation network, including the rail station of origin, access travel mode, and rail route, is illustrated in Figure 2.

Figure 3 shows the frequency distribution of distances from the individual's residence to the nearest rail station and the distribution of distances from the individual's residence to the chosen rail station. Note that the distance in this case refers to straight line distance. The mode of distribution of distances to the nearest rail station is lower than the mode of the distribution of distances to the chosen station. Note that the average distance from the individual's residence to the nearest station is 1.67 km, whereas the average distance from the individual's residence to the chosen station is 2.97 km. Second, although 86.6% of individuals reside within a radius of 2.0 km from the nearest stations, only 49.6% of these individuals chose the stations that are located within a radius of 2.0 km from their residences.

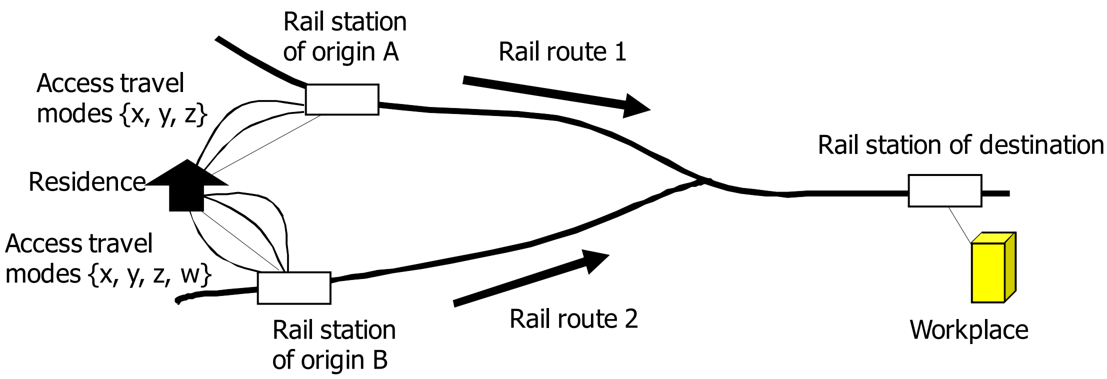

Figure 2 Schematic transportation network that includes the rail station of origin, access travel mode, and rail route

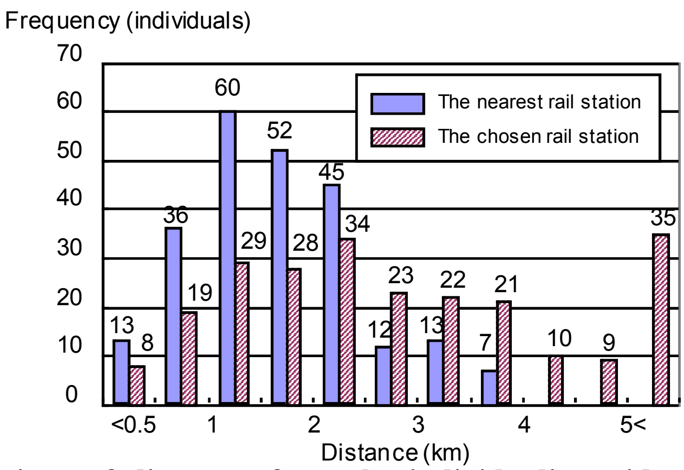

Figure 3 Distributions of distances from the individual's residence to the nearest stations and to the chosen stations

