EVALUATION OF ROUTE CHOICE CHARACTERISTICS OF EXPRESSWAY USING ANALYTIC HIERARCHY PROCESS

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ABSTRACT

This paper will weigh the factors involved in choosing a expressway: the OD distance, traffic purpose, and personal factors, etc., according to the AHP (analytic hierarchy process) method, and also discuss the comparison in utility among available routes. The route characteristics, or the factors in choosing a route, to be considered in this paper are seven: traveling time, traveling time reliability, expense, scenery, safety, traffic conditions and route complexity. Available routes are two: the Hanshin Expressway and highway.

Data were acquired through a questionnaire distributed on the Hanshin Expressway. Analysis of data yielded the weight distribution of the factors and the average weights at for each level, the average utility value of each route, the maximum utility route, the actually chosen route, and its hitting ratio.

1. Introduction

Generally, there are two or more routes between the points of departure and the destination, and each traveler chooses a route according to his own standards.

However, due to differing preferences and other personal factors, and also because of the difficulty in evaluating the characteristics of each route in a objective and quantitative sense, it is not easy to present an integrated index of the standards for choosing route.

In this study, it was assumed that the problem is a set of subjective decisions by drivers under complicated, somewhat vague conditions. The AHP method was employed for weighing the factors in choosing the expressway and for comparing the utility values of the available routes.

2. Application of AHP Method to Evaluation of Route Choosing Characteristics

Considered route characteristics, or the factors in choosing a route, were seven: a traveling time, traveling time reliability, expense, scenery, safety, traffic conditions, and route complexity. Available routes were A (Hanshin Expressway) and B (highway). The choice factors were arranged hierarchically as shown in Fig. 1.

The top level (level 1) is the overall objective - traffic route choice. Level 2 and 3 are the choice factors and the bottom level (level 4) is the two available routes. All the elements are correlated and connected with lines.

The hierarchical structure shown in this paper (Fig. 1) was arrived at by an expert using the ISM method on answers obtained from an earlier questionnaire.

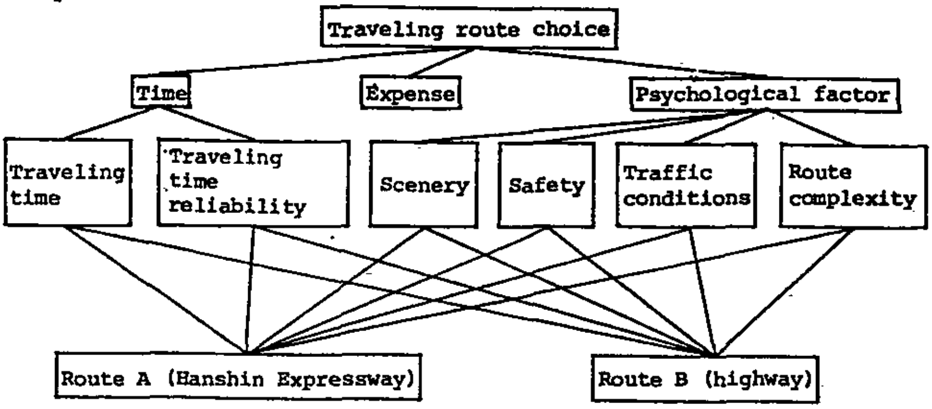

Fig. 1

In the current study, the questionnaire method was employed for computing the weights of the factors at each level. Three types of OD pairs of different distances were also set for examining how the weights of the factors would change. Only the OD1 is shown (Table 1).

Table 1

Evaluation factors in route choice		Route A (expressway)	Route B (highway)
Time factors	Expected traveling time	Approx. 15 min	Approx. 25 min
	Traveling time reliability	Reaching the destination roughly in the expected time	Reaching the destination roughly in the expected time
Expenses		The toll is ¥300	Not required
Psychological factors	Scenery	Poor because of soundproof walls	Buildings lining the street on both sides and a small number of trees
	Safety	Almost never involved in an accident	Rarely involved in an accident but occasionally surprised by a car or a person running out of a side street
	Traffic conditions	Annoyed by a traffic jam but still better than the highway because of no traffic lights	Annoyed sometimes by many traffic lights
	Route complexity	The route is easy to understand	Easy to understand as the road has no forks

The point of departure for all the OD pairs was the front of the Suma Aquarium and the destination was Sannomiya for OD1, the Koshien baseball field for OD2, and Osaka Castle for OD3. The destinations get further away in the order of OD1, 2, 3. 4,500 questionnaires (1,500 for each OD) were handed to car drivers at the Wakamiya and Minatogawa toll gates of the Hanshin Expressway. The drivers were asked to answer and mail back the questionnaires, shown in Table 2.

