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# Route Preference Model with Traffic Information on an Arterial Road in Korea

**M. Namgung*, S.L. Sung[1], M.S. Kim[2] B.J. Lee[3]**

In this study, the stated preference survey is conducted on a main street and an alternative detour in Iksan city, South Korea, in order to analyze drivers' responses to dynamic traffic information. Logit model is used to evaluate the factors influencing drivers' route choice behavior under Advanced Traveler Information System (ATIS). This probabilistic model is calibrated for analyzing discrete choice data. The results demonstrate that route choices for drivers who receive traffic information are different from those of drivers who do not receive this information. It is also observed that the information on travel time is more effective than that on travel speed in determining the road condition.

## INTRODUCTION

Traffic information helps drivers through providing information related to travel routes, traffic situations on a given street and possible detours. On the other hand, dynamic traffic information assists drivers in choosing a proper route under a given situation. If this information is properly used, traffic flow may be optimally distributed through the entire road system, which consequently would reduce traffic congestion.

Advanced Traveler Information System (ATIS) is one of the recent attempts for enhancing the quality of road network service through increasing efficiency and smooth traffic flow on streets, which is achieved through reducing traffic congestion and accidents as well as improving the traffic environment with the help of recent rapidly developing technologies in information processing and telecommunications [1,2]. Research on traffic information technology is conducted on both hardware technology, which targets at providing better traveler information and software technology, which questions the kinds of information that are to be provided for street users and how it should be presented [3,4].

In analysis of drivers' behavior, their responses to traveler information are closely examined; furthermore, the method, timing and target of appropriate information provision are studied.

The following important questions should be considered in providing traveler information: What kind of information does a driver need? How does he perceive the given information? And how does he make decisions based on the given information? These factors have profound effects on promoting an efficient traveler information system.

A number of approaches have evolved in recent years for modeling within a-day, day-to-day, long-run pretrip and enroute-route choice behavior. Most researches have provided significant insight into how this problem should be addressed. However, one of the important factors in providing travel information is drivers' behavior. There have been two fundamental approaches for modeling route choice behavior, namely, path algorithms and discrete choice models [5]. Traveler behavior analysis is characterized by the methods used in collecting detailed data on driver's behavior (in an environment where traffic information is provided) and by the methods used to create highly valid route choice models. As implementing traffic information systems has progressed in recent years, many studies have utilized Stated Preference (SP) data based on hypothetical scenarios, however, a few studies still use Revealed Preference (RP) data or actual behavioral data [6,7].

SP approach is an excellent method for gathering

*. *Corresponding Author, WonKwang University, 344-2 Shin Yong Dong, Iksan, ChunBuk, Seoul, Korea.*
1. *SeoNam University, 720 Kwang Chi Dong, Namwon, ChunBuk, Seoul, Korea.*
2. *Taejon National University of Technology, 16-1 Tog Myung Dong, Yu Song Gu, Taejon, ChungNam, Seoul, Korea.*
3. *WongKwang University, 344-2 Shin Yong Dong, Iksan, ChunBuk, Seoul, Korea.*

data at the present time, since in this approach data can be collected efficiently and the test environment is controlled easily; whereas, ATIS has yet to be widely implemented [8,9]. Questionnaires and simulators are two general methods of gathering data. Simulators use computer graphics to assist test participants in understanding the questions, making it possible to obtain high quality data systematically. Using a simple simulator called VLADIMIR, Bonsall [10] found that differences in drivers' knowledge about the network influenced their use of roadside information signs. Fowkes, T. and Wardman, M. [11] conducted an experiment on human factors to investigate the effects of traffic advisory and route guidance information on enroute behavior. Khattak et al. [6] investigated travelers' routes, departure times and mode selection decisions through a survey of the Bay Area automobile commuters. E. Hato et al. [12,13] applied the survey to analyze drivers' behavior in acquiring and using traffic information in an environment with multiple information sources.

