Influence of Traffic Information on Drivers' Route Choice Behavior

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Commuters' route choice behavior in the presence of traffic information is analyzed. A modeling framework for the acquisition and processing of pretrip and en-route information, drivers' route switching behavior, and the willingness to pay for more useful information is proposed. The estimation of these models is based on revealed preference data obtained from a 1991 survey of commuters to Massachusetts Institute of Technology. Trip characteristics and travelers' perceptions of the relevance and reliability of radio traffic reports were found to be important factors affecting radio traffic information acquisition and its influence on drivers' decisions. The key finding was that en-route diversion is primarily influenced by attitudinal factors and by information acquisition. Moreover, drivers' own observations are important factors affecting route switching. It can be concluded that a reliable and frequently updated traffic information system will stimulate the acquisition of traffic information and affect route diversion.

Increasing attention has been paid in recent years to the use of advanced traveler information systems (ATIS) for alleviating traffic congestion. ATIS can be classified into pretrip information services such as television and radio and telephone and route-planning information services; and en-route information services such as traffic information broadcasting services, telephone information services, in-vehicle navigation, route guidance systems, and variable-message signs. By collecting and transmitting real-time information on traffic conditions and transit schedules, ATIS possess the capability to improve the efficiency of the traffic system.

Figure 1 shows the potential influence of information on travelers' pretrip and en-route decisions. At the beginning of each trip, travelers decide on whether to travel or not to travel; the location of their destination; and their departure time, mode, and route choice. Travelers' decisions are influenced by two types of information: experience-based and real-time information. Experience-based information is acquired by actual traveling; it is subjective, limited, and imperfect because it reflects average values and cannot foresee daily variations in travel times. On the other hand, real-time information provided by ATIS gives travelers the ability to more accurately predict travel times to their destinations.

The information provided by these systems may lead travelers to decide to alter or postpone their trip or to choose a route other than the habitual one. The provision of public transport and parking information may influence their mode, departure time, and destination choices. If travelers acquire dynamic en-route information, they may decide to revise their preselected travel pattern by switching route, destination, or mode. In subsequent trips, travelers' decisions to acquire pretrip and en-route information, and to review their choices, will be based on previous travel experiences and the expected attributes of new travel choices.

This paper investigates the influence of traffic information on drivers' route choice behavior. Specifically, the impact of factors such as drivers' socioeconomic characteristics, travel characteristics, and information characteristics on the following decisions is examined:

- Pretrip traffic information acquisition;
- Pretrip route choice;
- En-route traffic information acquisition; and
- En-route switching decisions.

This paper consists of six sections. The second section discusses the major findings of recent research on route choice and route switching behavior. The third section presents the general framework of route choice behavior as influenced by traffic information. The fourth section describes the data collection method and presents descriptive data analysis results. The fifth section presents model specification and estimation results. The sixth section concludes the paper and offers suggestions for further research.

PREVIOUS RESEARCH

Revealed preference data and stated preference data are the two basic approaches of data collection for modeling users' decisions. The next two subsections describe data collected and models estimated by various researchers on the basis of each of the two approaches. An extensive review of the state of the art of route choice models is provided by Bovy and Stern (*1*).

Revealed Preference Approach

The revealed preference approach analyzes drivers' behavior in real-life situations, on the basis of respondents' reports (usually diaries of actual trips), on previous actions, or by observing traveler behavior in real-life situations (field study approach).

Diary Survey

Khattak et al. (*2*) used revealed preference data to estimate drivers' diversion decisions. The results showed that drivers prefer to stay on the usual route and are more likely to divert after receiving delay information from radio traffic reports than through self-observation. Attitudinal factors included in the models, indicating the drivers' inherent tendency to divert and risk propensity, were found to be significant. Hatcher and Mahmassani (*3*) addressed the day-to-day

