DRIVERS' EVALUATION OF ADVANCED TRAVELER INFORMATION SYSTEMS FOR INTER-CITY EXPRESSWAYS IN JAPAN

by

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ABSTRACT

This thesis proposes a comprehensive methodology for assessing drivers' evaluation of Advanced Traveler Information Systems (ATIS) on the most important artery in Japan, the Tomei Expressway, where traffic information systems have been in full-scale use for over 20 years.

We constructed a modeling framework for drivers' traffic information acquisition and their travel responses to acquired traffic information. This research is based on a survey that consists of a revealed preference (RP) part and a stated preference (SP) part. The RP part assessed drivers' actual traffic information acquisition and travel responses, and the SP part evaluated their choice from among hypothetical routes with various attributes, including different levels of quality of traffic information services.

From the estimation results of discrete choice logit models, we obtained a plethora of useful conclusions. For example, drivers who have acquired traffic information before their departure are most likely to acquire information during the trip. These drivers also tend to consult the same traffic information sources before and during the trip. Users of the Tomei expressway have a choice among multiple pre-trip and en-route traffic information services. The modeling results have shown that the most important factor affecting the choice among information sources is their perceived usefulness.

Drivers' responses to the acquired traffic information are represented by the following sequence. The first response is the choice of departure time. The second is the choice of an entrance to the inter-city expressway. The third is the choice of time spent at rest areas, and finally the fourth is the choice of an exit. Each of these decisions is strongly affected by the content of the acquired traffic information as well as drivers' previous decisions (e.g., drivers who have changed entrances are more likely to change exits).

Moreover, the data indicates that some drivers respond to traffic information, despite having no firm conviction that traffic delays will be shorter as a result of their actions. Therefore, the major effect of ATIS on inter-city expressways is psychological; it alleviates drivers' anxiety and frustration. Furthermore, considering the results of our survey, simply receiving traffic information has a greater effect on alleviating drivers' frustration than changing travel plans.

Finally, the major conclusion of the SP experiment is that current en-route traffic information services on the Tomei Expressway are valued by the drivers to be worth 14% of the toll. This finding implies that the benefits of the existing ATIS significantly exceed the costs.

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Chapter 1

Introduction

This thesis will address the effectiveness of the traffic information provision on drivers' behavior of the inter-city trip in Japan.

1.1 Main Issues of Inter-City Expressways in Japan

From the road administrator's viewpoint, there are three main issues concerning customer service: traffic safety, traffic congestion, and traffic information. Traffic Information is considered to be one of the quick but efficient solutions of traffic safety and traffic congestion problems.

1. Traffic Safety

The accident rate[1] on inter-city expressways is about one-ninth of that on ordinary roads. Once an accident occurs, however, the number of fatalities[2] can be so high that public awareness of traffic safety on these expressways is also rather high.

In recent years, 300 to 400 people have been killed on inter-city expressways in Japan each year.

2. Traffic Congestion

Compared with urban expressways, inter-city expressways have fewer problems with congestion. In areas surrounding large cities, however, congestion occurs frequently. For example on the Tomei Expressway, which is the most important artery connecting Tokyo

[1] 12 accidents/100 million vehicle-km for inter-city expressways and 105 accidents/100 million vehicle-km for ordinary roads

[2] In 1974 an accident occurred in a long tunnel, involved more than 200 vehicles, and killed over 100 people.

and Nagoya, occurred congestion in 6,315 congestion episodes[3] occurred in 1993 (averaging 17.3 congestion episodes per day). The total duration of these congestion episodes amounted to 10,138 hours in 1993 (averaging 27.8 hours per day). This means that, on average, the back up would continue for 1.6 hours for each congestion episode.

Congestion on inter-city expressways is divided into four types: congestion due to saturation, road work, accidents, and other (such as weather conditions, etc.). Congestion due to saturation occurs naturally when the road capacity is insufficient for traffic volume. This is the most common cause of congestion. To deal with saturation-induced congestion, a variety of measures that concentrate on expanding the traffic capacity have been proposed and are being implemented. Fundamental countermeasures such as increasing the number of lanes, increasing entrance or exit ramp lanes, increasing the operating lanes at tollgates, and improving access roads, need much expenditure and a long construction period. However, inter-city expressway users expect quick-acting countermeasures.

Practical and fundamental countermeasures to combat congestion are discussed with concrete examples in Chapter 2. In this chapter, commonly used countermeasures concerning traffic management (see Figure 1.1) are discussed.

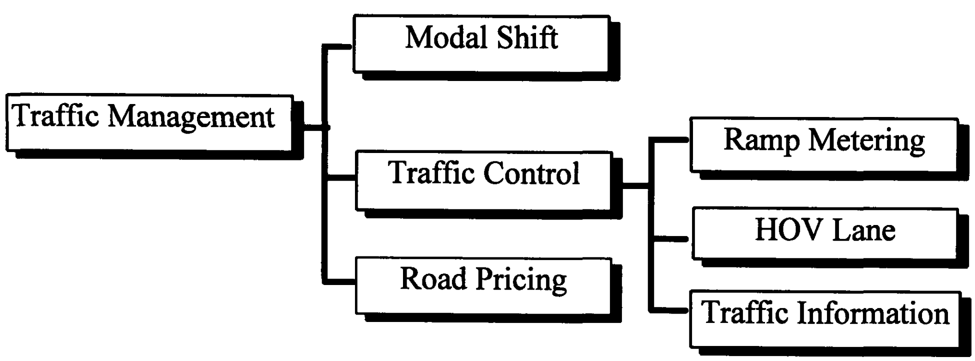


Figure 1.1 Traffic Management Configuration

[3] A congestion section, is defined as the traffic condition when the average speed drops to below 40 km/h.