As an analytical research on drivers' behavior with respect to route choice under ATIS, this study examines the changes in route preference behavior before and after provision of traveler information. A model is developed here for route choice based on the kinds of information received, the purpose of travel, travel time and other factors, using discrete choice model.

The route choice model developed in this paper is expected to present an effective way of providing traveler information through an information board, installed in automobiles or in streets, which eases heavy traffic by distributing and guiding it to alternative routes.

## DRIVING AND DRIVERS' PREFERENCES

For this research, Iksan city in South Korea was chosen as the study area, where the street that runs through downtown is shorter than the detour. Although the street through downtown should take less time than the detour, heavy traffic may drag the speed down and make the detour the faster route.

Traveler information can disperse the traffic demand when there are differences in volume of traffic on street network of a city depending on time and place. The time spent on the downtown street and detour, in fact, tends to vary according to time of travel.

A survey on the chosen route was performed by checking the license plates of vehicles on both the downtown street and detour in Iksan city, which is mapped out in Figure 1. Figure 2 summarizes the survey results and demonstrates the average time and speed on both the downtown street and detour for different trip types. The downtown street is 2.6

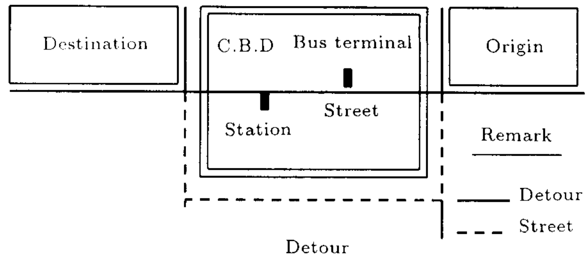


**Figure 1.** Outlined area sketch of the tested place.

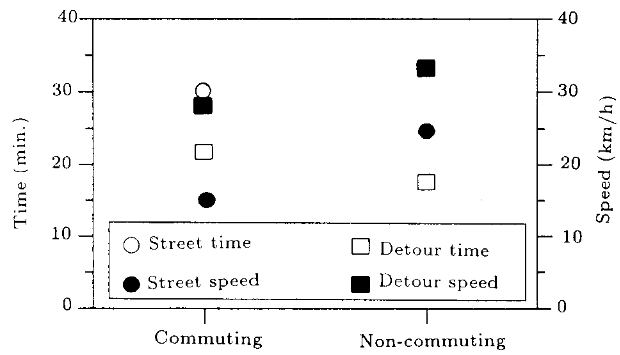


**Figure 2.** Average time and speed for each trip type.

km shorter than the detour; however, during rush-hours, going via the detour takes 6 minutes less and the speed of the automobile is about 12 km/h faster compared with that in the downtown street. During non-commuting hours, almost the same time was spent on both streets to get to a destination, though the vehicle speed was 9 km/h faster on the detour.

Comparative information is prepared for travelling time and vehicle speed on both the downtown street and detour during commuting and non-commuting hours based on the survey illustrated in Figure 2. Then, the stated preference survey method is used to investigate drivers' responses when drivers had access to comparative information.

Stated Preference data (SP data henceforth), in general, covers personal preferences and, thus, includes all stated conscious data; however, in this study, SP data is restricted to drivers' preferences concerning virtual alternative routes.

In SP survey of this study, the information difference was measured based on a method of experimental design of profiles at 4 different travelling times and speeds for each survey respondent. The survey was designed to allow plural choices by presenting selective combinations of questions, as in Table 1, rather than presenting all possible combinations of questions.

