IMPACT OF ATIS ON ROUTE CHOICE

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ABSTRACT

Advanced Traveler Information Systems (ATIS) are those vehicle features which assist the driver with planning, perception, analysis, and decision-making to improve the convenience and efficiency of travel. Information is a key to decision-making, and route choice is one of the most important decisions that the driver makes either before starting his trip or while driving en route. In this paper, several statistical analyses methods were performed on data collected from three waves of route choice surveys. The analyses yielded insight on the factors that affect traffic information use and route choice. The results indicated that traffic information is one of the main factors influencing route changes. This paper addresses the possible impact of ATIS on drivers route choice, and the interplay between route choice and traffic information. The results' implications for ATIS development is discussed in the paper.

1. INTRODUCTION

Extensive international interest in Intelligent Vehicle Highway Systems (IVHS) has generated a surge of research in the transportation field. This research has dealt with important technological issues, optimal control, human factors concerns, and travelers' behavioral responses. Advanced Traveler Information Systems (ATIS) is one area under IVHS that is strongly influenced by travelers' behavioral responses. In cases in which travelers have access to dynamic pre-trip or en route information, they may decide to acquire and use this information, and therefore revise their pre-selected travel pattern by switching to an alternate route.

The important role that traveler route choice behavior plays in ATIS has motivated numerous studies. Some of these studies have been conducted in a controlled laboratory setting using

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human subjects making repeated route choice decisions (e.g., Vaughn et al., 1993; Bonsall and Parry, 1990; Mahmassani and Herman, 1990), and some have attempted to provide insights using observed traveler route choice behavior (Abdel-Aty et al., 1994; Khattak et al., 1991; Haselkorn et al., 1991). While past work has clearly provided valuable insight, commuters' actual route diversions, route choice decision-making, and the potential impact of traffic information have not been adequately investigated.

The focus of this paper is on investigating the impact of traffic information, and the potential impact of ATIS, on drivers' route choice. Drivers' route switching decisions when faced with a traffic related incident will also be studied.

2. BACKGROUND AND EMPIRICAL SETTING

Direct empirical evaluation of commuters' collection and processing of traffic information would be an exceedingly difficult task. However, an indirect approach, that focuses on commuters decisions and route changing and relate such changing to factors determining information needs, can readily be undertaken and still provide valuable insight into the route choice decision-making process. Traffic information is widely available in the study area. To achieve these objectives we use data collected from three route choice surveys, conducted in May 1992, May 1993, and October 1993 of the Los Angeles area morning commuters. These surveys focused on commuters' behavior and decision-making. These surveys also provided important data on commuters' acquisition and use of pre-trip and en route traffic information available from numerous sources (e.g., radio), and their willingness to change routes in response to this information. The traffic information available in Los Angeles is similar to the traffic reports provided in most urban areas. Los Angeles commuters have access to traffic information from numerous radio stations that gives updates during peak periods. In addition, morning television provides information on traffic conditions from major freeways. Although this information differs from the information that would be provided by ATIS, valuable insights regarding ATIS effectiveness can still be gained. This is because the behavioral barriers, to use traffic information, are likely to transfer from one information system to another (Schofer et al., 1993). The possible impact of ATIS on route choice is investigated in the surveys using several stated preference techniques.

The first survey was conducted in May 1992 and yielded 944 completed interviews. The survey collected the respondents' specific commute routes and information that the respondents receive before and during their commute, and its effect on their route switching and decisions. Table 1 presents statistics from the sample related to traffic information acquisition and use. The second survey was conducted in May 1993 targeting the same sample of the first interview. A total of 564 was successfully contacted and interviewed. This survey was primarily concerned with investigating commuters decision-making, and perceptions and decisions regarding several commute characteristics, beside any changes that took place during the preceding year. A third and final survey was designed and conducted in October 1993. It is a mail-out/mail-back customized survey instrument targeting the same respondents interviewed in the CATI surveys. Based on each respondent's origin (home) and destination (work), and using GIS capabilities and network database minimum path routes were generated. The actual commute route for each respondent is presented in the questionnaire together with the generated fastest route. Several attitudinal and hypothetical questions about both routes are designed to develop models of route choice. Stated preference binary choice scenarios were also customized for each respondents using his actual commute route and travel time. ATIS is introduced in these scenarios as a system that predicts travel time and the cause of any delays. Such design enabled the investigation of the effect of ATIS on route choice. Detailed description of the surveys' design and data collected is contained in previous papers (Abdel-Aty et al., 1993; 1994; 1995).