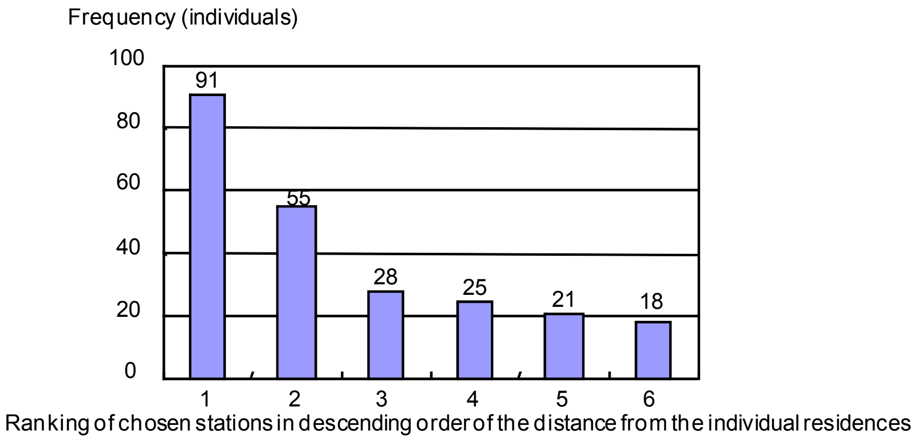

Figure 4 Distribution of the chosen stations in descending order of distance from the individual's residence

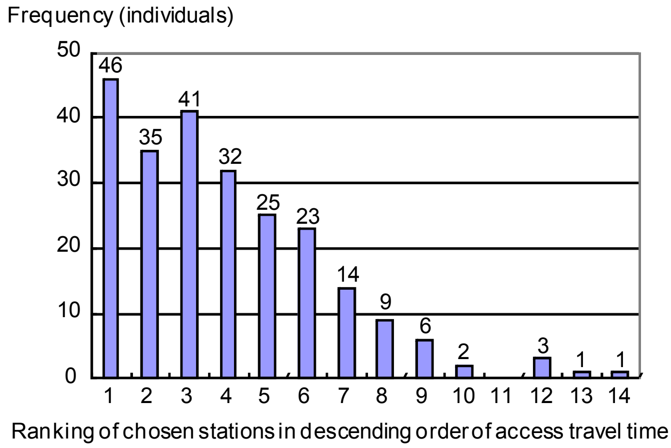

Figure 5 Distribution of the chosen stations in descending order of access travel time from the individual's residence

Figure 4 displays the frequency distribution of the chosen stations in descending order of distance from the individuals' residences to the chosen stations. This shows that 91 individuals chose the nearest station, whereas 55 individuals chose the second-nearest station, 28 individuals chose the third-nearest, and 25 individuals chose the fourth-nearest stations. These numbers indicate that many individuals chose the non-nearest stations from their residences.

Figure 5 presents the frequency distribution of the chosen stations in descending order of access travel time from individuals' residences to the chosen stations. The access travel time is estimated by calculating the expected travel time on foot along the shortest path from their residences to the stations. Note that the distance of the shortest path is either equal to or longer than the one-line distance. This implies that the stations where the individuals travel in the shortest access travel time are the most chosen. However, interestingly, the stations where the individuals travel in the second shortest access travel time are less chosen than the stations where the individuals travel in the third shortest access travel time. This may indicate that the access travel time is not a dominant factor in choosing the options.

Figure 6 shows the observed modal share of access travels from the individual's residences to the rail station. Dominant among the nodes, the shares of bicycle and bus are both approximately 35%. However, note that this does not imply that the individuals live at a large distance from the rail station, as shown in Figure 3.

Figure 7 depicts the frequency distribution of the chosen options in descending order of access travel time. An option refers to the combination of the rail station of origin, access travel mode, and rail route. This shows that 155 individuals out of 238 chose the options whose access travel time to the rail stations is the shortest among the three options. This implies that the individuals may prefer the options that involve shorter access travel time.