In Japan, control of the traffic volume using traffic management strategies is extremely difficult on inter-city expressways, for the following reasons.

(1) Modal Shift

The modal shift from the inter-city expressway to rail is not large. As regards freight, the proportion of transport volume handled by the inter-city expressway is growing from year to year, and the shift to rail has not been achieved successfully due to insufficient rail capacity. Concerning passenger transportation, the modal shift is also not entirely successful, because the Japanese bullet trains are already greatly used and it would be difficult to increase their capacity. Besides, the trip characteristics of the inter-city expressway users are different from those of the bullet train riders. For example, the average trip length of inter-city expressway users is about 50 to 100 km, while that of the bullet train users is over 300 km. Moreover, commuting traffic on inter-city expressways is so light that a diversion to public transportation can not be expected.

(2) Route Diversion

Since Japan does not have an adequate inter-city expressway network system to share the traffic volume, route diversion is inconsistent with reality. For long inter-city trips, the alternatives are so slow (most of them are ordinary roads and their average speed is approximately 30 km/h) that drivers usually have no choice but to use inter-city expressways. Although route diversion is useful and effective on urban expressways which have adequate network systems, it is not used on inter-city expressways.

(3) High Occupancy Vehicle (HOV) Lanes

HOV lanes are not practical. Since the length of inter-city expressways which have more than three lanes in each direction is very short and those multilane sections support heavy traffic volume in metropolitan areas, it is highly impractical to dedicate a lane to HOV. There is no HOV lane on inter-city expressways in Japan at present.

(4) Road Pricing

Road pricing is considered an effective countermeasure for traffic demand control. However all inter-city expressways in Japan are already toll roads and the politically determined toll rates are approximately the same throughout the country. Moreover the toll rate in Japan is now the most expensive in the world, and the users of inter-city expressways are sensitive to raising the toll rate. Thus there is little room to for congestion pricing on inter-city expressways.

3. Traffic Information

After discussing measures that have been used and proposed for reducing congestion, this research focuses on issues of traffic information, one of the most important means of alleviating congestion problems.

The Japan Highway Public Corporation (JHPC), which administers all the inter-city expressways in Japan, is trying to improve traffic information systems for a variety of reasons:

(1) The provision of traffic information is considered an easy countermeasure against traffic congestion, because traffic information would divert drivers to an alternate route. Even though, it is very rare for inter-city expressway users to switch routes. The psychological effect of receiving traffic information on the drivers is significant, because their anxieties and frustration can be reduced.

(2) The provision of traffic information is considered a countermeasure against traffic accidents, since the implementation of the fundamental countermeasures against traffic accidents, such as the improvement of geometric design, the widening of the carriageway, the improvement of the service level of snow removal and ice control, the raising of the level of illumination inside tunnels, etc. take much time and are expensive. Moreover, in terms of the direct effect of the traffic information service on traffic safety, drivers who have acquired information about congestion are more attentive and therefore more likely to avoid rear-end collisions, and drivers who have snow and ice or storm information can avoid hazardous situations.

(3) The social need for information has been growing in all areas of our information-oriented society. Drivers' demands for traffic information has also increased rapidly.

(4) The breakthrough in the telecommunication area, such as the practical use of optical fiber cables, has made it possible to provide a large amount of traffic information. In other words, technical innovation has prepared the groundwork for the information era.

1.2 Motivation underlying the Research

The JHPC and other urban expressway corporations have been pushing forward with Advanced Traveler Information Systems (ATIS). Existing ATIS services provide sophisticated traffic information, such as travel time and location of congestion and queue length, through variable message sign boards (including graphic map types), advisory traffic radios (dedicated local transmitting stations using automatically computer-synthesized announcements) and auto-answering telephone service, updated every five minutes. The ATIS were developed not only as countermeasures against traffic congestion and traffic accidents, but primarily as a part of customer service. Users of inter-city expressways, which are all toll roads, have never had the concept of paying money for traffic information, and the JHPC has no conception, either, of investigating the monetary value of traffic information services. However, the JHPC should be able to obtain customer evaluations of the ATIS and make a strategic implementation plan of them, something it has not achieved heretofore.

The improvement of traffic information service increases the utility of inter-city expressway users who have been diverted from ordinary roads. However, the following items are only considered to be of benefit to inter-city expressway users:

1. save travel time
2. save fuel cost, save wear of tires and engine oil
3. improve passenger comfort
4. reduce damage to freight
5. improve traffic safety

As stated above, all inter-city expressways in Japan are toll roads. The toll rates must be set at such levels as to be sufficient to cover the cost of construction, the acquisition cost of the right-of-way and interest charges, and the cost of current maintenance and operation. The period of toll collection is basically 30 years from the completion of the nationwide network. In addition the toll rates must be fair and reasonable so that each toll should not exceed the benefit normally received by the customer. However, the utility of the traffic information service is not counted as a user's benefit.

One particular characteristic of the toll system of inter-city expressways is the *pool system.* Since these expressways form a single road network which extends throughout Japan, their construction costs are accounted for at the network level rather than at the individual inter-city expressway link. Thus, toll rates are raised every three to five years subject to the expansion of the inter-city expressway network plan. After every raise, customers require an improvement of the service level, and the JHPC always lists a reinforcement of the traffic information system on the improvement menu in order to escape customers' criticism. The improvement of traffic information systems is easy to implement and attracts the attention of customers. However, as long as the JHPC does not know the real value of the traffic information service, it can not make a feasible investment plan for the ATIS. Moreover, as long as it does not know how and in what situations drivers require traffic information, it can not draw up a comprehensive and strategic master plan for the ATIS.