A summary of the surveyed items is given below:

- Questions on personal and demographic factors like: age, sex, occupation, total daily driving time, driving experiences on the downtown street and on the detour,

**Table 1.** Factors and levels of profiles.

| Factors | Levels |
|---|---|
| Trip type | Commuting / non-commuting |
| Route taken | Downtown street/detour |
| Travel time information | 10 / 15/ 20 / 25 / 30 min |
| Travel speed information | 30 / 40 / 50 / 60 / 70 / 80 km/h |
| Difference in travel time information | ±0 / ±5 / ±10 / ±20 min |
| Difference in travel speed information | ±0 / ±10 / ±20 / ±30 km/h |

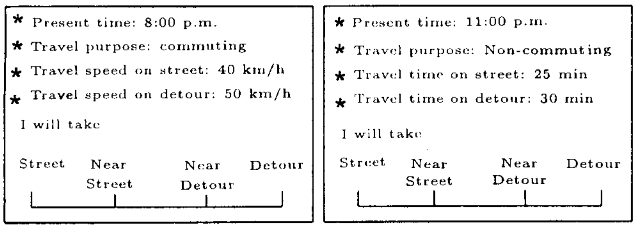


**Figure 3.** Outline of survey questions on route choice with traveler information based on the block planning.

- Questions given before providing information like: time spent on travelling (maximum, minimum and average), route chosen according to the streets and purpose of travelling (commuting vs. non-commuting),
- Questions given after providing information; four types of information were presented, respectively, on the vehicle speed and time spent on each route depending on the purpose of travelling (commuting or non-commuting), see Figure 3.

In this survey, for drivers from Chonju or Kimje travelling to northern areas of Iksan, the commuting or non-commuting time were considered. Out of 1,000 distributed survey questionnaires, 589 of 640 collected questionnaires were accepted as being valid. The total number of SP data, which were meaningful for model development, was 2,356 for route travelling time and speed.

## CONSTRUCTION OF DRIVERS' ROUTE CHOICE MODEL

### Kinds of Information and the Purpose of Travel

First, the route choice model of a driver after providing traveler information is discussed. Then, influence of information type and variety on driver's route choice is analyzed.

The expected utility, $V_i$, of the detour $i$ that a driver chooses is calculated by the following equation:

$$V_i = \theta_1 X_{1i} + \theta_2 X_{2i} + \theta_3 X_{3i} + \theta_0, \quad (1)$$

where $X_{1i}$ is the traveler information (either information on travel time or speed) of the detour; $X_{2i}$ is the traveler's previous experiences concerning the detour; $X_{3i}$ is the chosen route before providing the information; $\theta_0$ is a constant; and $\theta_1$ to $\theta_3$ are the parameters for each variable. The expected utility, $V_j$, of the downtown street $j$ can be presented by:

$$V_j = \theta_1 X_{1j} \ , \quad (2)$$

where $X_{1j}$ is the variable of the model.

It has been assumed that drivers consider the expected utilities of each route and select a route with the higher expected utility. In this case, the probability of choosing the detour is calculated by:

$$P_i = \frac{\exp(V_i)}{\exp(V_i) + \exp(V_j)} \ . \quad (3)$$

Table 2 represents the route choice model using Equation 3, with regard to the kind of information given.

The $t$-test was used to confirm the significance of the estimated parameters. Since the statistically significant $t$-value at 99% significance level is 2.576 and the $t$-value of every parameter (except the constant for non-commuting travel with time information for the detour) was $|t_k| \geq 2.576$, the values are all statistically significant and the corresponding explanatory variables, at 99% confidence level, are all influential factors in terms of probability of route choice.

As a result of the analysis of the route choice model based on the type of traveler information, the parameter of time information appeared greater than that of vehicle speed. The estimated parameters of commuting and non-commuting trips were almost the same for models based on speed information. For travel time information, the parameters of commuting trips were generally, larger than those of non-commuting trips, indicating that the non-commuting parameters have elasticity.