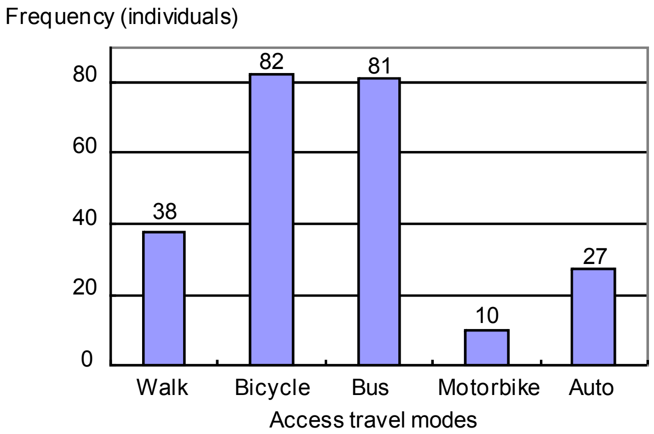

Figure 6 Share of chosen access travel modes

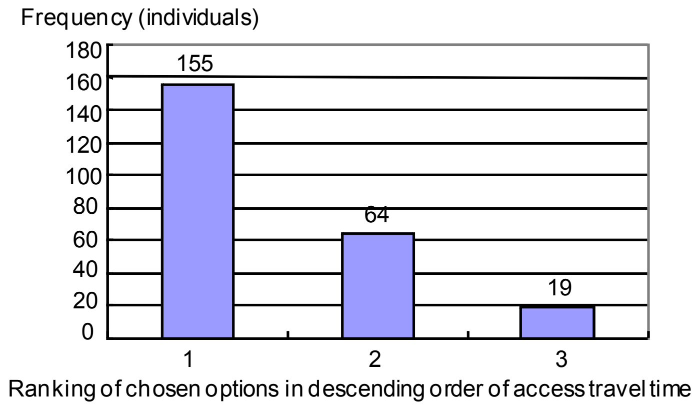

Figure 7 Distribution of chosen options in descending order of access travel time

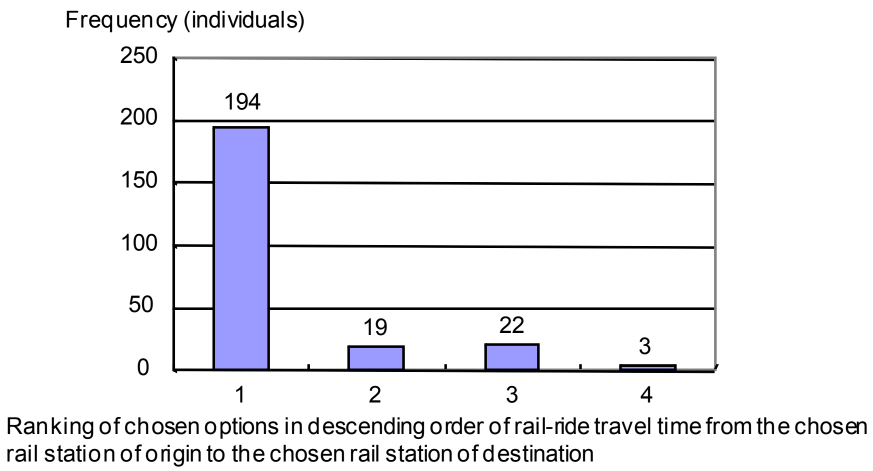

Figure 8 Distribution of chosen options in descending order of rail-ride travel time from the chosen rail station of origin to the rail station of destination

Figure 8 displays the frequency distribution of the chosen options in descending order of rail-ride travel time from the chosen rail station of origin to the chosen rail station of destination. This shows that 194 individuals (81.5%) chose the shortest option in travel time. This means that individuals prefer the options that involve shorter rail-ride travel time. It should be noted that we do not analyze the frequency distribution of the chosen options with respect to travel cost from the chosen rail station of origin to the chosen rail station of destination because the rail fare between any fixed pair of rail stations is usually the same in the Tokyo Metropolitan Area.

Figure 9 depicts the frequency distribution of chosen options in descending order of rail-ride travel time of available options from their residence to the chosen rail stations of destination. Note that Figure 9 covers the all available rail stations of origin, whereas Figure 8 covers only the chosen rail station of origin. Figure 9 indicates that 152 individuals (65.0%) chose the options with the first, second, or third shortest rail-ride travel times. Moreover, this means that the individuals prefer the options that include shorter rail-ride travel time.