1.3 Objectives of the Research

The purpose of this thesis is to propose a method for assessing drivers' evaluation of the ATIS. Also it analyzes the influence of the ATIS on drivers' responses by constructing behavioral models. This is a case study based on a survey of drivers on the Tomei Expressway. The most important point of this study is that the survey questioned the users of ATIS which has been in actual operation. Japan is the only country where ATIS are in full-scale practical use. Users of inter-city expressways have used ATIS for over 20 years, so that they have sufficient familiarity and knowledge about ATIS. The data gathered in this study provides us unique and significant findings about users' evaluation of ATIS. Furthermore this research focuses not on urban expressways which have networks, but on inter-city expressways. Although inter-city expressways do not have a complete network which would provide alternate routes for drivers, it is very useful to investigate how the users of the ATIS on inter-city expressways evaluate them and how the users respond to them. In addition, the methodology developed in this research can be applied to other inter-city expressways.

In evaluating the existing ATIS implemented on the Tomei Expressway, this research will identify:

(1) The traffic information sources which are more attractive for users and the important factors for this attractiveness of these information sources

(2) The contents of traffic information likely to affect drivers' decisions (such as departure time choice, route choice, entrance and exit choice, etc.)

(3) The drivers' concealed "willingness to pay" for ATIS

In order to achieve these goals, a four-stage methodology was implemented. This methodology consists of the:

(1) Development of an inter-city drivers' behavioral framework. The hypothesis underlying this framework is that information acquisition and response to traffic information behaviors are influenced by trip characteristics, information characteristics, drivers' socioeconomic characteristics, and drivers' personal characteristics. This behavioral framework specifies how and in what situations drivers acquire traffic information, which information sources drivers consult, and how drivers respond to traffic information, based on traffic conditions.

(2) Development of a data collection methodology which includes the survey design and data collection on the Tomei Expressway. This survey consists of the following parts:

[*Revealed Preference* (RP) *Part*] Trip characteristics, drivers' usage and evaluation of the ATIS, responses to traffic information and expectations of traffic delays, attitudes toward driving, and socioeconomic characteristics

[*Stated Preference* (SP) *Part*] Drivers' choice from among hypothetical routes

(3) Development of a modeling methodology which includes the following models:

1. Pre-trip traffic information acquisition
2. En-route traffic information acquisition
3. Responses to traffic information
4. Route choice

(4) Forecasting of :

1. How the drivers responses will be affected by the characteristics of traffic information

2. How the willingness to pay for the ATIS will be affected by the trip characteristics , drivers' socioeconomic characteristics, or drivers' evaluation of the ATIS.

It may be desirable to mention briefly the points of this methodology to summarize and to give a more concrete idea of the main topics of this research:

(1) The development of drivers' behavioral models for traffic information acquisition and responses to traffic information

The above mentioned behavioral models are derived from revealed preference (RP) data taken from the survey of drivers on the Tomei Expressway. The focus of this research is on the influence of traffic information on drivers' response.

As a result, we can capture the impact of each information source and of the contents of information on drivers' response, and then we can make it clear which information services should be expanded and what kind of contents of information should be improved. After understanding these factors, we could estimate what portion of drivers would exit the expressway to ordinary roads influenced by particular traffic information, e.g. "5 km ahead of you there exists a 10-km-long back up due to an accident, and it takes 40 minutes to go through the back up." These findings are to be used for comprehensive traffic management strategies on the inter-city expressway network, which will be completed at the beginning of the next century, and for an appropriate allocation of traffic volume among existing expressways and ordinary roads.

(2) An assessment of the drivers' evaluation of the ATIS

In assessing the drivers' evaluation, stated preference (SP) data from the survey are used. As mentioned in Section 1.1, drivers on inter-city expressways have little possibility to change their routes, so that their main alternatives are to change their departure times, to change entrance or exit interchanges, or to change their plans for spending time at rest areas. Therefore traffic information does not have a significant impact as far as saving travel time and travel cost is concerned. The major effect that the availability of traffic information on inter-city expressways has on drivers is considered to be psychological; it alleviates drivers' anxiety and frustration due to insufficient traffic information and justifies drivers' decisions to take inter-city expressways. They feel relieved knowing the actual traffic conditions even though there are no obstacles in the way.

Estimate drivers' perceptions of utility of routes and evaluate the benefit of the following en-route information service levels:

1) Future Tomei Expressway [*the length of the back up, travel time, and information about alternate ordinary roads*]

2) Present Tomei Expressway [*the length of the back up and travel time*]

3) Old Tomei Expressway [*the length of the back up*]

Based on the evaluation of each service level, we can make a feasible investment plan for future traffic information services, and also justify the investment in the existing traffic information services.

The JHPC plans to expand the state-of-the-art ATIS on the Tomei Expressway to other metropolitan areas. In carrying out this plan, the findings of this research should be applied.

Future expansion of the inter-city expressway network will lead to situation with valuable route diversion possibilities. These will present opportunities to implement more advanced traveler information system with route diversion recommendations.

1.4 Brief Literature Review

Current research efforts on ATIS fall into two main categories: travel behavioral modeling and traffic simulation (Khattak et al. (1995)). An extensive literature review on existing research efforts on travel behavior modeling is presented in Ben-Akiva et al. (1993). Based on this review, we would like to present an overview of state-of the-art research on ATIS.

1. Framework for Drivers' Behavior and Model Structure

Most research conducted to date has been focused on modeling the ATIS usage, travel response, and learning.

ATIS Usage

Polydoropoulou et al. (1993) proposed a modeling framework for pre-trip and en-route information acquisition, and the influence of the acquired information on drivers' route choice and route switching. Abdel-Aty et al. (1994) also proposed simultaneous models for usage and travel response of commuters.

Travel Response

Modeling Pre-Trip Choices

Cascetta and Biggiero (1992), Polak and Jones (1992), and Polydoropoulou et al. (1994) have developed models of the influence of pre-trip information on travelers' mode choice, departure time, route choice, and frequency of route changes. Cascetta and Biggiero (1992) estimated logit models for departure time and path choice for home-to-work trips, based on an RP survey. Polak and Jones (1992) studied the impact of in-home pre-trip traffic information.