Table 1: Traffic information acquisition and use (percent of the sample)

Listen to pre-trip traffic reports	36.5
Listen to en route traffic reports	51.3
Listen to both pre-trip and en route	27.6
Rate traffic reports as extremely or very accurate	50.0
Divert when faced with a traffic related incident	29.1
Only respondents who listen to pre-trip traffic reports:	
Change departure time due to pre-trip reports	41.1
Change route at least once per month due to pre-trip traffic reports	44.2
Listen to pre-trip reports every day	63.7
Receive traffic reports by radio	71.9
Receive traffic reports by TV	28.1
Only respondents who listen to en route traffic reports:	
Change route at least once per month due to en route reports	43.1
Listen to en route reports every day	55.2
Receive traffic reports by radio	95.3
Receive traffic reports by VMS	4.7

3. JOINT ESTIMATION OF ROUTE SWITCHING AND INFORMATION ACQUISITION

To assess commuters' propensity to change routes and acquire traffic information, we focus on the joint decision on whether or not commuters follow the same route to work every day and whether or not they receive traffic information (pre-trip or en route). The objective is to examine the association between information use and route choice. For such a joint decision, the bivariate (two-dimensional) probit formulation is appropriate. The modeling methodology is explained in previous paper by the authors (Abdel-Aty et al., 1994).

Gaining an understanding of this issue will aid in how traffic conditions and other factors affect the use of traffic information and route switching. In particular, building a model that predicts route-switching behavior as a function of information use will aid in evaluating the potential impacts of ATIS on route choice.

Two bivariate probit models were developed after investigating several alternative model formulations. The first estimating whether respondents often receive traffic reports before leaving home to work (pre-trip), and whether they are multiple route users. The second estimating whether respondents often receive traffic reports while driving to work (en route), and whether they are multiple route users.

Estimation results for the pre-trip information / multiple route user model are given in Table 2. All variables included are self-explanatory and their coefficients are readily interpretable.

Turning first to the pre-trip information model, we find that people who perceive no variation in traffic conditions on their usual commute route are less likely to listen to pre-trip traffic reports. Females, long distance commuters and/or respondents who reported uncertainty in travel time as a major problem, are more likely to listen to these reports.

For multiple route choice model, high income (≥ $75,000), high level of education (college graduate or completed some college), and the number of days driving to work in two weeks increases the likelihood of using multiple routes. The positive coefficient of receiving pre-trip information indicates that commuters that receive pre-trip information are more likely to use more than one route to work, while the significance of the variable indicates the important effect of receiving pre-trip traffic information on using multiple routes.

Estimation results for the en route information / multiple route user model is similar to the previous model, except that gender is replaced by a college graduate dummy variable, which significantly increases the likelihood that a respondent receives en route traffic reports. The positive coefficient of receiving en route information indicates that commuters who receive en route information are also more likely to use more than one route to work.

Table 2: Bivariate probit model estimating whether the respondent receives traffic reports before leaving home to work, and whether he is a multiple route user.

	Coefficient	t-stat
PRE-TRIP INFORMATION MODEL		
Constant	-0.416	-3.79
X_1 No variation in traffic conditions dummy (1 if no variation is perceived, 0 otherwise)	-0.361	-3.68
X_2 Female dummy (1 if female, 0 otherwise)	0.110	1.15
X_3 Uncertainty of travel time dummy (1 if reported that trip time uncertainty is a major problem, 0 otherwise)	0.436	3.23
X_4 Distance from home to work	0.013	3.40
MULTIPLE ROUTE MODEL		
Constant	-2.033	-6.95
X_5 Income dummy (1 if income ≥ $75,000, 0 otherwise)	0.302	2.43
Y_1 Receiving pre-trip information dummy (1 if receive pre-trip information, 0 otherwise)	1.002	2.74
X_6 No. of driving days in the last 2 weeks	0.032	1.26
X_7 Level of education dummy (1 if respondent is a college grad. or completed some college, 0 otherwise)	0.409	2.55
Error-term Correlation	-0.518	-2.38