Figure 10 shows the frequency distribution of the chosen options in descending order of the rail-ride travel cost of the available options from an individual's residence to the rail stations of destination. Note that the available options include different pairs of rail stations of origin

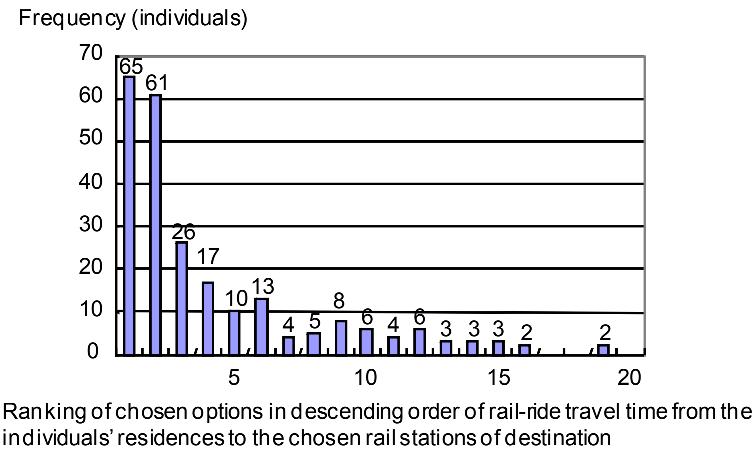

Figure 9 Distribution of chosen options in descending order of rail-ride travel time of available routes from individuals' residences to rail stations of destination

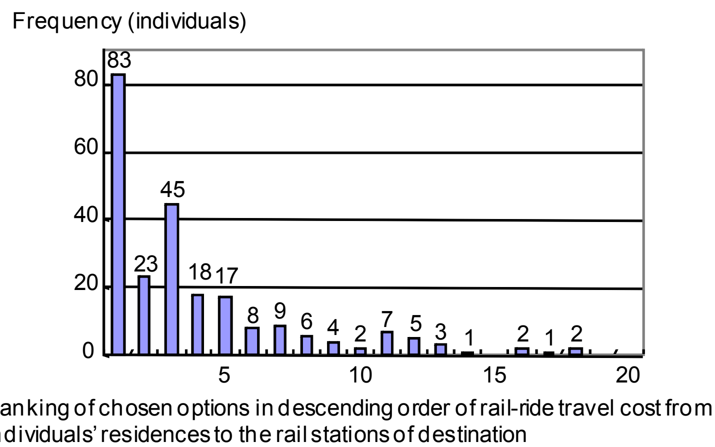

Figure 10 Distribution of chosen options in descending order of rail-ride travel cost of available routes from individuals' residences to the rail stations of destination

and destination. As the travel cost may vary among the different pairs of rail stations of origin and destination, the travel costs of such options may also differ. Figure 10 indicates that the individuals chose most the option with the lowest travel cost. However, interestingly, the number of individuals choosing the options with the third lowest rail-ride travel cost is more than that of individuals choosing the option with the second lowest rail-ride travel cost. This may imply that the travel cost is not a dominant factor in choosing the options.

Figure 11 shows the frequency distribution of the chosen options in descending order of total travel time of available options from an individual's residence to the chosen rail stations of destination. Note that the total travel time includes the rail-ride travel time and access travel time. This indicates that 160 individuals (67.2%) chose the five shortest total-travel-time options. This means that the options chosen by one-third of individuals cannot be covered by applying the EBA rule with respect to the total travel time in the choice set generation.

Figure 12 displays the frequency distribution of chosen options in descending order of total travel cost of available options from their residence to the rail stations of destination. Note that the total travel cost includes the rail fare and access travel cost. This may imply that the total travel cost does not substantially impact the individual's choice.