Modeling En-Route Choices

Adler et al. (1992 a, b, 1993), Bonsall and Parry (1991), Jayakrishnan and Mahmassani (1991), Khattak et al. (1991, 1992), Lotan and Koutsopoulos (1993) have made modeling efforts on various aspects of en-route traveler behavior in the presence of information. Jayakrishnan and Mahmassani (1991) presented a model of the path selection decisions of individual motorists along their journey in response to supplied information. Khattak et al. (1991) investigated short term driver diversion response to incident-induced congestion delay and evaluated the ways in which drivers use real-time traffic information. Khattak et al. (1992) used SP data to evaluate the effects of real-time traffic information, along with driver attributes, roadway characteristics and situational factors on drivers' willingness to divert. Bonsall and Parry (1991) developed an interactive route-choice simulator to investigate drivers' compliance to route guidance advice. Lotan (1992) modeled the route choice process and the drivers' perceptions in the presence of information by using concepts from fuzzy sets theory, approximate reasoning and fuzzy control. Adler et al. (1992 a, b, 1993) used a driving simulator to collect data for estimation and calibration of predictive models of drivers' behavior under the influence of real-time information.

Learning

Models of Trip-to-Trip Adjustments

Ben-Akiva et al. (1984) suggested a simplified model of day-to-day travel adjustment and Vythoulkas (1990) extended the model which assumed that individuals were informed about actual travel time on the previous day and that they used this information in making their travel decisions for the next trip. Horowitz (1984) assumed that drivers acquire their information on travel costs from previous commuting experiences. Hatcher and Mahmassani (1992) addressed the day-to-day variation of individual trip scheduling and route decisions for the evening commute.

Updating perceptions

Iida et al. (1992 a) investigated the mechanism of travel time prediction by analyzing the dynamics of the route choice behavior using laboratory-like experiments that repeatedly asked participants to respond to hypothetical route choice situations. Van. der Mede and Van Berkum (1991) used a route-choice computer game to simulate and model individuals' route choice sequences in situations where RTI (Road Transport Informatics), and a particular VMS (Variable Message Sign) were available or not. Vaughn et al. (1993) and Yang et al. (1993) instructed each participant using a simulator whose objective is to minimize travel time by deciding when to follow the ATIS recommendation.

2. Data Collection Methodologies

Data collection methodologies can be classified into three main groups: travel surveys, travel simulators, and field experiments.

Travel Surveys

A. General Traveler population Surveys

1. *To capture user response to commercially available traffic information services*

This type of surveys have only addressed the acquisition of radio traffic reports and the influence of such information on drivers' route choice behavior (see Khattak et al. (1991), Mahmassani et al. (1989,1991), Kaysi (1992), Lotan (1992)).

2. *To address user response to un-implemented ATIS services*

Polydoropoulou (1993b) conducted a pilot survey to investigate the willingness to pay for the ATIS. A nationwide ATIS-related survey was conducted at the University of Washington (Ng et al. (1993)). Khattak et al. (1995) explored how people respond to

ATIS through a survey of Bay Area automobile commuters, and travelers' response to future ATIS technologies through stated preference.

B. Survey targeting Operational Test and Simulation Experiment Subject

Surveys conducted in conjunction with actual field experiments provide the opportunity to investigate awareness and access decisions related to actual ATIS. These surveys are also helpful in collecting information regarding trip decisions (ATIS usage and travel response), perceptions of information quality, and learning effects. Multisystems (1993,1994) conducted ATIS-related surveys in association with the SmartTraveler system. Kantonwitz et al. (1993) presented a focus group study conducted to investigate customer evaluation of the Travtek.

Travel Simulators

Koutsopoulos et al. (1993) presented the categories of data collected so far from travel simulators developed by various research teams, based on the available reports and informal communication with developers of these simulators. Existing travel simulators have been utilized to collect data only for *Usage*, *Travel Response*, and *Updating of Perceptions* of the modeling framework.

Field Experiments

Whitworth (1993) presented a comprehensive review of the role of operational tests in understanding user response to ATIS. This review says there are many demonstration projects in the U.S. which provide data supporting the various stages of user response to ATIS. User response is primarily based on the evaluation plans that have been developed for these operational tests. The ATIS usage stage and route choice dimension of the travel response stage are covered quite well, however little or no data is expected from these demonstration projects with regard to awareness or willingness to pay.

3. Studies on Drivers' Response to ATIS in Japan

Since Japan has more than 20 years experience in full-scale practical use of ATIS, especially in the Tokyo and the Osaka metropolitan areas, there are many studies related to ATIS. These studies fall into three main categories:

1) Field Survey on Drivers' Behavior

2) Experimental Approach to Drivers' Behavior

3) Simulation of Route Choice in the presence of information

Field Survey on Drivers' behavior

Iida et al. (1992 b, 1993 a) conducted a survey of drivers who could obtain travel time information on three routes connecting Sakai (about 15 km south from Osaka, population 806,000) and Osaka C.B.D. and then estimated MNL route choice models to illustrate the degree of the influence of travel time information on drivers' route choice. Uchida et al. (1992) analyzed the departure time choice behavior of commuting drivers by using an empirical data collected through roadside surveys and a panel survey. Taniguchi et al. (1993) and Hato et al. (1995) introduced a floating-car technique on the Metropolitan Expressways and on the alternate ordinary surface roads, as well as an SP survey to investigate the influence of traffic information on drivers' route choice.

