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IMPACT OF TRAFFIC INFORMATION ON COMMUTERS' BEHAVIOR: EMPIRICAL RESULTS FROM SOUTHERN CALIFORNIA AND THEIR IMPLICATIONS FOR ATIS

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ABSTRACT

This paper presents a statistical analysis of commuters' travel behavior, information use and their impact on the development of Advanced Traveler Information Systems (ATIS). The analysis is based on a 1992 computer-aided telephone interview survey of Los Angeles area morning commuters. Cross tabulations are performed on the data to explore interrelationships among variables and provide a basis for subsequent model estimation.

Two models are estimated. The first is a multinomial logit model of whether a commuter receives both pre-trip and enroute traffic information, only pre-trip information, only enroute information, or doesn't receive any information. The second model is a bivariate probit of whether an individual receives pre-trip information and whether the individual receives enroute information. The estimation results of the logit model showed significant effect of several commute characteristics and socioeconomic attributes on the choice to receive traffic information either enroute, pre-trip, or both. Freeway use and commute time are among the factors that increase the likelihood of receiving traffic information; the model also showed significant effect of gender and education on the willingness to acquire and use information.

Bivariate probit models not only supported the results of the logit model but also indicated very significant relation between the propensity of receiving enroute and pre-trip information. The results indicate that commuters who receive pre-trip traffic information are less likely to receive enroute information as well, suggesting the significance of pre-trip information.

INTRODUCTION

In an ongoing Partners for Advanced Transit and Highways (PATH) project at US Davis, ATIS Impact on Travel Demand, a variety of issues regarding traveler response to information are being investigated (see, for example Vaughn, et. al.,[1,2] Yang, et. al.,[3] Abdel-Aty, et. al.[4]). These early papers focused on development of learning models of drivers adaption to traffic advice, particularly when the advice is not always correct. A second objective of the project deals with studying the actual route choices of drivers and the effect of traffic information on these choices, with the objective of developing refined route choice models that can include the effect of traveler information. This paper is concerned with the second objective of the project.

To probe into drivers' route choice behavior, a telephone survey of Los Angeles area morning commuters has been conducted. The survey is designed to investigate how much information drivers have about their routes, their awareness of alternate routes, their awareness of traffic conditions which could affect their route choices, and their use of available traffic information either enroute or pre-trip or both. The survey, undertaken in May and June, 1992, is differentiated from previous studies in that the specific routes taken by individuals are obtained for their morning commute. In addition to the reported analyses of route choice behavior, the specific routings will be used in subsequent studies to understand choice behavior on real routes.

This paper describes the survey design and presents general descriptive statistics that show the characteristics, preferences and perceptions in commuters'

route choice behavior. The paper concentrates on commuters' willingness to acquire traffic information. Previous papers investigated the effect of information on route choice.[5,6] A multinomial logit model is estimated of whether a commuter receives both pre-trip and enroute traffic information, only pre-trip information, only enroute information, or doesn't receive any information. Bivariate probit models were chosen to describe each commuter's use of traffic information pre-trip and enroute. This paper presents new modeling of traffic information acquisition, building on previous more general analyses of route choice behavior and information use with the same data set.[5,6]

ROUTE CHOICE SURVEY

The route choice survey utilized the computer-aided telephone interview (CATI) technique. A CATI survey allows interviewer/respondent interaction and automatically handles branchings with complete reliability and lower interviewer error. It is also believed to yield a higher response rate than a mail survey.

The survey targeted a random sample of adult commuters residing in the area covered by the South Coast Air Quality Management District, which includes most of the contiguously populated areas of Los Angeles, Orange, San Bernardino and Riverside Counties. The sampling, based on a Mitofsky-Waksberg cluster sampling design[7] covered both listed and unlisted numbers. The Mitofsky-Waksberg sampling reduces the number of unproductive dialings, and improves efficiency.[8]

The Survey Content

The following information was obtained from each respondent:

- Identification of the specific primary commute route by segment (each different road/freeway in sequence for the entire commute route).
- Availability of alternate commute routes, and identification of the secondary route by segment.
- Detailed information on both primary and secondary routes, including perceived traffic conditions.
- Individual's perception of the severity of different types of delays and other problems.
- Traffic Information that the respondent receives before and during the commute, and its effect on behavior and awareness of the highway/street network.
- Demographic and socioeconomic data, including household income, gender, employment status, and education level.