Finally, Figure 13 depicts the frequency distribution of the chosen options in descending order of generalized cost of available options from an individual's residence to the rail stations of

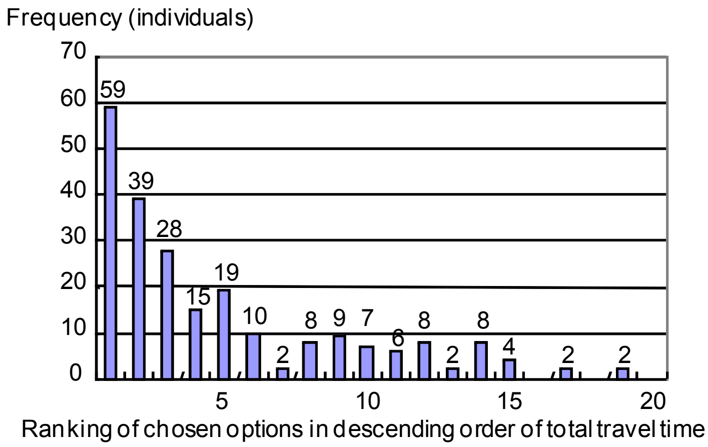

Figure 11 Distribution of chosen options in descending order of total travel time

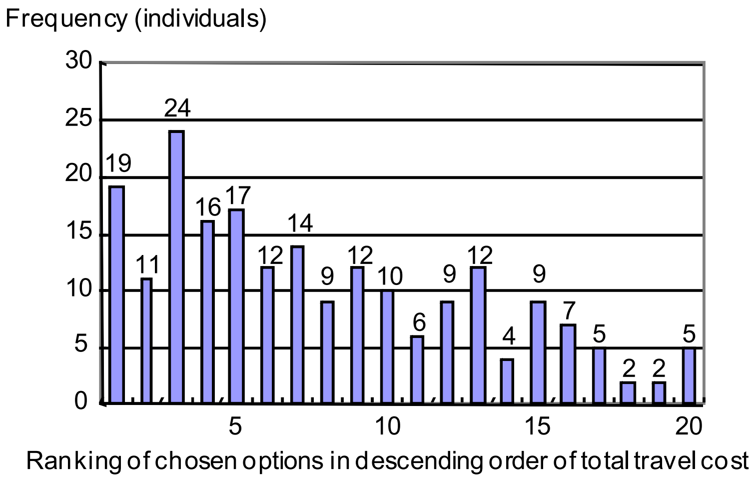

Figure 12 Distribution of chosen options in descending order of total travel cost

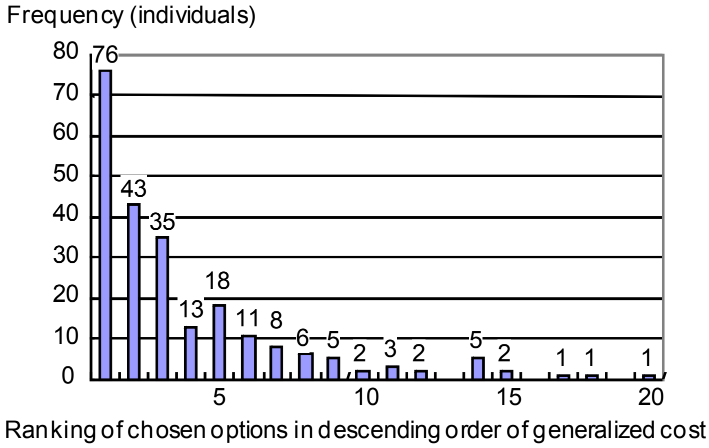

Figure 13 Distribution of chosen options in descending order of generalized cost

destination. The generalized cost is calculated with the total travel time and total travel cost by assuming the value of travel time as 40.0 yen/minute. This reflects past empirical research on the value of travel time in the Tokyo Metropolitan Area (Kato, 2007). The basic tendency seems to be the same as Figure 11. However, 185 individuals (77.7%) chose the five lowest generalized-cost options. This means that the EBA rule with respect to the generalized cost can cover more individuals than the EBA rule with respect to the total travel time.

5. EMPIRICAL ANALYSIS

The individual's simultaneous choice of the rail station of origin, access travel mode, and rail route is empirically analyzed under the condition that the locations of his/her residence and the destination station are given. It is assumed that the individuals make decisions about choosing the best option in two steps. In the first step, the individual's choice set is generated by eliminating the options according to certain aspects. An option is defined as a combination of the rail station of origin, access travel mode, and rail route. The access travel modes considered in the options include on foot, bicycle, bus, motorbike, and automobile, while the available rail stations of origin and rail routes vary among individuals. Additionally, it is assumed that an individual has five options in his/her choice set at the second step.