Experimental Approach to Drivers' Behavior

Iida et al. (1989 a,1991 a) analyzed drivers' dynamic route choice behavior from the results of an SP panel survey. Iida et al. (1990 a,1991 b, 1993 b) also constructed travel time prediction models considering the pattern of drivers' route choice in the presence of travel time information based on an SP panel survey. Iida et al. (1992 c) analyzed an interaction between drivers' travel experiences and their dynamic route choice behavior using an SP panel survey

Simulation of Route Choice in the Presence of Information.

There are many studies on route choice simulation. Those studies attempt to construct a dynamic route choice model which can simulate the route choice behavior and traffic flow under the operation of providing information on the hypothetical network (for example, see Iida et al. (1989 b , 1990 b, 1992 d, 1993 c, 1993 d, 1993 e), Kobayashi (1990, 1992), Kobayashi et al. (1993 a, 1993 b), Uchida et al. (1991), Moritsu et al. (1992, 1993), Nakagawa (1993), and Wakabayashi (1993)).

4. Conclusions

The above literature review revealed that data collection efforts focused so far on inter-city drivers' behavioral responses to conventional information sources (such as radio and TV) or hypothetical ATIS. Since ATIS are implemented for more than 20 years on inter-city expressways in Japan, we have the differential advantage to collect revealed preference data of inter-city drivers' behavior toward a variety of existing ATIS.

Current modeling efforts have not been able to quantify travelers' willingness to pay for ATIS. The design of the SP experiment in this study will allow making inferences on travelers' evaluation of various levels of information sources.

Travelers' usage models have been focused on the decision to acquire or not traffic information. We will be able to extend these models, and develop models of the actual choice of a specific ATIS among various pre-trip and en-route alternative choices.

Furthermore, existing travel response models mostly focused on travelers' decisions to change their usual commuting behavior. No models have been developed so far for the inter-city travelers.

Finally, most studies conducted in Japan on drivers' behavior are based on SP data. We will use our stated preference experimental results to compare with the results of these studies.

1.5 Thesis Outline

This thesis consists of eight chapters. Chapter 2 introduces the ATIS in Japan which has already more than 20 years history of full-scale practical use. This chapter also reviews the background information of drivers who use inter-city expressways in Japan. Chapter 3 discusses the model structure and the framework for drivers' behavior. The basic concepts underlying the drivers' responses in the presence of traffic information are analyzed. Chapter 4 discusses data collection methodologies including questionnaire design. Chapter 5 presents descriptive statistics of our survey comparing them with the previous surveys conducted on the inter-city expressways in Japan. Chapter 6 presents the analysis and interpretation of the estimation results of approaches used to model the acquisition of pre-trip traffic information, the acquisition of en-route traffic information, and the response to traffic information. Chapter 7 explores drivers' perception of the utility of the ATIS services on the inter-city expressways by estimating our route choice model based on the SP data. Chapter 8 presents contributions and major findings as well as plans for future work.

Chapter 2

Advanced Traveler Information Systems in Japan

In this chapter, the Advanced Traveler Information Systems (ATIS) in Japan are introduced. To understand the background of this study which developed drivers' behavioral models of responses to the ATIS, it would be useful to know what is going on concerning ATIS in Japan. First, the inter-city expressway system and countermeasures against traffic congestion are explained. Then the discussion focuses on the ATIS on the Tomei Expressway. Last, traffic information sources other than the ATIS are explained

2.1 Inter-City Expressway System

Japan started to improve public facilities as the infrastructure in the 1950's after restoring itself from the devastation of World War II. In this period, the improvement of roads was recognized as indispensable for the well-balanced development of national land, and thus it became an urgent issue, as the traffic demand on roads grew remarkably. At that time, roads in Japan were out-of-date by several decades compared to behind those in Europe and in North America. In order to respond to expanding traffic demands, it was also necessary to secure financial resources for roads, however, it was quite difficult to carry out the planned development within the limited national budget. Therefore, the toll road system was introduced in 1952. Using this system, the costs for road construction were borrowed from the government and financial institutions and the repayments were made by toll collection after roads opened. In 1956, the Japan Highway Public Corporation (JHPC) was established. The JHPC is a special nationwide organization that is capable of widely utilizing not only governmental funds but also private funds, and of managing the toll road business efficiently and comprehensively.

Since its establishment, the JHPC has expanded the nationwide inter-city expressway system and contributed a great deal to the nation's economic development and social welfare. The JHPC now operates 5,614 km of national inter-city expressways which have a master plan that requires the completion of the network of 11,520 km by the beginning of the 21st century (see Table 2.1 and Figure 2.1). Inter-city expressways have now become the arteries of the Japanese Archipelago. Not only are they essential to industry for moving freight and conducting business effectively, they have also become indispensable to daily life, for both work and leisure.

Table 2.1 Roads in Japan (as of April 1, 1993)

Classification	Total Length (A) (km)	Paved Length (B) (km)	(B)/(A) (%)
National Inter-city Expressway	(5,614) 5,404 (0.5)	(5,614) 5,404 (0.7)	(100.0) 100.0
Urban Expressway	473 (0.1)	473 (0.1)	100.0
National Highway	53,304 (4.7)	52,400 (6.4)	98.3
Prefectural Road	123,536 (10.9)	115,184 (14.1)	93.2
Municipal Road	948,169 (83.8)	641,669 (78.7)	67.7
Total	1,130,886	815,130	72.1

Source: The JHPC, (1994), ANNUAL REPORT, Tokyo
Note: Percentage(%) of all roads is shown in( )
Figures of National Inter-city Expressway in ( ) are as of September 1, 1994

In 1990, inter-city expressways accounted for 20.2% of freight transport (ton-km) and 4.8% of passenger transport (person-km). In addition, although inter-city expressways carried an estimated 40.3% of freight and 7.3% of passengers transported by automobiles, they accounted for only 0.6% of the total length of paved roads in Japan (see Figure 2.2).