Figures 4 and 5 compare the preference ratio of the route choice model predictions with their respective observed values for the detour according to the type of information given about the downtown street and detour. If time information was given, the two rates coincide, whereas if vehicle speed information was given, the predicted rate tends to be higher than the

**Table 2.** Results of the route choice model depending on the kind of information and the travel purpose.

| Variables | Travel Time Information | | Travel Speed Information | |
|---|---|---|---|---|
| | **Commuting** | **Non-Commuting** | **Commuting** | **Non-Commuting** |
| Travel time information (min) | -0.140 (-15.9) | -0.105 (-8.1) | | |
| Travel speed information (km/h) | | | 0.070 (12.4) | 0.061 (12.0) |
| Detour experience dummy (> 4 = 1) | 0.765 (5.0) | 0.779 (3.1) | 1.094 (5.7) | 0.805 (4.4) |
| Expected route dummy (detour = 1) | 1.378 (7.1) | 1.014 (3.3) | 1.741 (7.4) | 1.338 (5.9) |
| Constant on detour | -1.023 (-5.1) | -0.492 (-1.5) | -1.341 (-5.5) | -1.114 (-4.7) |
| Number of samples | 1263 | 421 | 842 | 842 |
| Initial likelihood, $L(0)$ | -863.6 | -284.7 | -544.7 | -557 |
| Maximum likelihood, $L(\hat{\theta})$ | -644.7 | -234.3 | -406.8 | -443.2 |
| Adjusted likelihood ratio, $\bar{\rho}^2$ | 0.251 | 0.169 | 0.250 | 0.201 |
| Hit ratio (%) | 74.2 | 72.4 | 77.0 | 76.5 |

(): $t$-value

observed rate. It was found that the parameter values of the model were negative when time information was provided but positive when vehicle speed information was given, indicating that the model is reasonable.

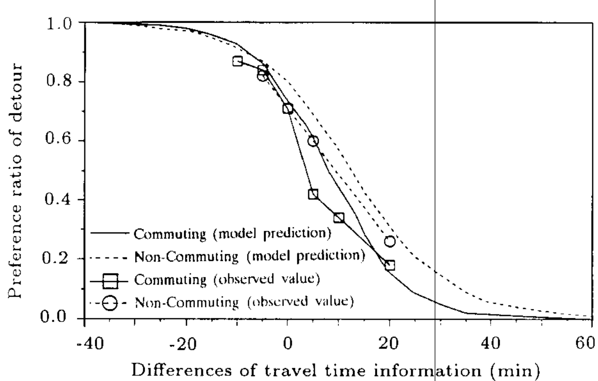


**Figure 4.** Comparison of the model presented here and observed values with time information.

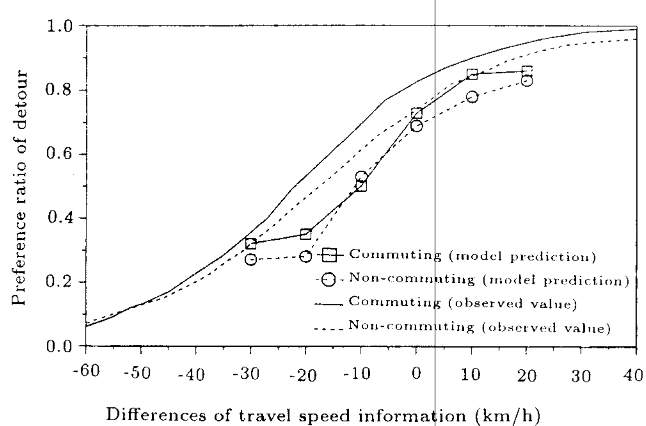


**Figure 5.** Comparison of the model pesented here and observed values with vehicle speed information.

## Driving Time

Tables 3 and 4 present the route choise model when travel time and travel speed, are given as information, respectively. In these tables, "short driving" means less than 2 hours of driving day and "long driving" more than 2 hours a day.

To test the significance of the estimated parameters, $t$-test was used. In the case of long-time non-commuting trips with travel time information, most parameters are statistically significant, because $t$-value was 1.96 with a 95% efficiency level and the $t$-values of all parameters except the experimental variable are $|t_k| \geq 1.96$. Moreover, each variable with a 95% confidence degree might be considered a factor having an effect on a choice probability.

Comparison between the parameters of the traffic information variables reveals that short driving are more influenced by route choice due to a higher value for parameter of traffic information.