Description of the Sample

In all, 944 commuters were surveyed, in May and early June 1992. Summary statistics for the sample are presented in Table 1.

• Commute distance on usual route (miles)	12.75
• Travel time on usual route (minutes)	28.14
• Trip duration (including stops)	31.9
• Percent of respondents commuting in single-occupant autos/carpool/public transit	78.8/14.6/4.9
• Percent receiving pre-trip traffic reports	36.5
• Percent receiving en-route traffic reports	51.25
• Percent of respondents with flexible/ somewhat flexible / fixed work starting time	24.4/30.4/45.2
• Percent male/female	51.3/48.7
• No. of household cars	2.31
• No. of years at present address	7.24
• No. of years at present job location	5.52
• Percent own/rent their homes	59/41
• Household income	38,750
• Percent of college graduates	43.8
• Think traffic congestion is a problem or major problem (percent)	61.3
• Think trip time uncertainty is a problem or major problem (percent)	31.9

Table 1. Sample Summary Statistics (Averages Unless Noted)

To test the representativeness of the sample for the study area, several socioeconomic and commute characteristics were compared to, and statistically tested with, the 1990 Census,[9] the 1991 California Statewide Travel Survey results (CSTS),[10] and the 1990 California Statistical Abstract.[11] In most cases the null hypothesis that the values from the route choice survey are not different to the corresponding statistical sources were not rejected at the 0.05 level of significance, implying that the sample well represents the population in the study area (among the variables tested with the three cited data bases are: Income, mode split, home ownership, gender, across the four counties).

TRAFFIC INFORMATION USE

Initial analysis of the survey data using cross-tabulations produced information on general tendencies in

the data. Traffic information questions were divided into two groups depending on where the information is received, either before (pre-trip information) or while driving (enroute information) to work. About 36.5% of the respondents listen to traffic reports before leaving their homes, and 51.25% listen while driving. Close to 27.6% of the respondents listen to traffic reports both at home and enroute, and 60.1% listen to reports either at home or enroute, while 39.9% never listen to reports. These findings are consistent to a great extent with Khattak.[12] Most respondents who receive traffic information perceive traffic reports to be either very accurate or somewhat accurate. Figure 1 depicts the respondents' perception of the accuracy of the traffic reports they receive.

Commuters who listen to traffic reports tend to do so every day. Almost 64% of respondents listening to reports before leaving home; 55% of respondents listening while driving, indicated that they receive reports every day (Figure 2).