In Japan, road systems are divided into two categories. One is the *expressway* and the other is the *ordinary road.* The expressway consists of the inter-city expressway and the urban expressway, and the ordinary road consists of the national highway, the prefectural road, and the municipal road.

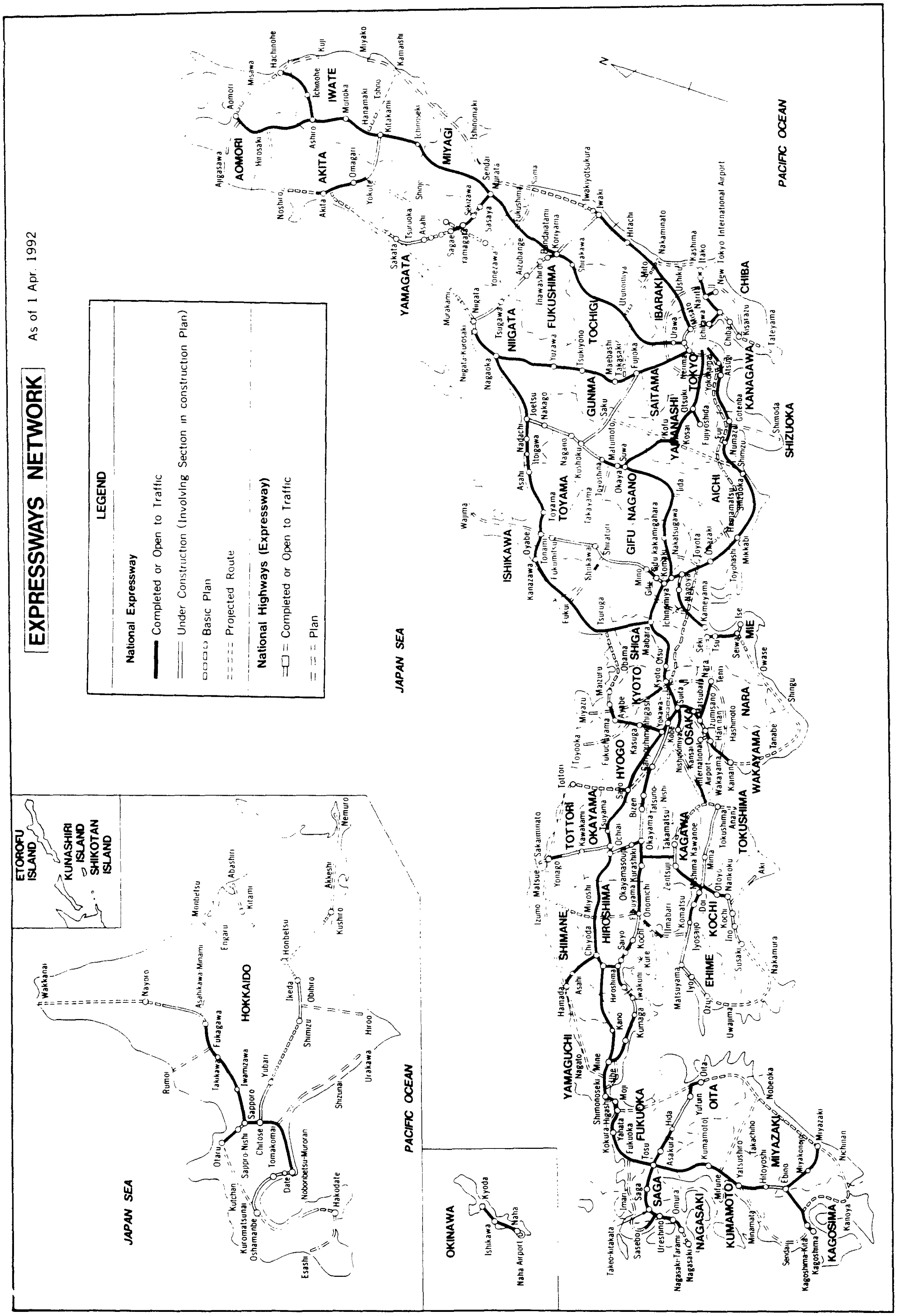


Figure 2.1 Master Plan for Inter-City Expressway Network

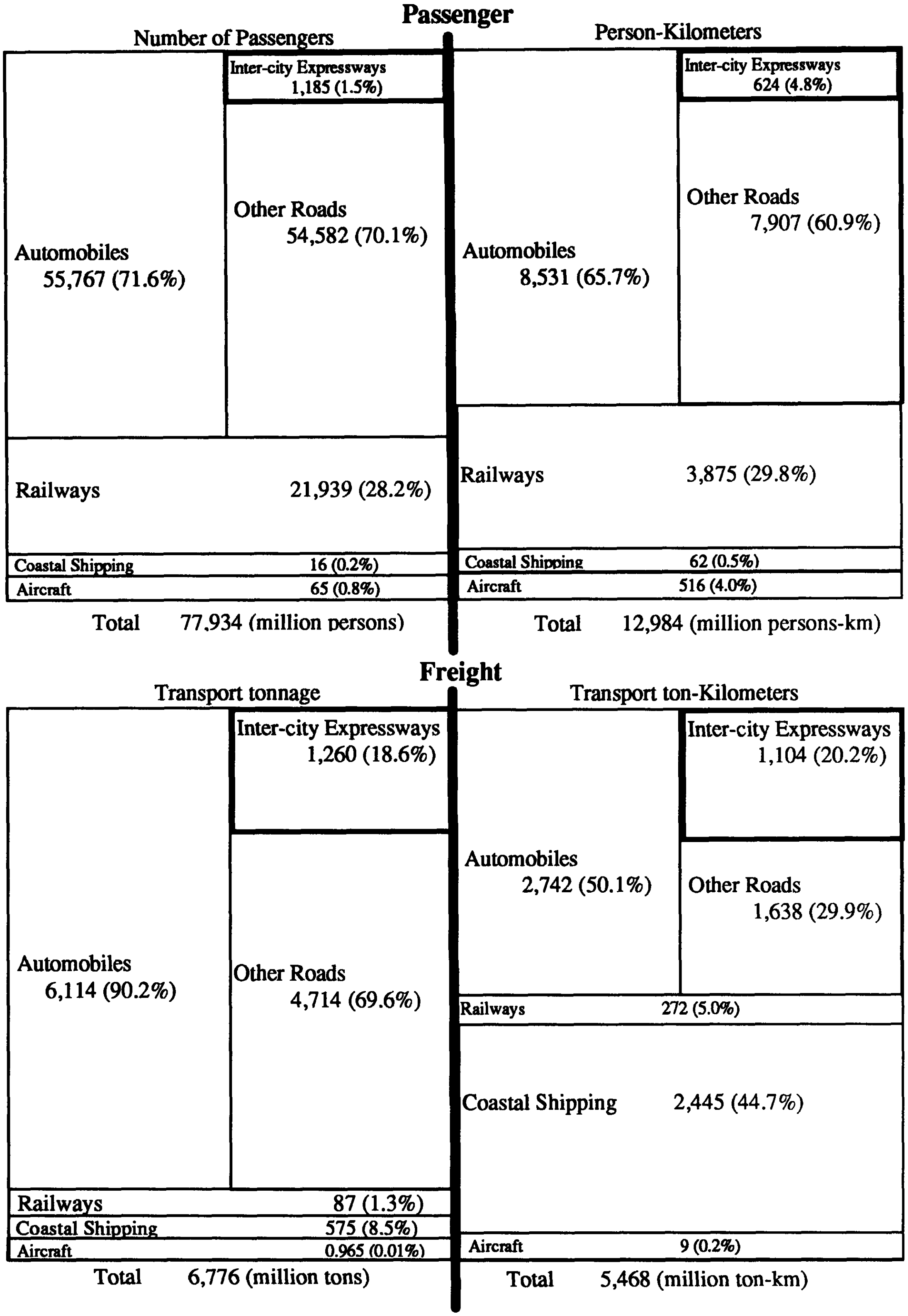


Figure 2.2 Share of Inter-City Expressways in Domestic Transportation

2.2 Countermeasures against Traffic Congestion

The most effective countermeasure is to increase road capacity and to complete the nationwide network of inter-city expressway. To meet this requirement, the Japanese Government decided to construct 11.520 km of inter-city expressway network, of which 5,614 km has already been completed. This level of road infrastructure is low compared to the standard in industrialized countries on the basis of population, area, GNP, number of automobiles, and vehicle-km statistics (see Table 2.2).

Table 2.2 International Comparison of Expressways

Country		Japan	U.S.A.	Former Wes Germany	U.K.	France	Italy
Length	km	5,929	72,857	8,959	2,903	7,450	6,767
$\frac{\text{Length}}{\text{Land area}}$	$\frac{\text{km}}{10{,}000\text{km}^2}$	157.0	77.7	360.4	118.9	135.1	224.6
$\frac{\text{Length}}{\text{Population}}$	$\frac{\text{km}}{10{,}000}$	0.48	2.88	1.40	0.51	1.31	1.19
$\frac{\text{length}}{\sqrt{\text{Area} \times \text{Popuration}}}$	$\frac{\text{km}}{\sqrt{10{,}000 \times 10{,}000\text{km}^2}}$	8.67	14.97	22.44	7.76	13.28	16.32
$\frac{\text{Length}}{\text{Automobile ownership}}$	$\frac{\text{km}}{10{,}000\text{vehcles}}$	0.99	3.82	2.68	1.09	2.81	2.20
Annual average length of constructio (1985-1989)	km/year	260	501	181		200	

Source: Ministry of Construction, (1993), ROAD HANDBOOK, Tokyo

Note: 1. Length is based on "World Road Statistics 1992" (IRF), as of the end of 1990.