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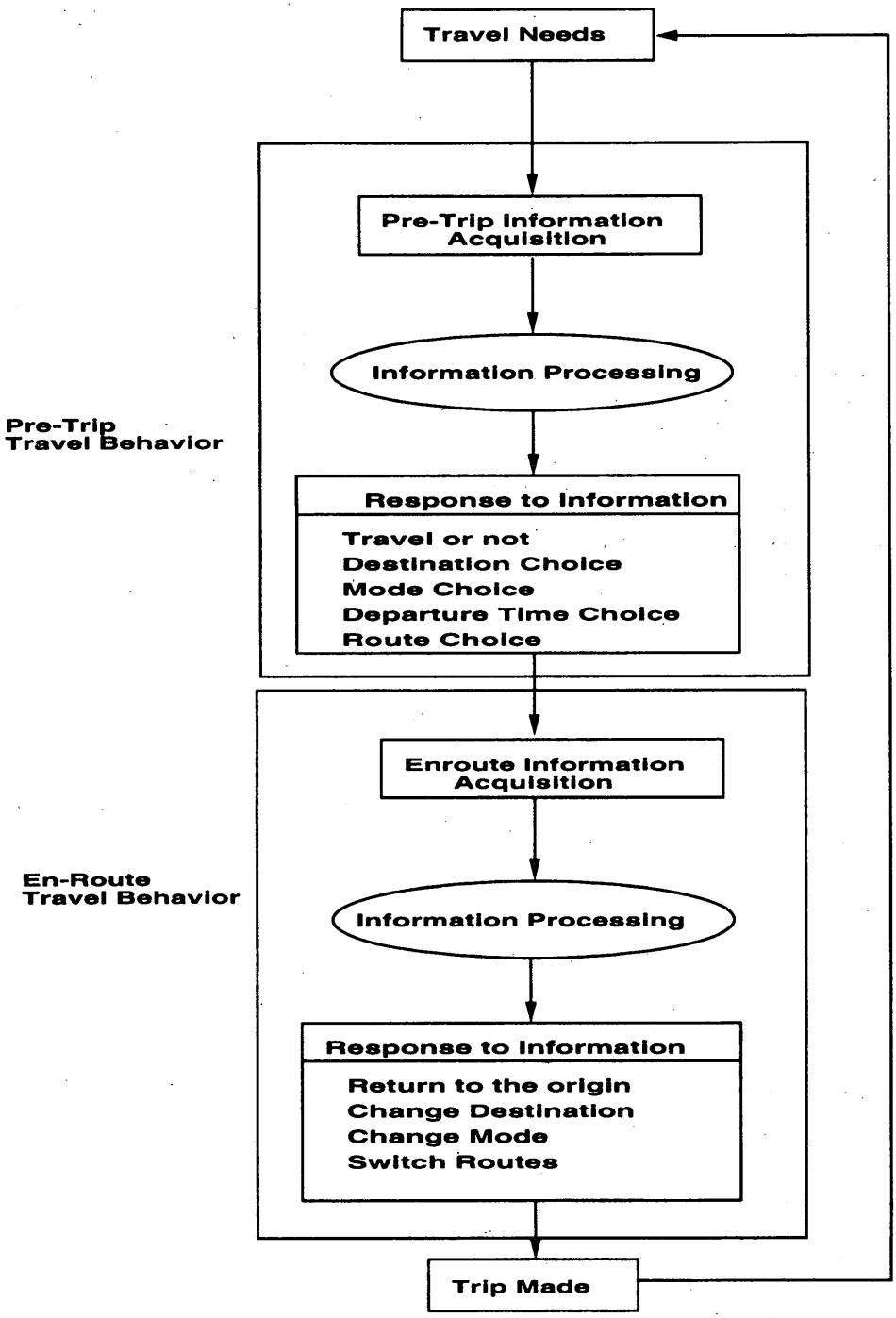

FIGURE 1 Impact of traffic information on travelers' decisions.

variation of individual trip scheduling and route decisions for the evening commute. It was found that trip chaining significantly influences route switching behavior and that commuters tend to change departure times more frequently than they change routes.

Cascetta and Biggiero (*4*) estimated models for departure time and route choice for home-to-work trips. The analysis indicated that travel time spent on secondary roads played an important role in route choice. Safety and comfort variables also were found to be significant.

Field Study

The field study approach analyzes drivers' behavior through field observation of drivers, such as observation of actual diversion behavior in response to information acquisition. Although a number of operational tests of ATIS are being conducted, no data have been available for the estimation and calibration of drivers' behavior models (*5*). However, this approach holds significant potential for providing critical revealed preference data, and efforts are under

way to extract useful information from a number of operational tests already in existence or being planned.

Stated Preference Approach

Two different approaches of extracting stated preference data on potential driver behavior in hypothetical situations, namely, by surveys and by simulators are described.

Surveys

Khattak et al. (*6*) used stated preference data to evaluate the drivers' willingness to divert from their usual route to an alternate route. Drivers expressed a higher willingness to divert if expected delays on their usual route increased, if they experienced travel times that were longer than usual, and if congestion was incident induced, as opposed to recurring. Respondents were less willing to divert if the alternate route was unfamiliar or unsafe or had several traffic stops. Socioeconomic characteristics were found significant in predicting willingness to divert. The results of a computer-based survey, conducted by Polak and Jones (*7*) to study the impact of in-home pretrip traffic information on travelers' behavior, showed that even among regular car users, there is a demand for multimodal pretrip information.