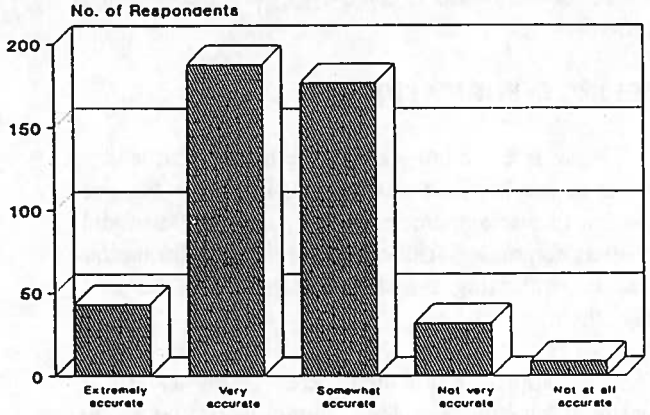

Figure 1. Commuters' Perception of the Accuracy of Traffic Reports

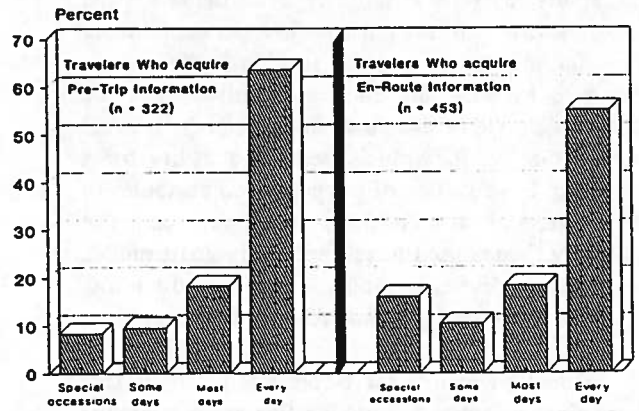

Figure 2. Frequency of Listening to Traffic Reports

Association Between Gender and Information Use

More females (40%) listen to traffic reports before leaving home to work than males (33%) -- while more males (54.4%) listen to reports en route than females (47.7%). The hypothesis of independence of gender and receiving traffic information was rejected using pearson chi-square at a 0.05 level of significance, which indicates significant association between gender and information use. It was also found that females more often change their routes or departure times as a result of listening to traffic reports before leaving their homes, while males more often change their routes as a result of traffic reports they hear while enroute to work. More complete analyses and modeling of route change is contained in a previous paper.[6]

Association Between Traffic Conditions and Information Use

It was also found that respondents who stated that traffic conditions on their usual route are bad or very bad, or that there are substantial difference in traffic from day to day, reported that they listen to traffic information before leaving and while driving, more than respondents who indicated that traffic conditions are good or very good, or that traffic conditions are about the same every day. Again the hypothesis of independence between traffic conditions and listening to reports was rejected at the 0.05 level. Evidently those commuters who perceive a large variation in their traffic conditions, or that traffic conditions are bad on their routes, try to find out more about these conditions by listening to traffic reports.

Commuters who use freeways may be more likely to receive traffic information if their freeway traffic conditions are perceived as heavy or very heavy. The relation was confirmed using chi-square test for pre-trip information, but not found for enroute information, indicating that commuters plan for using freeways ahead, i.e., try to find out their freeway(s) conditions in advance, possibly because these are the segments of their route that are exposed most to delays.

Effect of Traffic Information on Route Choice

About 15.5% of the respondents said they use more than one route to work. This may be considered a low percentage, but indicates a very promising potential benefit from an information system that would make more people aware of alternative routes.

The most frequent reason for changing routes, cited by 34% of respondents, is the traffic that the respondents see on the roads (see Figure 3). The need to make stops on the way and traffic reports comes next (15.5% and 14% respectively). Additional reasons include the time of day (8%) and the day of the week (5.5%). This indicates that the primary reason for switching routes is the traffic conditions the commuters experience during their trip (they see on the road), an ATIS system could provide

them in advance with these conditions so that they can divert before running into the congestion which might cause delays and inconvenience, with the condition that the information is better and useful than the commuters' experience and what they see. If the percent of respondents that base their choice on the traffic they see is added to others who base their choice on traffic reports, then about 50% of the commuters depend on information-related sources for choosing their routes.

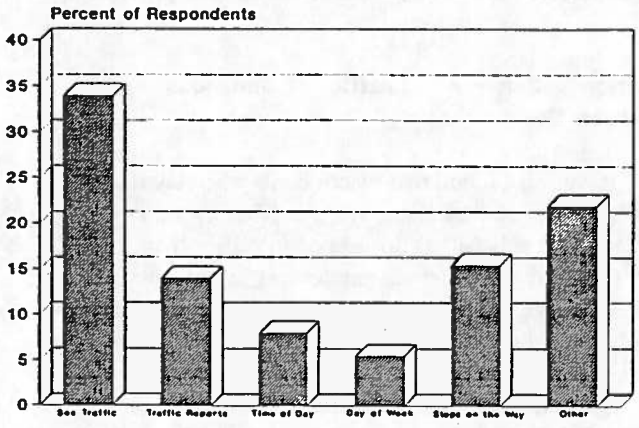

Figure 3. Bases for Choice Between Primary and Secondary Routes

Use of secondary routes is directly related to use of traffic reports. Secondary routes are used by 18% of respondents who listen to traffic reports before leaving home and 19% of those who listen to traffic reports while commuting, but only 11% of non-report listeners use secondary routes. The null hypothesis of independence was rejected, indicating that the use of alternative routes and receiving traffic information are statistically associated.