2. As of the end of 1991 for France; as of the end of 1989 for Italy; length of Interstate Highway as of 31 December 1991 in "Highway Statistics 1991" for U.S.A.; length of expressways as of the end of 1992 fiscal year for Japan.

3. In New Road Improvement 6-Year Program starting in 1992, U.S.A. plans to construct 155,000 miles (approximately 248,000 km) as National Highway System.

4. Population is based on "Monthly Bulletin of statistics, December 1992," and as of the midpoint of 1991.

5. Land area is for 1990 in "international statistics Abstract 1992/1993" (management and coordination Agency)

6. Automobile ownership is based on "Automobile Statistics in Major Countries 1992" (Japan automobile manufacturers Association), and as of the end of 1991.

7. Annual average length of construction for the former West Germany is an average of 1986-1987.

2.2.1 Reconstruction

Reconstruction work of the existing bottleneck section is the most effective countermeasure against traffic congestion by increasing its road capacity. It requires much expenditure and a long construction period, however, slow but steady progress has been made in recent years. The Tomei Expressway and The Meishin Expressway which were constructed in the earliest stage, have been playing an important role as an artery indispensable for daily life and economy for more than a quarter century. These expressways have experienced rapid motorization, and their traffic volume has greatly increased beyond their original design level, thereby inducing frequent traffic congestion. Therefore the reconstruction of these inter-city expressways started as a response to an urgent problem and is now under way in the sections where the traffic volume is extremely large.

2.2.2 New Tomei Expressway and Meishin Expressway

The JHPC has a plan to construct the Super-Expressways which permit highspeed driving at approximately 140 km/h. After completion of these new expressways, their six-lane carriageways will support the heaviest traffic volume of this section, however, it may not happen until the second decade of the next century.