Simulators

A review of recent efforts to collect data using travel simulators to study and model travelers' behavior in the presence of information is provided by Koutsopoulos et al. (*8*). Bonsall and Parry (*9*) developed an interactive route choice simulator to investigate drivers' compliance with route guidance advice. Estimations of regression models showed that the acceptance of advice depended on its credibility, which was a function of past experience, local conditions, and psychological factors. Koutsopoulos et al. (*10*) developed a travel simulator and used concepts from fuzzy sets theory, approximate reasoning, and fuzzy control to model route choice process and the drivers' perceptions in the presence of information. It was found that traffic conditions on one path might affect the perceived attractiveness of an alternative path. Preliminary analysis of data obtained from a simulator developed by Adler et al. (*11–13*), showed that en-route diversion behavior is influenced by the familiarity of drivers with the potential alternative routes and their traffic conditions, the information provided, changes in travel speeds, and drivers' risk preference. Vaughn et al. (*14*) and Yang et al. (*15*) also used data from a travel simulator to model sequential route choice behavior. A logit model showed that as the perceived delay on a route increases, the probability that this route is chosen decreases. Furthermore, as the accuracy of the system increases, the probability of following the advised route increases. A second modeling approach using concepts from neural networks revealed that most subjects make route choices on the basis of their most recent experiences. Therefore, the relative accuracy of the information provided plays an important role on the immediate choices. Finally, Chen and Mahmassani (*16*) developed a travel simulator that is connected to a traffic simulation model. This simulator allows multiple users to drive through the network, interact with each other, and influence the systems performance.

FRAMEWORK FOR ROUTE CHOICE BEHAVIOR

This section presents a general framework for route choice behavior, which describes the choice factors and choice structure, as well as the potential impacts of both pretrip and en-route information on drivers' decisions.

Choice Factors

The ultimate choice—that is the route to be taken—is the result of the following factors: (*a*) driver characteristics, (*b*) travel characteristics, and (*c*) information characteristics.

The traveler's route choice depends on socioeconomic characteristics, such as age, gender, income, personality, habits, preference, driving experience, and familiarity with the transportation network. Travel characteristics (such as trip purpose, flexibility in arrival time, availability of alternatives) and traffic conditions associated with the travel alternatives play a significant role in determining the route choice behavior. Constraints imposed by the purpose of the trip also are important factors. Moreover, each traveler has only limited knowledge of all available routes.

Information attributes play an important role in defining the attitudes of travelers toward information (*17*). Information must be reliable and accurate, or else travelers will tend to reject further information acquisition and develop a negative attitude toward information acquisition. Only information provided in a timely manner that is responsive to changing traffic conditions and relevant to the travelers' trips will positively affect travelers' decisions and their attitudes toward information acquisition.

The decision-making process is dynamic because of the feedback from each trip. A learning process is central to the driver's cognition as the information acquired through experience of earlier travel choices is processed before the next decision is made. Moreover, the characteristics of each known alternative route do not have the same importance in a driver's final decision. On the basis of a factor importance hierarchy, the traveler formulates a choice set of sufficiently attractive alternatives (*1*). From this set travelers make their choices, with the chosen route being the one that best satisfies their needs and is consistent with their personal constraints and preferences. Finally, travel choice inertia also plays a role, dictating that certain thresholds be crossed before drivers change their habitual behavior (*2*).

Impact of Pretrip Information on Route Choice

Drivers may adjust their destination, mode, departure time, and route choices on the basis of information acquired before beginning a trip. If they decide not to acquire pretrip information, drivers will rely on their historical perceptions and experiences and, therefore, start their trip following the habitual route.

When information is acquired by drivers, the perceived importance of indicated traffic conditions, combined with the drivers' general attitudes and preferences, influence their pretrip route choice decisions. The derived benefits from acquiring and utilizing information to make pretrip decisions will then serve as feedback to drivers that updates their attitudes and preference toward pretrip information acquisition. Therefore, pretrip decisions for subsequent trips will depend on their perceived benefits on previous trips.

Impact of En-Route Traffic Information on Route Choice

Drivers' attitudes toward traffic information acquisition will play an important role in their en-route travel choices. If drivers do not acquire pretrip traffic information, their route choice will be based on their past experiences. On the other hand, if information is acquired, their route choice might be modified accordingly. En-route information could be acquired either passively (from en-route observations or variable-message signs) or voluntarily. Voluntary en-route information acquisition usually takes place when the level of service on the preselected route is different from what was anticipated; the driver might seek to acquire traffic information for both the actual and alternate routes. After traffic information is acquired, drivers may choose to ignore it (follow preselected route) or to divert. The perceived benefits of drivers' actual decisions are expected to affect the updating of their attitudes toward the acquisition of and response to traffic information as well as their future route choice behavior.