Summary Statistics
Log Likelihood at zero = -1061.761
Log Likelihood at market share = -790.804
Log Likelihood at convergence = -758.191
Likelihood ratio index = 0.286
Number of observations = 733

Note: Variables' coefficients are defined for receiving reports and multiple route use

4. ANALYSIS OF ROUTE SWITCHING DECISIONS IN CASE OF AN INCIDENT

In an attempt to understand commuters' decisions when faced with a specific event or traffic related problem, the respondents were asked if they could remember a specific traffic event -- or traffic related problem on their usual commute route -- that caused unusual congestion within the last month, and what was their reaction. The commuters had to choose one of the following three alternatives:

1. Stay on the same route (either in traffic or get off then continue).
2. Divert to another route.
3. Divert only around the location of the problem.

The multinomial logit model (MNL) is used to estimate commuters' choice when faced with an unexpected incident. Estimation results for the MNL are given in Table 3. Examining specific coefficient estimates, we find that females are more likely to stay on the same route when encountering incident-related congestion, indicating their reluctance to divert from their route.

It is also found that the carpool dummy variable has a positive coefficient, showing that carpoolers tend to divert from their used route either to another route or around the location of the problem.

Perceiving not driving through unsafe neighborhoods as extremely or very important, increases the probability of the commuter staying on his route, and not risking diversion which might lead him to unfamiliar routes that could be unsafe. While commuters perceiving less congestion as extremely or very important are less likely to stay on the same route but try to avoid congestion by diverting.

Receiving en route information is most likely to be a dependent (endogenous) variable, therefore the utility of receiving en route information was estimated using a binary logit model (Abdel-Aty et al., 1993). The variable was then entered (instrumented) in the MNL. The variable has a positive coefficient, indicating that individuals who receive information en route are more likely to divert around the location of the problem, possibly because of advice given by the traffic information source after starting their trip.

The same model was estimated again by instrumenting receiving pre-trip information, using a the binary logit model (Abdel-Aty et al., 1993), and entering the variable with alternatives 2 and 3. The model is close to the previous model. Pre-trip information also increases the likelihood of diversion either to another route or around the problem. Contrasting the effect of en route and pre-trip information, it is possible to realize that individuals receiving en route information are more likely to divert only around the problem, while individuals receiving pre-trip information know the problem in advance, and have the option of planning another route and avoiding the route which has the problem, or diverting only around the location of the problem.

5. THE EFFECT OF TRAVEL TIME VARIABILITY ON ROUTE CHOICE

Investigating the effect of travel time variation on commuters' route choice would be very difficult largely because it is extremely time consuming to collect data that support the analysis. Therefore, in the context of this study there is no alternative but to solicit preferences in hypothetical settings, as often done in many marketing research contexts.

Table 3: MNL estimating the respondent's choice when faced by a traffic related problem (accident, severe congestion, etc.) during the last month, including the effect of En route information.

	Coefficient	t-stat.
Stay on the same route constant	2.0741	3.373
Divert to another route constant	0.2289	0.858
X_1 Female dummy variable (1)	0.7582	2.358
X_2 Carpool dummy variable (2,3)	0.8351	1.978
X_3 Perceive not driving in unsafe neighborhood as very or extremely important (1)	0.9315	2.019
X_4 Receive en route information - instrumented (3)	0.4434	1.986
X_5 Perceive less congestion as very or extremely important (1)	-1.1113	-1.884

Summary Statistics
Log Likelihood at zero = -250.484
Log Likelihood at convergence = -171.978
Likelihood ratio index = 0.313
Number of observations = 228

Note: Alternative 1 = stay on the same route , Alt.2 = divert to another route, Alt.3 = divert only around the location of the problem. Variables coefficients are defined with the alternative indicated in parentheses.

Five stated preference choices are included in the second CATI survey. In each choice the respondent is asked to choose between two hypothetical routes. The first route has fixed travel time everyday (5 days a week), while the second route has a possibility that the travel time increases on some day(s). For example, Route 1 has a travel time of 30 minutes everyday, while Route 2 takes 20 minutes 4 days per week and 40 minutes one day per week. In this case the respondent is informed that if he chooses Route 1, he is certain that travel time will be 30 minutes everyday, but if he chooses Route 2 he must expect that it is possible on any one day of the week that travel time could be 40 minutes, and 20 minutes on the other 4 days. The choices are designed such that the travel time on the first route is always longer and certain, while that of the second route is shorter but uncertain. The mean travel time on the second route changes and reaches in some choices the mean of route 1. The sequence of the choices are randomized across respondents in order to avoid any ordering biases.