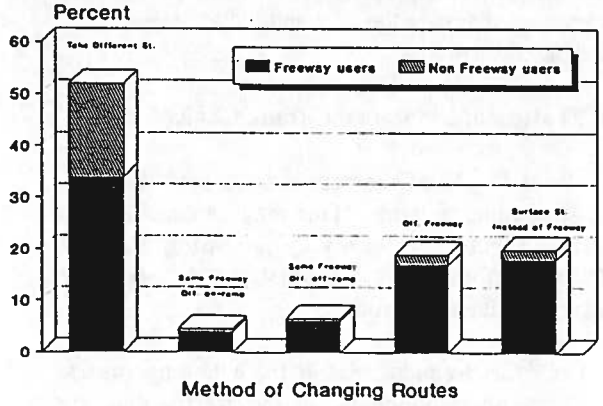

Figure 4. Route Changing Based on En-Route Traffic Reports

Surface streets are heavily used as primary (50% of the respondents use only surface streets in their primary route to work) and secondary routes (62% of secondary route users use only surface streets in this route). About 53% of those who change their routes based on enroute traffic reports take different surface streets, 2% take the same freeway, but different on-ramps, 7% take the same freeway with different off-ramps, 18% take different freeways, and 20% take surface streets instead of a freeway. These statistics are based on a question answered by 195 respondents, which is larger than the 138 respondents who indicated that they use more than one route to work, possibly because most respondents didn't perceive minor deviations as a completely alternative route. Also most of the responses are by freeway users (Figure 4), either changing there surface street or freeway segments. It is important that this existing reliance on surface streets be clearly understood when evaluating ATIS development. One of the often cited objections to route guidance is the diversion of traffic to surface arterials. The survey results indicate how frequently this is already occurring. Real-time in-vehicle route guidance may not result in dramatic increases in secondary route use, so much as provide access to more efficient secondary routes. A second phase of the survey will explore this possibility.

MODELING INFORMATION USE

There is a need to identify the factors that lead a commuter to receive information and, if so, the type of information (pre-trip and/or enroute). Building a model that predicts commuters' choices of receiving information will aid in evaluating the development of ATIS and assessing their impact.

The approach pursued here is the use of a conventional multinomial logit model formulation to estimate the probability that a commuter will choose to receive: 1) both pre-trip and enroute traffic reports, 2) only pre-trip reports, 3) only enroute reports, or 4) doesn't receive any traffic information (the independence from irrelevant alternatives assumption (IIA) may have been violated here because the four alternatives may be correlated, which will be examined in the future). It could be assumed that an individuals perceived utility for a specific choice is a function of the perceived attributes of the alternative, and an individuals characteristics. The random utility theory used in estimating the logit model, assumes that an individuals choice is based on the utility gain experienced by the individual for a particular choice.

Estimation results for information use choices model are given in Table 2. Looking first at the commute route attributes, we find that freeway users and commuters who have longer commute distances are more likely to receive information (either pre-trip, enroute, or both). However, the log transformation indicates that this effect diminishes with increasing commute distance. Commute time has a positive impact on receiving both pre-trip and enroute information.

	Coefficient	t-statistic
Receive pre- & en-route reports constant	-1.8799	-7.117
Receive pre-trip reports constant	-2.8793	-9.115
Receive en-route reports constant	-1.4510	-5.478
X_1 No variation in traffic conditions dummy (4)	0.3466	2.087
X_2 Female dummy (2)	0.8820	3.324
X_3 Female dummy (3)	-0.1782	-1.059
X_4 College graduate dummy (1,3)	0.3947	2.645
X_5 Freeway user dummy (4)	-1.0077	-5.317
X_6 Last trip time on usual route to work (1)	0.0156	3.523
X_7 Log of commute distance (4)	-0.5656	-2.356
X_8 Uncertainty of travel time dummy (4)	-1.1645	-3.846
Summary Statistics		
Log Likelihood at zero = -1183.900		
Log Likelihood at market share = -1086.505		
Log Likelihood at convergence = -992.316		
Likelihood ratio index = 0.162		
Number of observations = 854		

Note: Alternative 1 = receiving both pre-trip and en-route traffic reports, Alt.2 = receiving only pre-trip reports, Alt.3 = receiving only en-route reports, Alt.4 = doesn't receive any traffic reports. Variables coefficients are defined with the alternative indicated in the table.