DATA COLLECTION AND ANALYSIS

In this study revealed preference data were obtained from a diary survey of Massachusetts Institute of Technology (MIT) commuters conducted in the spring of 1991 (*18,19*).

Survey Instrument

The survey included the following two parts.

Part 1:

Part 1 contained four groups of questions on the usual commuting trip to MIT, the drivers' socioeconomic characteristics, and the drivers' attitudes and preferences. The questions about the commuting trip were about the usual departure and arrival times, flexibility in arrival time, traffic conditions usually encountered, number of alternative routes used, and the duration and purpose of stops made. The second group of questions sought information regarding the driver's sex, marital status, education, income, profession, number of years at current dwelling unit, and current job.

The third group of questions utilized a five-point scale to indicate the driver's level of agreement with the following factors:

1. Statements that indicate the familiarity of drivers with the network, such as "I am very familiar with at least two significantly different routes to work";
2. Statements that reflect the general attitudes of drivers toward diverting, such as "I like discovering new routes or I often change routes while driving", and
3. Statements that revealed the perceptions of drivers toward the validity and effectiveness of traffic reports, such as "Radio traffic reports are usually reliable" or "I often change my route after listening to radio traffic reports."

Finally, the fourth group of questions indicated the importance of several factors in choosing the route to work. For these statements, a five-point scale was used to indicate how drivers rate the importance of factors such as time of day, commuting time, habit, traffic reports, risk of delay, and weather conditions in choosing their commuting route.

Part 2:

Part 2 consisted of a detailed 1-week diary of morning commute trip information. A questionnaire was included to be completed on each of the 5 days. The questions related to pretrip and en-route traffic information acquisition, their influence on the commuters decisions, the driver's en-route diversion decisions, and the anticipated and observed traffic conditions. The questionnaire also asked about the duration and purpose of stops made.

A related set of questions in this part of the survey used a five-point scale to indicate agreement with day-specific perceptions about the commuting trip, such as "Traffic conditions today were better than usual"; "I am satisfied with my route choice today"; and "Traffic information received today was useful." In the next subsection an overview of the statistics obtained from the conducted survey is presented.

Summary of Results

A total of 1,300 individuals responded to Part 1 of the survey. Of these, 898 completed Part 2 of the survey and reported 3,218 trips. The average range of commuting time was between 29 and 40 min. The average number of routes used was 1.6, in spite of the fact that more than 75 percent of the drivers were very familiar with more than two routes. Among the respondents, 14 percent had no flexibility in arrival time, 17 percent had flexibility up to 15 min, 17 percent had flexibility of 16 to 30 min, 15 percent had flexibility from 31 to 60 min, and 37 percent had flexibility of more than 1 hr.

A total of 22 percent of the commuters usually made stops while commuting to MIT, whereas 78 percent never made stops. The average duration of stops was 2.2 min. Approximately 38 percent of the stops had as a purpose dropping off a passenger, whereas only 5 percent of the stops were made to pick up a passenger. Almost 60 percent of the respondents had a postgraduate degree. Approximately 28 percent were administrative staff, 20 percent support staff, 26 percent faculty, and 8 percent students.

Attitudes and Preferences

Table 1 presents the answers of the statements reflecting the attitudes and preferences of drivers. Category 1 corresponds to the response "strongly disagree," whereas Category 5 corresponds to the response "strongly agree." Although 63 percent of the drivers rarely or never change their planned route while driving, 16 percent often make such a change. From the sample of drivers, 37 percent indicated that they often listen to radio traffic reports, and 27 percent usually follow the recommendations. Only 25 percent of the drivers think that radio traffic reports are reliable, whereas 22 percent consider them as not relevant. Among the drivers who listen to radio traffic reports, 20 percent often change their routes after listening, whereas 50 percent completely ignore traffic reports when they are different from their observations. In the latter case, only 9 percent continue to follow the radio's advice. Among all the surveyed commuters, 10 percent were willing to pay to get more useful information, whereas 68 percent were not.