It should also be noted that in this model, the sign condition is satisfied and the sign of travel information for time (negative) and for speed (positive) are consistent with what has been expected. Moreover, it is more efficient to offer traffic information to commuters, because they show more sensitivity towards traffic information in their route choice than non-commuters.

## CONCLUSION

In this study, a route choice analysis of a CBD route and its alternative detour has been conducted considering the provided traffic information. Moreover, the stated preference survey has been carried out to evaluate this effect. Route choice models have been established using logit model which have the information categories of driving purpose and daily

**Table 3.** Results of the route choice model according to the driving time when travel time information is given.

| Variables | Short Driving | | Long Driving | |
|---|---|---|---|---|
| | Commuting | Non-Commuting | Commuting | Non-Commuting |
| Travel time information (min) | -0.148 (-11.9) | -0.121 (-6.5) | -0.133 (-10.4) | -0.088 (-4.8) |
| Detour experience dummy (> 4 = 1) | 0.440 (2.3) | 0.721 (2.2) | 1.109 (3.6) | 0.792 (1.6) |
| Expected route dummy (detour = 1) | 1.334 (4.9) | 0.885 (2.0) | 1.418 (5.5) | 1.156 (2.7) |
| Constant on detour | -0.960 (-3.6) | -0.349( -0.8) | -1.254 (-3.5) | -0.629(-1.1) |
| Number of samples | 678 | 226 | 585 | 195 |
| Initial likelihood, $L(0)$ | -469.2 | -155.2 | -388.3 | -128.4 |
| Maximum likelihood, $L(\hat{\theta})$ | -347.4 | -122.6 | -290.4 | -110.3 |
| Adjusted likelihood ratio, $\bar{\rho}^2$ | 0.255 | 0.195 | 0.247 | 0.123 |
| Hit ratio (%) | 72.3 | 73.5 | 75.7 | 71.8 |

(): $t$-value

**Table 4.** Results of the route choice model according to the driving time when travel speed information is given.

| Variables | Short Driving | | Long Driving | |
|---|---|---|---|---|
| | Commuting | Non-Commuting | Commuting | Non-Commuting |
| Travel speed information (km/h) | 0.071 (9.4) | 0.069 (9.5) | 0.070 (8.0) | 0.053 (7.3) |
| Detour experience dummy (> 4 = 1) | 0.769 (3.2) | 0.770 (3.3) | 1.750 (4.6) | 0.994 (2.8) |
| Expected route dummy (detour = 1) | 1.418 (4.3) | 1.538 (4.7) | 2.144 (6.2) | 1.167 (3.7) |
| Constant on detour | -0.954 (-3.0) | -1.229 (-3.9) | -2.128 (-4.7) | -1.176 (-2.8) |
| Number of samples | 452 | 452 | 390 | 390 |
| Initial likelihood, $L(0)$ | -301.7 | -303.0 | -239.9 | -253.4 |
| Maximum likelihood, $L(\hat{\theta})$ | -229.9 | -231.6 | -172.4 | -210.0 |
| Adjusted likelihood ratio, $\bar{\rho}^2$ | 0.230 | 0.229 | 0.274 | 0.163 |
| Hit Ratio (%) | 76.5 | 76.8 | 80.3 | 75.9 |

(): $t$-value

driving time. Results of a comparative study of a modified likelihood rate, conducted to determine the appropriateness of the established model, show that this model is most appropriate during the commuting time.

Extremely low $t$-test values are not observed for the estimated parameters and most of the $t$-values show a significance of over 95%. The analysis of the route choice model demonstrated higher parameter values for travel time information compared to travel speed information. Furthermore, the $t$-test value for the estimated parameter of travel time was higher than that of travel speed. Thus, travel time information showed a higher elasticity than travel speed information.

The value of the parameter was (-) with time information and (+) with speed information; thus, the model presented in this study satisfies the sign condition. For drivers, who had a long driving time, the likelihood rate was especially low. The more experienced drivers showed a more fixed pattern and less variety in their route choices due to lower parameter value in the utility function.

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