Table 2

Questionnaire

Question 1: Which is more appealing to you, route A or B, with regard to the following items?
Consider that "appealing" means pleasing.

Example of Answer

As to $\boxed{\text{safety}}$, I prefer $\boxed{\text{route B}}$ to $\boxed{\text{route A}}$ $\boxed{\text{strongly}}$.

Safety	absolute	very strong	strong	weak	equal	weak	strong	very strong	absolute	
route A	4	3	2	1	0	1	2	3	4	Route B

Question 2: Simply, which route do you prefer A or B?

1. $\boxed{\text{Route A}}$ 2. $\boxed{\text{Route B}}$

Question 3: You supposedly considered various conditions in answering the Question 2, such as traveling time and expense. Of the following contrasting sets of two factors, which do you give precedence over the other?

Example of Answer

I give $\boxed{\text{very strong}}$ precedence to $\boxed{\text{expense}}$ over $\boxed{\text{time}}$.

Time	absolute	very strong	strong	weak	equal	weak	strong	very strong	absolute	
factor	4	3	2	1	0	1	2	3	4	Expense

The questionnaires allowed for two purposes in driving: one was commutation and business, and the other was recreation. If a driver was traveling for an other purpose, he was asked to suppose that he was traveling for the allowed purposes, and to answer the two types of questionnaires. Each driver was also asked to enter his age, sex, address, etc. for further breakdown of the analysis. 948 copies of the questionnaire were returned and 869 were deemed valid.

Accordingly, 1,738 cases (2 x 869) were analyzed by the AHP method for each driver yielding weights for the factors at each level and the utility of each route for each driver.

3. Total of Answers to Questionnaires

The results of computations made for each driver were totaled according to the OD distances, traffic purposes, and personal factors (age, sex, and area of residence). The results are outlined. Due to lack of space, only the OD distances and their analysis will be shown below.

OD Distance

The weights of the route choice factors acquired from Question 3 were distributed as shown in Fig. 2 to 4. The diagrams were prepared according to the levels of the hierarchical structure. The figure at the upper right of each diagram is the average weight of each factor. The meaning of the weight distribution of each factor at each level follows below.