TABLE 1 Respondents' Attitudes and Preferences

Number	Statement	Strongly disagree 1 %	2 %	3 %	4 %	Strongly agree 5 %	Not relevant %
1	I am very familiar with at least 2 different routes to work	7.3	4.4	5.0	6.4	74.5	2.4
2	I often change my planned route while driving	41.0	21.6	18.8	7.9	8.0	2.5
3	I like discovering new routes	22.4	11.6	25.0	15.6	18.0	7.3
4	I am willing to try new routes to avoid traffic delays	5.2	5.5	13.4	22.4	50.5	3.0
5	I always listen to radio traffic reports	24.4	13.5	21.0	12.1	25.2	3.9
6	I usually follow the recommendations of radio traffic reports	19.1	15.5	21.9	15.8	11.4	16.3
7	Radio traffic reports are usually reliable	8.5	14.7	30.9	17.3	7.9	20.7
8	When traffic reports are different from my own observation I ignore them	5.1	5.4	16.2	18.9	31.3	23.1
9	I often change my route after listening to radio traffic reports	13.6	19.5	25.9	14.0	6.4	20.7
10	I trust my own judgment more than the traffic reports	8.1	13.8	26.5	20.2	16.2	15.2
11	Traffic reports do not provide relevant information	16.9	23.6	23.7	11.7	10.1	14
12	I am willing to pay in order to get more useful traffic information	54.5	13.9	12.5	5.3	3.4	10.4

Route Choice Factors

Table 2 presents the importance of different travel attributes when drivers choose their route to work. Category 1 corresponds to the response "Not important at all," whereas Category 5 corresponds to "Very important." Almost 61 percent of the drivers perceive time of day as a very important factor in choosing their route to work. However, 76 percent of the drivers perceive commuting time as the most important factor in their route choice. Other factors identified as important in route choice process were risk of delay (57 percent), habit (50 percent), radio traffic reports (19 percent), and weather conditions (38 percent).

Commuting time is stated to be the most important route choice factor. At the same time, the small percentage of travelers who attach importance to radio traffic reports can be attributed to the perceived poor reliability and lack of relevance of these reports. Therefore, a route guidance system that provides accurate and relevant instructions would be a more useful information tool for the drivers.

Daily Commute Characteristics

A summary of the results of the second part of the survey, which reflected daily commute characteristics, is reported in Table 3. Pretrip traffic information was acquired in 27 percent of the trips made. A total of 16 percent of the drivers was influenced by this information. En-route traffic information was acquired in 24 percent of the trips made. Of the trips made, 67 percent presented the opportunity for

TABLE 2 Importance of Factors Affecting Route Choice Behavior

Number	Attribute	Not important 1 %	2 %	3 %	4 %	Very important 5 %
1	Time of day	15.7	7.1	11.1	16.3	44.9
2	Commute time	9.2	4.6	10.0	20.6	55.5
3	Habit	12.3	8.6	29.8	26.1	23.3
4	Time spent stopped in traffic	5.3	5.3	10.3	29.0	50.1
5	Number of traffic lights	10.9	11.5	24.2	25.4	27.9
6	Traffic reports	30.7	22.7	28.1	12.4	6.1
7	Risk of delay	8.6	8.5	26.1	30.6	26.2
8	Weather	25.9	16.7	19.3	15.9	22.1

TABLE 3 Traffic Information and Route Choice Behavior

Question		Percentage
Received pre-trip traffic information		
	From radio	22
	From TV	5
	No	73
Pre-trip information influence route choice		
	A lot	4
	Somewhat	12
	Very little	12
	Not at all	68
Received en-route traffic information		
	Yes	24
	No	76
Received traffic information before switching for new route		
	Yes	8
	No	92
Reason for switching		
	Radio Traffic Reports	12
	Own observation	62
	Forced detour	5
	Other	22

switching routes; route switching was actually observed in 6 percent of these trips. Among the trips in which route switching was observed, 8 percent received traffic information before switching. The reasons for switching were split as follows: 12 percent because of radio traffic reports, 62 percent because of drivers' own observations, and the remaining 26 percent for other reasons.

MODEL SPECIFICATION AND ESTIMATION RESULTS

This section presents the estimation results from modeling the acquisition of pretrip traffic information, the influence of this information on drivers' behavior, the acquisition of en-route information, route switching decisions, and the willingness to pay for more useful traffic information.

As discussed in Section 4, 3,218 trips were made by 898 individuals over a 5-day period. The totality of these trips was used to estimate discrete choice models using standard maximum likelihood estimation (MLE) techniques [see Ben-Akiva and Lerman (*20*) for further discussion of discrete choice models]. Because choices over time were observed, the dynamic complications of serial correlation were present. By using the standard statistical packages, obtained parameter estimates would be consistent but not efficient. The Jackknife method (*21*) was used to calculate the correct standard errors of the estimated coefficients. This method gives a nonparametric estimation of the standard errors.