A binary logit model is developed with individual-specific random error components and normal mixing distribution to account for using more than one observation from each respondent (for a description of the methodology used, please refer to Abdel-Aty et al., 1995). The overall observations are used to estimate the model, which gives a total of 2820 observations (i.e., 564 respondents each making 5 choices).

The model is presented in Table 4, and shows that commuters' perceptions and attitudes have important effect on their choice, that is, if the respondent perceives shorter travel distance as extremely or very important, then he is likely to choose route 2 trying to minimize his travel time. Gender also had a significant effect on route choice. Males are found to be more likely to choose route 2. This indicates that males are more risk prone, and are ready to choose uncertain routes trying to minimize their travel time.

The standard deviation of the travel time on route 2 has a negative coefficient, indicating that the more the variation in travel time on route 2, the less likely this route is to be chosen. This result shows that commuters realize travel times and its variability on their alternative routes and try to minimize them. Also, the larger the difference in the expected travel time between Route 1 and 2, the more likely the respondent chooses route 2, indicating that commuters realize the saving in travel time and chooses the route which achieves a minimum travel time. These two variables show clearly that commuters try to minimize their travel time, but only if travel time variation is acceptable. If travel time varies significantly on a particular route then they will choose the longer and certain route.

Receiving traffic information is a very significant variable in this model. Information is more likely to affect the degree of uncertainty, and hence influences the commuter's route choice. Acquiring pre-trip traffic information was instrumented using a binary logit model (Abdel-Aty et al., 1993). The variable has a significant positive coefficient which indicates that commuters who listen to pre-trip information are more likely to choose the uncertain route, possibly because they are confident that they can know if there is delays on a particular day, and avoid this route. The significance of the information variable validates the SP choice sets used in this study, because people do acquire information in the real world to reduce their uncertainty. A second model describing the route choice with normal mixing distribution is estimated. This model is similar to the previous model, but receiving pre-trip traffic information is substituted by receiving en route information. The model is similar to a large extent to the previous one and shows also the significant effect of en route information on route choice.

Table 4: Estimates of the model describing route choice with normal mixing distribution and Gaussian quadrature estimation, including the effect of pre-trip traffic information.

		Coef.	t-stat.
	Constant	-2.394	-5.89
X_1	Attitude toward shorter distance dummy (1 if extremely or very important, 0 otherwise)	0.550	3.26
X_2	Standard deviation of travel time on Route 2 (min.)	-0.067	-6.32
X_3	Difference in expected travel time between Route 1 & 2 /week	0.067	10.31
X_4	Receive pre trip information - instrumented	0.416	2.54
X_5	Male dummy variable	0.548	3.25
σ	Standard Deviation of ξ_i	1.462	13.51

Summary Statistics
Log Likelihood at zero = -1954.675
Log Likelihood at market share = -1784.392
Log Likelihood at convergence = -1133.804
Likelihood ratio index = 0.419
Number of observations = 2820

Note: Variables' coefficients are defined for route 2

6. ROUTE CHOICE MODEL INCLUDING THE EFFECT OF ATIS

The main objective of this section is to investigate the effect of ATIS together with roadway type, travel time and familiarity with a particular route, on the route choice. Stated preference (SP) methods become an attractive option in transportation research when revealed preference methods cannot be used in a direct way to evaluate the effect or demand for non-existing services (e.g., ATIS). SP methods are easier to control, more flexible, and economical as each respondent may provide multiple observations for variations of the explanatory variables.

In the third mail survey, each respondent is provided with three scenarios, in each, he has to choose between two routes. The choices is binary, route 1 is customized for each respondent so that the SP design would be as realistic as possible, while route 2 is hypothetical. For route 1 it is stated: **"Your primary route using ...."** and then a segment of the respondent's actual route is written. The travel time of route 1 is the respondent's actual commute time as he stated it in the CATI surveys, and the road type is the actual route type of his primary route (mainly freeway, mainly surface streets or freeway/surface streets). The objective here is to use the route that the respondent is familiar with, and make the SP design realistic.