The following five rules of generating the individual's choice set are considered on the basis of the analysis shown in Section 4:

(1) Elimination by total travel time
The individual's choice set is generated by eliminating the options by his/her total travel time. The total travel time is defined as the sum of access travel time and rail-ride travel time. This rule is widely used in the rail travel demand analysis in the Tokyo Metropolitan Area (Yai et al. 1997; Morichi et al., 2001; Kato et al., 2003).

(2) Elimination by generalized cost
The individual's choice set is generated by eliminating the options by his/her total generalized travel cost. The generalized travel cost is defined by the sum of the total travel cost and the total travel time multiplied by the value of time. The value of time is assumed to be 40.0 yen/minute. This is because Kato (2007) shows that the average value of travel time in the Tokyo Metropolitan Area is around 40.0 yen/minute.

(3) Two-step elimination by access travel time and by total travel time

The individual's choice set is generated in two steps. The first step involves the selection of access travel modes by eliminating the options as per the access travel time. Then, in the second step, the options are selected by elimination according to the total travel time. Note that the two fastest travel modes are selected from each individual's residence to each rail station of origin in the first step.

(4) Two-step elimination by rail-ride travel time and by total travel time
The individual's choice set is generated in two steps. The first step involves the selection of rail routes by eliminating the options as per the rail-ride travel time from each rail station of origin to the destination station. Then, in the second step, the options are selection by elimination according to the total travel time. Note that the two fastest rail routes are selected in the first step.

(5) Two-step elimination by access distance and by total travel time
The individual's choice set is generated in two steps. The first step involves the selection of rail stations of origin by eliminating the option as per the access distance from the individual's residences to the stations. Then, in the second step, the options are selected by elimination according to the total travel time. Note that the four rail stations of origin are selected in the first step.

"(1) Elimination by total travel time" and "(2) Elimination by generalized cost" include the single-step elimination by a single requirement. The former uses the total travel time for eliminating the options while the latter uses the generalized cost for eliminating the options. "(3) Two-step elimination by access travel time and by total travel time", "(4) Two-step elimination by rail-ride travel time and by total travel time", and "(5) Two-step elimination by access distance and by total travel time" include the two-step elimination by two requirements. In the first step, the options are screened by using the first requirement, then in the second step, the remaining options are again screened by using the second requirement.

Then, the five MNL models are estimated with the choice sets generated by the above five methods. The conditional indirect utility function is defined as

$$U_i = \sum \theta_j \cdot x_{ij} + \varepsilon_{ij} , \tag{2}$$

where U_i is the individual's indirect utility function under the condition that he/she chooses an option i, x_{ij} is the j th explanatory variable of the option i, θ_j is the unknown coefficient of the j th explanatory variable, and ε_{ij} is the error component. The model assumes that the choices of the origin station, access travel mode, and rail route are independent. This assumption may not be suitable in some cases. For example, suppose that there are two stations along the same rail line and one station is next to the other station. Then, the option including that station has some similarity to the option including the other station because both options include the same rail line. However, our analysis neglects the interaction among different choices. This is primarily for the purpose of analytical simplicity. Our main concern is not the model structure of the second step, but the method of generating the choice set because the practical demand analysis of rail transit route choice does not consider it. One of the goals of our analysis is to contribute to the practical demand analysis in the Tokyo Metropolitan Area. Furthermore, our model assumes the independence of error components in the indirect utility function among options. If there was some covariance in the error components among options, this assumption may not be suitable. However, past empirical analyses with the MNL model show that the model can be statistically significant even if the independence of error components is assumed (for example, see Kato, 2007).