The modeling approach consisted of two stages. In the first stage, it was assumed that the attitudes and preferences of drivers are related to explanatory variables such as socioeconomic characteristics, perceptions about information characteristics, and trip characteristics. To model the above relation, ordered response models were estimated in which the dependent variables are the five-point scale responses that reflect the attitudes and preference of the drivers [see Polydoropolou (22) for more details].

In the second stage, driver behavior was modeled using binary choice models. However, these models incorporated the fitted values of the attitudinal and preference variables obtained from the ordered response models. In that way, any notion of endogeneity appearing in the model was avoided. Note that since revealed preference data were used in the model estimations, the inclusion of reported attitudes as independent variables in the choice models could have rendered endogeneity implications. Finally, to avoid another endogeneity problem, the fitted probabilities of the pretrip and en-route information acquisition were used as explanatory variables, when included in the en-route information acquisition and route switching models, respectively.

The data used in the model estimations may not be representative of the population at large because the sample population was restricted to MIT commuters. However, the estimated models presented are indicative of the underlying travel decision-making process.

Modeling Acquisition of Pretrip Information

Binary logit models were used to model the acquisition of pretrip traffic information. For such models the dependent variable was 1 if a commuter acquired pretrip information and 0 otherwise.

The estimated model parameters are presented in Table 4. If travel time often exceeds its usual range, then drivers are more likely to acquire pretrip information. Moreover, the longer the commuting trip is, the more prone drivers are to acquire pretrip traffic information. On the other hand, if the drivers have more than a 16-min flexibility in arrival time, they are less likely to acquire pretrip traffic information.

Driver perceptions about the reliability and relevance of radio traffic reports also influence pretrip traffic acquisition. When traffic reports are perceived as unreliable or irrelevant, drivers are less likely to acquire pretrip traffic information. This result validates the results of most travel simulator studies that investigate the effects

TABLE 4 Acquisition of Pretrip Traffic Information

	Variable number	Variable name	Coefficient estimate	t statistic
	1	Constant	-1.442	-4.74
Trip Characteristics	2	Travel time often exceeds its usual range	0.654	4.53
	3	Average travel time (max)	0.06	2.65
	4	Flexibility > 16 min.	-0.386	-2.86
Perceptions & attitudes	5	Radio traffic reports are not reliable	-0.231	-3.88
	6	Radio traffic reports are relevant	0.597	6.13

Summary statistics
Number of observations =3218
$\mathcal{L}(\mathbf{0}) = -2230.5$
$\mathcal{L}(\hat{\beta}) = -1799.5$
$-2[\mathcal{L}(\mathbf{0}) - \mathcal{L}(\hat{\beta})] = 862$
$\rho^2 = 0.193$
$\bar{\rho}^2 = 0.191$

of information reliability on travelers' behavior [see, for example, previous work (*9,10,14,15*)]. Furthermore, it indicates that ATIS should provide reliable and relevant information to be accepted by the users.

Modeling Influence of Pretrip Traffic Information

To model the influence of pretrip information, only trips made by drivers who acquired pretrip traffic information were taken into account (728 trips) (see Table 5). Binary logit models were estimated in which the dependent variable was 1 if the driver was influenced by the radio reports and 0 otherwise.

The reliability of traffic reports, as well as the willingness of drivers to try different routes to avoid traffic congestion, are significant factors. The less reliable traffic reports are, the less likely this information is to influence driver decisions. Moreover, the more often drivers have a tendency to change their preselected routes, the more likely they are to be influenced by the acquired information.

If information indicated that traffic conditions were better than usual on the preselected route, drivers were likely to decide to stay on their route. On the other hand, if information indicated that the traffic conditions were worse than usual on the preselected route, drivers were likely to use an alternative route. Therefore, in both cases pretrip information had an influence on the drivers' decision about the route to follow. The results also indicate that information positively influences drivers' behavior only when it is relevant to their trip patterns.

Modeling Acquisition of En-Route Information

The acquisition of en-route traffic information is also a binary logit choice model. The dependent variable is 1 if a commuter acquired en-route information and 0 otherwise (see Table 6).

If travel time often exceeds its usual range drivers are more likely to acquire en-route traffic information. The longer the maximum travel time, the more drivers tend to acquire en-route information. Drivers who consider traffic reports to be relevant are more willing to acquire en-route information. A driver who acquired pretrip information is more likely to acquire en-route information. Finally, if the conditions encountered are worse than expected, drivers are more prone to acquire en-route traffic information.