Table 2. Multinomial Logit Model Estimating Whether the Respondent Receives Both Pre-Trip and En-Route Traffic Reports, Only Pre-Trip Reports, Only En-Route Reports, or No Reports

Turning to commuters' perceptions of traffic conditions on their route(s). Commuters who perceive that there is no variation in traffic conditions on their usual route are more likely not to receive any traffic information, while commuters who perceive travel time uncertainty as a major problem are less likely not to receive information, apparently in an attempt to decrease this uncertainty by gaining information about their commute route(s).

Several socioeconomic variables have significant effects on information use. Females are more likely to receive only pre-trip traffic information, but less likely to receive only enroute information, indicating females preference for pre-trip reports. The positive coefficient of the high level of education (college graduate) increases the likelihood of receiving either both types of information or enroute information only.

The simultaneous bivariate probit model structure is used in order to identify the contributing factors that influence the willingness to acquire pre-trip and enroute information. Considering in this case two binary choices; whether a commuter receives pre-trip traffic information, and whether he receives enroute traffic information. Then the two choices may be represented by a simultaneous equation system. Assuming the error term in the two equations are correlated, then the two equations should be estimated simultaneously using full-information maximum likelihood (FIML) or sequentially equation by equation using limited-information maximum likelihood (LIML). The FIML is desirable because it offers consistent and efficient estimates, while allowing to test the error correlation across equations. Thus FIML is adopted in this paper. The methodology of simultaneous equations and bivariate probit models is described and used in Abdel-Aty et al., and Kitamura et al., 1993.[6,13]

Distributional assumptions need to be made on the random error terms in order to express response probabilities. The probit formulation in a situation involving two binary choice endogenous variables would imply that the joint distribution of the error terms is given by the bivariate standard normal distribution.

The estimation results of a set of bivariate probit models are presented in Table 3. The results are similar to a large extent to the logit model presented above: perception of no variation in traffic conditions decreases the likelihood of receiving pre-trip and enroute traffic reports. Perception of trip time uncertainty and commute distance positively impact receiving both types of information. Females are more likely to receive pre-trip information, and college graduates are more likely to receive enroute information.

The significant positive correlation between the two error terms (receiving pre-trip information and receiving enroute information) indicates the presence of heterogeneity, i.e., the unobserved individual factors similarly affect the choice of receiving both types of information.

The second model is similar to the first one, but receiving pre-trip information dummy variable is included as an explanatory variable to estimate receiving enroute information. This variable has a negative coefficient indicating that individuals who are receiving pre-trip information are less likely to receive enroute information. The opposite is found when using receiving enroute information dummy variable as an explanatory variable to estimate receiving pre-trip information (model 3), the positive coefficient indicates that commuters who receive enroute information are more likely to receive pre-trip information as well. The other variables are similar to a large extent to the first model.

Models 2 and 3 show that commuters value pre-trip information more than enroute, probably receiving this type of information satisfy their needs to know about their commute situation and hence decide about departure time and route choices, which might make enroute information less important to them. Also some of the commuters who receive enroute information could be receiving it because