The data used in the model estimation comprises the revealed preference data of 238 individuals collected in our survey, as shown in Section 2. The following variables are used for utility functions in the models: access travel time, access travel cost, rail-ride travel time, rail-ride travel cost, transfer times, a dummy for SR, and a dummy for automobile. The transfer time is defined as the number of transfers from the rail station of origin to the final rail station. Note that this does not include the transfer from the access travel to the rail-ride and from the rail-ride to egress travel. The dummy for SR is defined as 1 if the option includes the use of SR, and as 0 otherwise. The dummy for automobile is defined as 1 if the option includes the use of an automobile, and as 0 otherwise. Socio-demographic variables such as gender and age are not included in our analysis because they cannot be included in conditional indirect utility functions of specific options owing to substantial differences among the choice sets of different individuals.

The estimation results are shown in Tables 1 and 2. First, the likelihood ratios, one of the

Table 1 Estimation results: (1) elimination by total travel time and (2) elimination by generalized cost

(1) Elimination by total travel time			
Variables	Units	Coefficients	t–statistics
Access travel time	Minutes	–0.3243	–6.537***
Access travel cost	Yen	–0.003	–1.411
Rail–ride travel time	Minutes	–0.1667	–2.903***
Rail–ride travel cost	Yen	–0.0053	–1.705*
Transfer times	Times	–0.4765	–1.17
Dummy for Saitama Railway	–	–2.515	–2.607**
Dummy for automobile	–	11.456	0.07
Initial log–likelihood		–183.47	
Final log–likelihood		–117.78	
Likelihood ratio		0.348	
Chi–squared		131.4	
(2) Elimination by generalized cost			
Variables	Units	Coefficients	t–statistics
Access travel time	Minutes	–0.3541	–7.004***
Access travel cost	Yen	–0.0019	–0.868
Rail–ride travel time	Minutes	–0.2261	–4.024***
Rail–ride travel cost	Yen	–0.0022	–0.638
Transfer times	Times	–0.4846	–1.227
Dummy for Saitama Railway	–	–2.6665	–2.707***
Dummy for automobile	–	11.404	0.06
Initial log–likelihood		–183.47	
Final log–likelihood		–124.53	
Likelihood ratio		0.311	
Chi–squared		117.9	

Note: *** means significant in 99% confidence level; ** means significant in 95% confidence level; and * means significant in 90% confidence level.

Table 2 Estimation results: (3) two-step elimination by by access travel time and by total travel time; (4) two-step elimination by rail-ride travel time and by total travel time; and (5) two-step elimination by access distance and by total travel time

(3) Two-step elimination by access travel time and by total travel time			
Variables	Units	Coefficients	t–statistics
Access travel time	Minutes	–0.3194	–6.467***
Access travel cost	Yen	–0.0032	–1.468
Rail–ride travel time	Minutes	–0.1815	–3.261***
Rail–ride travel cost	Yen	–0.0055	–1.783*
Transfer times	Times	–0.4309	–1.113
Dummy for Saitama Railway	–	–2.1959	–2.433**
Dummy for automobile	–	11.339	0.06
Initial log–likelihood		–183.47	
Final log–likelihood		–117.20	
Likelihood ratio		0.351	
Chi–squared		132.5	

(4) Two-step elimination by rail–ride travel time and by total travel time			
Variables	Units	Coefficients	t–statistics
Access travel time	Minutes	–0.3251	–6.653***
Access travel cost	Yen	–0.003	–1.389
Rail–ride travel time	Minutes	–0.1553	–2.649***
Rail–ride travel cost	Yen	–0.0049	–1.489
Transfer times	Times	–0.4795	–1.124
Dummy for Saitama Railway	–	–2.6204	–2.609***
Dummy for automobile	–	11.413	0.07
Initial log–likelihood		–183.47	
Final log–likelihood		–117.12	
Likelihood ratio		0.352	
Chi–squared		132.7	

(5) Two-step elimination by access distance and by total travel time			
Variables	Units	Coefficients	t–statistics
Access travel time	Minutes	–0.293	–5.761***
Access travel cost	Yen	–0.0025	–1.149
Rail–ride travel time	Minutes	–0.1816	–3.161***
Rail–ride travel cost	Yen	–0.0058	–1.717
Transfer times	Times	–0.5346	–1.24
Dummy for Saitama Railway	–	–2.2801	–2.267**
Dummy for automobile	–	11.532	0.06
Initial log–likelihood		–183.47	
Final log–likelihood		–114.61	
Likelihood ratio		0.366	
Chi–squared		137.7	