TABLE 5 Influence of Pretrip Information

	Variable number	Variable name	Coefficient estimate	t statistic
	1	Constant	-1.464	-9.6
Perceptions & Attitudes	2	Radio traffic reports are not reliable	-0.598	-2.5
	3	Often change planned route while driving	0.519	2.6
Pre-trip Information	4	Indicated traffic conditions : none	-1.432	-3.5
	5	Indicated traffic conditions worse than usual	0.607	2.4
	6	Indicated traffic conditions better than usual	0.878	3.1

Summary statistics
Number of observations = 728
$\mathcal{L}(\mathbf{0}) = -504.61$
$\mathcal{L}(\mathbf{c}) = -370.31$
$\mathcal{L}(\hat{\beta}) = -345.16$
$-2[\mathcal{L}(\mathbf{0}) - \mathcal{L}(\hat{\beta})] = 318.90$
$\rho^2 = 0.3160$
$\bar{\rho}^2 = 0.3041$

TABLE 6 Acquisition of En-Route Information

	Variable number	Variable name	Coefficient estimate	t statistic
	1	Constant	-3.598	-16.26
Trip Characteristics	2	Travel Time Often Exceeds its Usual Range	0.412	2.75
	3	Usual Travel Time (max)	0.031	6.77
Perceptions	4	Traffic Reports are Relevant	0.253	1.89
Pre-trip Information	5	Acquired pre-trip information	3.439	2.89
Actual Traffic Conditions	6	Observed Conditions Worse than Usual	0.158	1.90

Summary statistics
Number of observations = 3218
$\mathcal{L}(\mathbf{0}) = -2230.5$
$\mathcal{L}(\hat{\beta}) = -1598.9$
$-2[\mathcal{L}(\mathbf{0}) - \mathcal{L}(\hat{\beta})] = 1263.2$
$\rho^2 = 0.283$
$\bar{\rho}^2 = 0.280$

Modeling En-Route Switching Behavior

A binary logit model was used to model the influence of en-route information. The dependent variable is 1 if drivers switched from the preselected route and 0 otherwise (see Table 7).

The negative sign of the constant shows the tendency of drivers to follow their preselected route. A "switch" is a deviation from their habitual behavior. The importance of risk of delay is a significant factor in the route choice behavior. As the importance drivers attach to it increases they become more likely to divert. When travelers are under time pressure, they try to avoid traffic congestion by switching to alternative routes. Moreover, drivers who often change their preselected routes while driving are more likely to divert from the preselected route. This factor indicates an important attitudinal component in the drivers' diversion decisions: a driver with a risk-taking attitude is more likely to switch to another route than one who prefers following the same route and does not like changes. The above results coincide with those of Khattak et al. (2) and Adler et al. (*11*).

The observed traffic conditions are an important factor in the estimation results in Table 7. The results indicate that traffic conditions that are worse than usual encourage travelers to divert. Furthermore, when a driver acquires traffic information about the alternate route and this information indicates traffic conditions that are worse than usual, drivers are less likely to switch to the new route. This result was also obtained by stated preference studies about the expected delays on alternative routes and switching decisions [see, for example, previous work (*6*, *13–15*)].

Modeling Willingness to Pay for More Useful Traffic Information

An ordered probit model was used for modeling the subjects' willingness to pay for more useful information. The dependent variable took values from 1 to 5, with 1 indicating a strong disagreement for paying for more useful information and 5 indicating a strong agreement for paying for more useful information (see Table 8).

Age has a significant effect on drivers' willingness to pay. Older drivers are more willing to pay than younger drivers. Income also appears significant because drivers with a yearly income of more than $80,000 are more willing to pay than drivers with less income.

TABLE 7 Route Switching Behavior

	Variable number	Variable name	Coefficient estimate	t statistic
	1	Constant	-2.869	-19.42
Perceptions & Attitudes	2	Risk of Delay Importance	2.236	-2.16
	3	Often Change Planned Route While Driving	2.235	2.16
Actual traffic Conditions	4	Observed Conditions at the Beginning of the Trip Worst than Usual	1.223	7.276
En-Route Information for New Route	5	Indicated Conditions for Alternative Route Worse than Usual	5.611	5.42

Summary statistics
Number of observations = 3218
$\mathcal{L}(\mathbf{0}) = -2230.5$
$\mathcal{L}(\hat{\beta}) = -702.28$
$-2[\mathcal{L}(\mathbf{0}) - \mathcal{L}(\hat{\beta})] = 3056.44$
$\rho^2 = 0.685$
$\bar{\rho}^2 = 0.683$