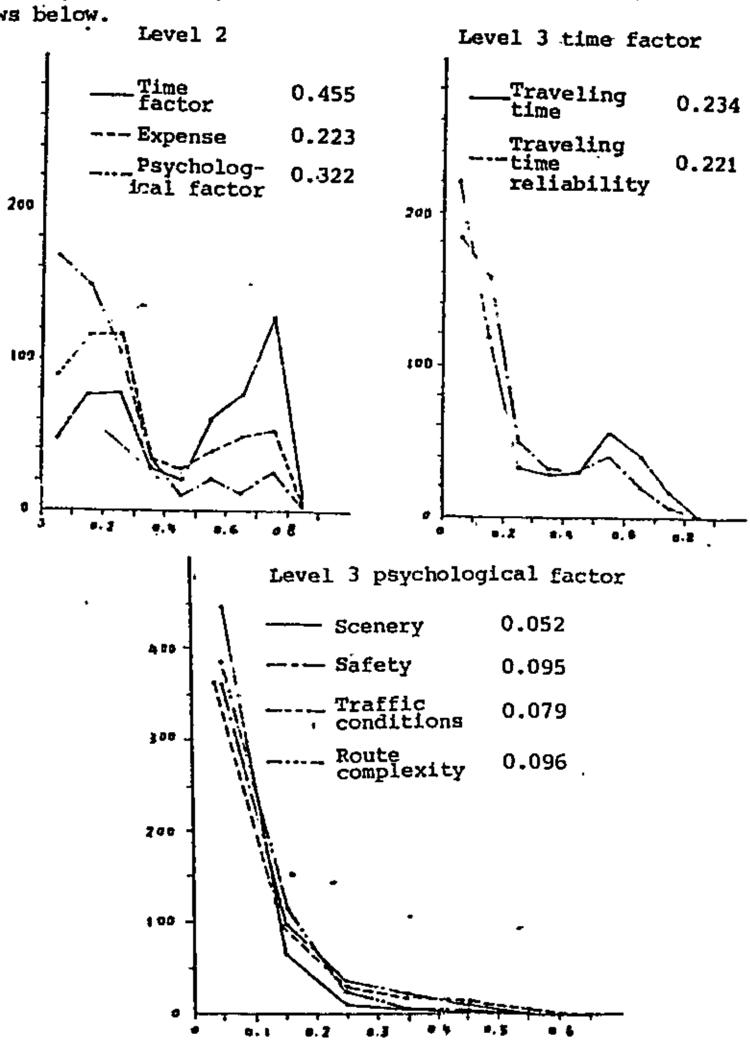

Fig. 2 Distribution of Weights of Factors (OD1)

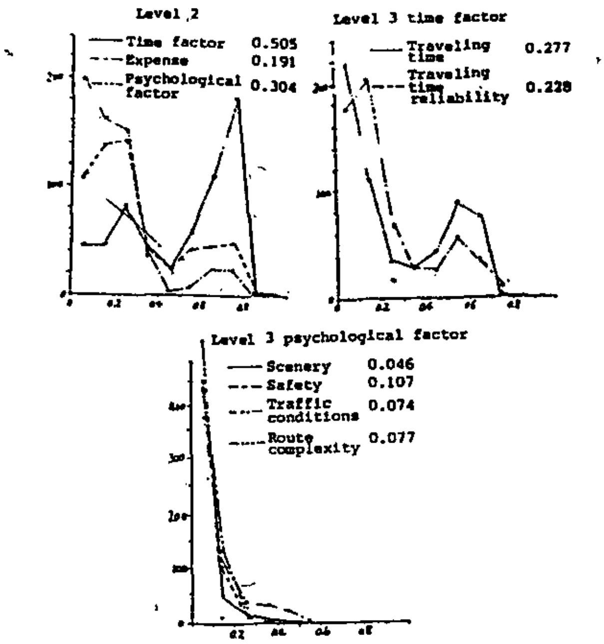

Fig. 3 Distribution of Weights of Factors (OD2)

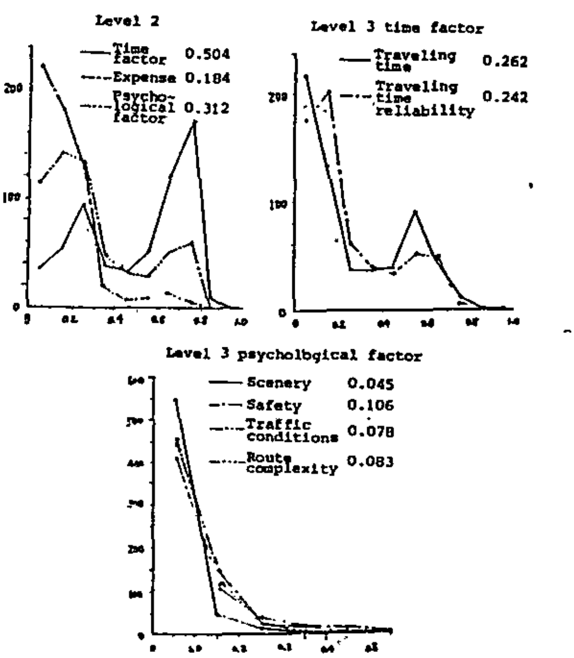

Fig. 4 Distribution of Weights of Factors (OD3)

Level 2

(1) Time Factor

The average weight increased as the OD distance increased (between OD1 and OD2) but settled to about 0.5 after the distance exceeded a certain OD distance (OD2 and OD3). The distribution patterns were consistent with two peaks at about 0.2 and 0.7.