Traffic information is available on either route 1 or route 2, but not both. If traffic information is available then an estimation of the travel time on that day is given. In case the information system estimates travel time above the normal, then the cause of the delay is given to the respondent. The cause of the delay is either: accident, maintenance, stalled vehicle, or regular congestion. Advanced traffic information systems (ATIS) were defined to the respondents as: "a system that can offer you personalized information about your trip, and advise you with other routes to take while considering current traffic conditions".

A binary logit model is developed to estimate the commuters' choice between route 1 (customized according to the respondent's actual primary route and his travel time) and route 2 (a hypothetical alternative route). The overall observations are used to estimate the models, this gives a total of 417 observations (i.e., 139 respondents each making 3 choices).

The model is presented in Table 5. The model shows that commute distance has a significant effect on route choice. The positive coefficient of the log of commute distance on the actual primary route (route 1) indicates that respondents with longer distances tend to choose the alternative route (route 2). This indicates that people with long commutes are more disposed to trying out an alternative route in an attempt to minimize their trip. The use of the log transformation indicates that this effect is non-linear, with marginal increases in distance playing a stronger role in shorter commutes.

As the percent of "normal travel time on route 2 to the normal travel time on route 1" increases, the less likely the respondents are to choose route 2. This variable shows that the respondents compare the travel time on both routes to make a route choice decision that minimizes their travel time.

The roadway type is also significant on route choice. If route 2 involves freeway use then this route are more likely to be chosen, indicating the existence of freeway bias. The result also supports the results of the RP model, that is commuters preference for fewer different roadway segments on their route, which is probably the case with the use of freeways.

If the information system predicts a travel time on route 2 that is less than the travel time on route 1, then this increases the likelihood of route 2 being chosen. This variable shows the importance of a travel information that provides travel time estimates.

Age was the only socioeconomic variable to enter into the model. Older respondents are found to be less likely to use route 2, probably because this is considered an unfamiliar route. They apparently prefer to use their primary route and don't risk using an alternative. Commuters perception of the reliability of their actual commute route affects their choice. Respondents who perceive their actual commute route (route 1) to have good or excellent travel time reliability were less likely to choose route 2. This indicates their confidence in their route.

Table 5: Estimates of stated preference route choice model with normal mixing distribution and Gaussian quadratures estimation.

		Coef.	t-stat.
	Constant	0.103	0.10
X_1	Log of commute distance in miles	0.631	1.97
X_2	Normal travel time on route 2 / normal travel time on route 1	-1.585	-1.55
X_3	Freeway use dummy variable (if route 2 is mainly freeway or includes freeway, 0 otherwise)	0.412	3.18
X_4	ATIS dummy variable (1 if predicted travel time on route 2 $<$ normal travel time on route 1, 0 otherwise)	1.204	3.37
X_5	Old age dummy variable (1 if $>$ 55 years, 0 otherwise)	-0.545	-1.46
X_6	Travel time reliability on route 1 dummy variable (taking on the value of 1 if travel time reliability on actual primary route is perceived to be good or excellent, 0 otherwise)	-0.552	-2.18
σ	Standard Deviation of ξ_i	0.613	2.46

<u>Summary Statistics</u>

Log Likelihood at zero = -289.042
Log Likelihood at market share = -270.978
Log Likelihood at convergence = -192.961
Likelihood ratio index = 0.332
Number of observations = 417

Note: model coefficients are defined for route 2

7. CONCLUSIONS AND IMPLICATIONS FOR ATIS

This paper investigated the potential impact of ATIS on route choice. Several modeling techniques were used to represent drivers' behavior in route choice and route switching, including the effect of traffic information either pre-trip or en route. The models showed several significant factors that influence route choice and traffic information acquisition. Traffic information was consistently found to influence route choice and route switching.

The implications of the results for ATIS could be summarized as follows:

- There exist indications of the preference for pre-trip traffic information, especially by certain groups (e.g., freeway users and females).
- Traffic information acquisition increases the possibility that commuters' use more than one route.
- Information acquisition increases the likelihood of diversion around incidents.
- Strong indication of the importance of travel time reliability for route choice, which means that:

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travel time is not the dominant route choice criteria,
avoid advising commuters to uncertain routes even if the minimum path,
there is a need to develop reliability measures as part of ATIS, and
there is a need to investigate whether to display reliability information to drivers.

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