Note: *** means significant in 99% confidence level; ** means significant in 95% confidence level; and * means significant in 90% confidence level.

indexes of model fitness, are higher than 0.3 in all models. They imply that the model fitness of those models is sufficiently high. Second, all variables have the expected signs. Third, t-statistics of access travel time, rail-ride travel time, and dummy for Saitama Railway are all significant at the 95% or 99% confidence level, while the t-statistics of other variables are not significant in all models. Further, the access travel cost and the rail-ride travel cost have lower t-statistics than the access travel time and the rail-ride travel time. This may reflect that the commuters do not mind the travel cost much because they are usually compensated for their travel expenses as an additional salary from their employers in Japan. The values of rail-ride travel times estimated from the models are 31.5, 102.8, 33.0, 31.7, and 31.3 yen/minute, respectively, while the values of access travel times estimated from the models are 108.1, 186.4, 99.8, 108.3, and 117.2 yen/minute, respectively. The values of access travel time are higher than those of rail-ride travel time probably because the physical burden of travel is more serious in access travel than in rail-ride travel. The estimated values of rail-ride travel time are smaller than 40 yen/minute, except for the value of travel time estimated from "(2) elimination by generalized cost". Note that 40 yen/minute is the given value of travel time used for calculating the generalized cost. As 40 yen/minute may be considered as an average value of rail-ride travel time and access travel time, the difference of the given value of travel time from the estimated value possibly leads to small impacts on estimation results of the model with "(2) elimination by generalized cost".

The Chi-squared indexes, another index for evaluating the model fitness, show that the model with "(5) two-step elimination by access distance and by total travel time" has the highest model fitness, followed by "(4) two-step elimination by rail-ride travel time and by total travel time" and "(3) two-step elimination by access travel time and by total travel time". Interestingly, "(2) elimination by generalized cost" has the lowest model fitness followed by "(1) elimination by total travel time", although we expect that the EBA rule with respect to generalized cost cover more individuals than the EBA rule with respect to the total travel time. Note that "(1) elimination by total travel time" has been widely used in past urban rail demand analysis in the Tokyo Metropolitan Area. These results conclude that two-step elimination according to access distance and total travel time may be recommendable.

6. CONCLUSIONS

This paper examined the characteristics of choice behavior of urban rail users in the Tokyo Metropolitan Area and proposed the heuristic rules of generating the individual's choice set by eliminating the options according to his/her aspects. Then, we empirically applied the proposed rules to the simultaneous choice analysis of the rail station of origin, access travel mode, and rail route with the MNL models. The results show that the choice set generation rule with two-step elimination by access distance and by total travel time exhibits the best fitness in parameter estimation. Although the rule of eliminating by total travel time has been widely used in past urban rail demand analyses in the Tokyo Metropolitan Area, it may be preferable to use two-step elimination by access distance and by total travel time instead.

Finally, the following topics still remain for future research. First, the individual's choice set size is fixed in our empirical analysis with the MNL models in the form of five options. However, the commuters may have a larger or smaller choice set. The appropriate size of the choice set should be further examined. Second, although the proposed method of generating the individual's choice set is tested from the perspective of model fitness with the MNL model, it may not reflect the real choice set recognized by the individuals. Although it is quite difficult to grasp the choice set identified by the individual, we should investigate whether the proposed rule of choice set generation fits the individual's recognition. Third, numerous empirical travel demand models are used for urban rail route choice (see Kato et al., 2007). Moreover, other types of discrete choice models, including the mixed logit model (Train, 2003; Kato and Fujiu, 2007), probit model (Yai et al., 1997), and C-logit model (Cascetta et al., 1996), should be examined. Finally, the empirical analysis in this paper shows the behavior of commuters residing near the SR Line. The commuters in other areas may exhibit different behaviors. It is necessary to examine the other cases with the same approach as that followed in this paper.

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