TABLE 8 Willingness to Pay for More Useful Information

	Variable number	Variable name	Coefficient estimate	t statistic
	1	Constant	-0.649	-3.82
Socioeconomic Characteristics	2	Age > 50	0.128	2.24
	3	Income >80K	0.320	3.29
	4	Faculty	0.153	1.22
	5	Administrative Staff	0.038	0.31
	6	Support Staff	-0.297	-2.19
Trip Characteristics	7	Flexibility > 16 min	0.153	1.62
	8	Travel Time Exceeds Often the Usual Time Range	0.133	1.27
Perceptions & Attitudes	9	Traffic Reports are not Important in my Route Choice	-0.260	-2.61
	10	Traffic Reports are Very Important in my Route Choice	0.155	1.26
	11	Habit Importance	-0.001	-2.56
	12	Like Discovering New Routes	0.279	2.42
	13	Thresh 1	0.494	14.23
	14	Thresh 2	1.115	24.17
	15	Thresh 3	1.616	22.66

Summary statistics
Number of observations = 776
$\mathcal{L}(\mathbf{0}) = -920.19$
$\mathcal{L}(\hat{\beta}) = -858.62$

Profession also plays an important role. With the "base case" used for this variable being the student category, faculty and administration staff are more willing to pay, whereas support staff are less willing to pay than students for more useful information. If travelers do not consider radio traffic reports to be an important factor in their route choice, they are less willing to pay for more useful information. These might be people experiencing relatively short commuting times or having a lot of flexibility when choosing their travel patterns. On the other hand, if traffic reports are considered to be an important factor that influences route choice, then the willingness to pay for more useful information increases. This is a positive indicator for future ATIS implementation issues. ATIS will be successfully implemented if they satisfy travelers' needs by providing reliable and relevant information.

Drivers having more than 16 min of flexibility are more likely to pay for more useful information. The traffic information will give these drivers the opportunity to optimize their departure time choice and avoid traffic congestion. If the travel time often exceeds its usual range, drivers are more willing to pay for more useful information. However, if travelers choose their route by habit, they are less willing to pay for more useful information.

Impact of Driver Perceptions of Information Characteristics on Information Acquisition

The models presented in the fifth section indicate that the acquisition of pretrip and en-route traffic information is influenced by driver perceptions of the reliability and relevance of the provided information. To assess the sensitivity of information acquisition decisions to changes in driver perceptions of the reliability and relevance of traffic information, two improvement levels in these perceptions were assumed. In the first case whereby perceptions improved by one level on the five-level scale, a 4 percent increase in the number of drivers acquiring pretrip traffic information (31 to 35 percent and a 2 percent increase in acquisition of en-route information (from 30 to 32 percent) were forecasted. In the second case, when all drivers were assumed to perceive radio traffic information as reliable and relevant, the forecasted increases in pretrip and en-route information acquisition were 7 percent (from 31 to 38 percent) and 3 percent (from 30 to 33 percent), respectively.

Although the percentage increases were not very significant—possibly a reflection of general attitudes toward information provided by radio traffic reports—the exercise helps visualize the potential applications of the modeling framework in forecasting traveler response to ATIS options, including the acquisition of traffic information characterized by various reliability levels. It is believed that if the modeling framework is utilized with data of traveler behavior obtained from field tests using actual ATIS or from travel simulators, the sensitivity to information characteristics will be more significant.

CONCLUSIONS AND FURTHER RESEARCH

A general framework and model structure for drivers' route choice behavior in the presence of traffic information were formulated in this paper. The following travel decisions were analyzed:

- Acquisition of pretrip traffic information;
- Influence of pretrip traffic information on commuters' decisions;
- Acquisition of en-route traffic information; and
- Drivers' switching behavior.

Model estimation was based on the results of a survey of MIT commuters conducted in 1991. The questions in the survey, related to pretrip and en-route information acquisition, provided the opportunity to evaluate the direct impact of traffic information on users' decisions. In addition, attitudes and perceptions were incorporated into the models using a two-stage process that eliminated inconsistencies or biases from the estimations.

Perceptions about the relevance and reliability of the radio traffic reports were found to be important factors that affect radio traffic information acquisition. Therefore, it can be said that a more reliable and more frequently updated traffic information system than radio would stimulate the acquisition of traffic information. En-route diversion is influenced by attitudinal factors of the drivers and by information acquisition. It was also found that the drivers' own observations are an important factor toward route switching. This finding is important for the efficient implementation of route guidance systems. Only a system that gives accurate and precise directions that correspond to and reflect actual traffic conditions will be successful at gaining driver confidence in following its route choice instructions. Finally, the model showing willingness to pay indicates that drivers with higher incomes and the potential for travel time savings are more willing to pay for more useful information.

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Publication of this paper sponsored by Committee on Transportation Supply Analysis.