(2) Expense

The basic distribution pattern remained unchanged but the average weight decreased as the OD distance got longer.

(3) Psychological Factors

The average weight declined more or less as the OD distance got longer, but the distribution patterns were consistent and there were two peaks at about 0.2 and 0.7.

Level 3 Time Factors

(1) Traveling Time

The average weight increased with the OD distance. The basic pattern of distribution remained the same and changed corresponding to the rise of the average weight.

(2) Traveling Time Reliability

The basic pattern of distribution was not changed but the average weight rose with the increase in OD distance.

Level 3 Physical Factors

The basic patterns of distribution for scenery, safety, traffic conditions, and route complexity were the same and were not changed by the change of OD.

The utility value of each route was computed by the AHP method according to seven selection factors, or route characteristics from the answers to Question 1. According to the result and the weight of each factor, the route utility value for each driver was computed.

The average route utility value was 0.609 for route A and 0.391 for route B at OD1; 0.684 for route A and 0.316 for route B at OD2; and 0.681 for route A and 0.391 for route B at OD3.

If the route utility value for each driver was found, the most appealing route would be the route (A or B) which has a higher utility value. This route is called the maximum utility route. The frequency of the maximum utility route in case of route A, was 70.5% at OD1, 86.2% at OD2, and 86.6% at OD3. In fact, there is a route actually chosen in answering to the Question 2. In this case, the frequency was 73.4% at OD1, 90.1% at OD2 and 91.6% at OD3 in case of route A.

Next, the reliability of the AHP method against route choice behavior will be examined based on each route utility value per person and the answers (result) of Question 2.

The model is deemed reliable if the utility value of the route chosen in the answers to Question 2 is higher than that of the other routes, then reliability of this model could be tested. In this way, how the results of the Questionnaire represent route choice behavior was examined.

The results of hitting ratio were 84.8% at OD1, 88.0% at OD2 and 88.8% at OD3.

In other words, as OD distance becomes longer, the hitting ratio is considered to be higher.

Overall average weights calculated from the total data were as follows: those from level 2 are 0.4895 for the time factor, 0.1985 for expense and 0.312 for the psychological factors. Those from level 3 time factors are 0.259 for traveling time and 0.2305 for traveling time reliability. Those from level 3 psychological factors are 0.048 for scenery, 0.103 for safety, 0.0765 for traffic conditions and 0.0845 for route complexity.

4. Conclusion

The following is the outline of the analysis in this paper.

(1) The structure of route choice factors is not collateral but hierachical. Consequently, the relation between route characteristics and the choice standard among available routes can be clarified structurally.

(2) Intangible psychological factors which can not be handled by conventional quantitative analytic methods can be treated.

(3) The weight distribution of choice factor is made clear. How the distribution changes with differences between OD pairs was also learned. The results represent the actual state.

(4) The hierarchical structure of the choice factors can be evaluated by C.I. and the AHP method and the contents of the questionnaires by the hitting ratio.

3 (5) Existing routes and planned routes can be evaluated by the frequency of maximum utility route and the average utility value of each route.

(6) Another method of comparative evaluation of alternatives of this kind is the multi-attribute utility function. The method, however, has a problem in the identification of utility functions and is difficult to apply to a complicated structure. The AHP method can evaluate a complicated problem relatively easily and systematically.

Further subjects for study include:

(1) Further analysis of this problem should be made by changing the hierarchical structure according to the variety of traffic purposes, etc.

(2) The most important point in the AHP method is the value of the pair comparison matrix. The questionnaire method should be studied so that the value shall represent selection behavior. Whether or not the figures used for pair comparison are satisfactory should be also examined.

(3) Comparisons with a method based on the utility functions and the study of evaluation methods combined with the AHP method are necessary. Human behavior proceeds along illogical lines. From this standpoint, it may be interesting to do an analysis by integrating the fuzziness in to the AHP method.

We would like to thank the members of the Hanshin Expressway Public Corporation for their cooperation in distributing the questionnaires.

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