	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
PRE-TRIP INFORMATION MODEL						
Constant	-0.5390	-4.802	-0.5234	-5.001	-1.2365	-4.615
X_1 No variation in traffic conditions dummy (1 if no variation is perceived, 0 otherwise)	-0.3087	-3.054	-0.3242	-3.269	-0.2013	-1.443
X_2 Female dummy (1 if female, 0 otherwise)	0.2218	2.424	0.1793	2.531	0.2377	2.331
X_3 Uncertainty of travel time dummy (1 if reported that trip time uncertainty is a major problem, 0 otherwise)	0.4460	3.155	0.5017	3.508	0.0557	0.188
X_4 Distance from home to work	0.0156	3.917	0.0158	4.084	0.0005	0.047
X_5 Receive en-route information dummy (1 if respondent receives information, 0 otherwise)	–	–	–	–	1.6169	2.090
EN-ROUTE INFORMATION MODEL						
Constant	-0.3200	-2.977	0.0113	0.108	-0.3220	-2.967
X_1 No variation in traffic conditions dummy (1 if no variation is perceived, 0 otherwise)	-0.2146	-2.123	-0.2751	-2.985	-0.2129	-2.098
X_2 College graduate dummy (1 if respondent is a college grad, 0 otherwise)	0.1953	2.120	0.1331	2.236	0.1567	1.603
X_3 Uncertainty of travel time dummy (1 if reported that trip time uncertainty is a major problem, 0 otherwise)	0.6836	4.352	0.6084	4.150	0.7330	4.585
X_4 Distance from home to work	0.0267	6.403	0.0236	6.244	0.0282	6.857
X_5 Receive pre-trip information (1 if respondent receives information, 0 otherwise)	–	–	-0.8574	-7.409	–	–
Correlation	0.5562	11.213	0.9680	17.015	-0.4119	-0.716
Summary Statistics						
Log Likelihood at zero	-982.459		-982.459		-982.459	
Log Likelihood at market share	-929.811		-929.811		-929.811	
Log Likelihood at convergence	-876.480		-874.603		-875.335	
Likelihood ratio index	0.108		0.110		0.109	

Note: Variables' coefficients are defined for receiving reports

Table 3. Bivariate Probit Models Estimating Whether the Respondent Receives Traffic Reports Before Leaving Home to Work, and Whether He Receives Information While Driving

they are listening anyway to a radio station (most radio stations provide in between their programs information about traffic particularly during commute hours). This is not the case for pre-trip information, most commuters who receive it most probably want to acquire information about their commute situation. This result suggests the importance of pre-trip traffic information.

SUMMARY AND CONCLUSIONS

A computer-aided telephone interview (CATI) survey, designed to gain a basic understanding of drivers' route choice behavior and to collect detailed information about commute routes, has been carried out as part of a research project at the University of California at Davis. A

variety of statistical methods are used to explore how commuters use traffic information in deciding about routes to travel to work.

Initial analysis using descriptive statistics illustrated several trends in commuters' route choice decisions. Only 15.5% of the respondents reported that they do not always follow the same exact route to work, which indicates the potential benefit from an information system that would make more commuters aware of alternative routes. Surface streets are heavily used as primary and secondary routes, indicating that diversion of traffic to surface arterials is already occurring, perhaps in an inefficient way. Real-time, in-vehicle route guidance may provide access to more efficient secondary routes.

About 36.5% of the respondents listen to traffic reports before leaving their homes, and 51.2% listen while driving. In general 60.1% listen to reports at home and/or enroute. Most respondents who receive traffic information perceived traffic reports to be either accurate or somewhat accurate.

Respondents that perceive traffic conditions on their usual route as bad or substantially different from day to day, were more likely to listen to traffic reports either before their departure, during driving, or both. The data also suggest that respondents who reported heavy traffic conditions on their freeway segment were more likely to receive traffic reports before leaving their homes. Many commuters thus seem to seek traffic information prior to beginning their freeway trip.

Multinomial logit model showed significant effect of several commute characteristics and socioeconomic attributes on the choice to receive traffic information either enroute, pre-trip, or both. Freeway use and commute time were among the factors that increase the likelihood of receiving traffic information, also the model showed significant effect of gender and education on using information. Bivariate probit models not only supported the results of the logit model but also indicated a significant relation between the propensity of receiving enroute and pre-trip information.

Results from the cross tabulations illustrated that freeway users and females are more likely to receive pre-trip information. Also results of the bivariate probit models showed that individuals who receive pre-trip traffic information are less likely to receive enroute information (but those who receive enroute information are more likely to receive also pre-trip information), which shows that pre-trip information is preferred. The results above indicate the importance of pre-trip information and give us some understanding of commuters' willingness to acquire and use information that might help us in the design and development of ATIS systems.

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