2.2.3 Completion of the Inter-City Expressway Network in the Tokyo Metropolitan Area

From the 1950's until the mid 1960's, the expressway network which comprised the skeleton of the Tokyo metropolitan area had been the subject of careful study which resulted in the formulation of the "Three Rings (Central Circular Route, Tokyo Outer Ring Road, and Metropolitan Inter-city Expressway) and Nine Radials." Almost 30 years have passed since this plan was first conceived, and at present, Nine Radials have been constructed according to the original concept. However, with respect to the Three Rings, by 1987, only the east half of the Central Circular Route had been placed in service. In November 1992, a northern part of the Tokyo Outer Ring Road started its service. Metropolitan Inter-city Expressway has just begun its construction work (see Figure 2.3).

The west half of the Tokyo Bay Shore Highway is near completion, and Trans-Tokyo-Bay Highway will be completed in spring, 1997. The construction of the inter-city expressway network is making little progress, however, it is alleviating congestion problems gradually in the Tokyo metropolitan area. By the completion of the network, which may not occur until the middle of the next century, the congestion problems will dramatically improve.

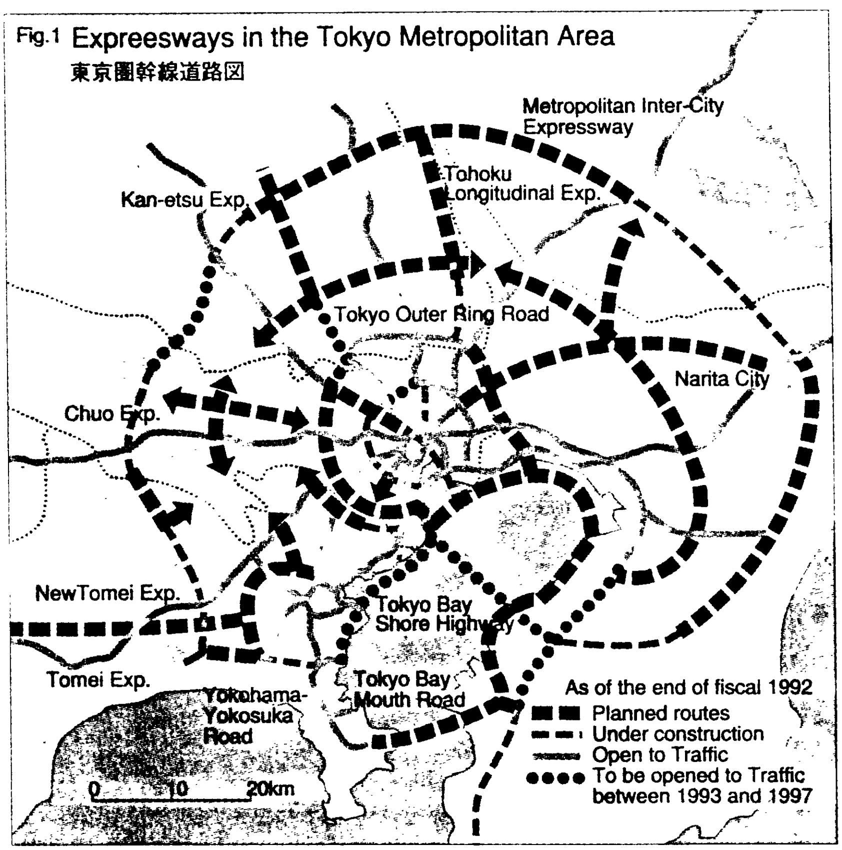


Figure 2.3 Expressways in the Tokyo Metropolitan Area

Source: Ministry of Construction, (1993), ROADS IN JAPAN, Tokyo.

2.3 Advanced Traveler Information Systems

2.3.1 Historical Background

In 1963, for the first time since the establishment of the JHPC, a section (71 km) of the Meishin Expressway was opened to traffic. At that time, "traffic patrol squads" were already organized in order to control traffic. The tasks of traffic patrol squads include immediate actions in case of accidents, removal of obstacles to traffic, aid to disabled cars, and collection of traffic information. This was the beginning of the traffic management systems of the JHPC. (These traffic patrol squads have no police powers, so they can not issue tickets to violators. However, as road administrators they can control vehicle restrictions, especially against overweight trucks. Before the traffic patrol squads were organized, it was discussed if they should have police powers or not. The security officers of the former Japan National Railways had police powers in the railroad territory.)

In 1969, the Tomei Expressway was completed, and also sections of the Chugoku Expressway and Kinki Expressway in the Osaka metropolitan area were opened. Besides, the network of the Hanshin Expressway Public Corporation (urban expressways in the Osaka metropolitan area) had expanded. The congestion on the Meishin Expressway in the Osaka metropolitan area became worse than ever. Moreover, an international exposition was planned to be held in Osaka for six months from March 1970. At this time the comprehensive traffic management system was introduced to the expressways in the Osaka metropolitan area. The traffic information was gathered by vehicle detectors and traffic patrol squads, and sent to the traffic control center where the dispatchers controlled variable message signs on the expressways. This system was the prototype of the traffic management system of the JHPC.

The New Tokyo International Airport, which is 70 km away from downtown Tokyo, was opened in May 1978. After the completion of the Tokan Expressway in April 1982, passengers for the airport became able to choose among two alternate routes which are both inter-city expressways. However, the routine congestion occurred especially during the morning and evening peak hours, and some passengers missed their flights due to traffic delay. In order to minimize the traffic delay and make effective use of the road capacity by sharing traffic demand between the two routes, through variable message signs the provision of traffic information to drivers for their route choice started (see Figure 2.4).

WIDE AREA TRAFFIC INFORMATION

Shortcut to the center of Tokyo, Take the Tokan Expressway

Length of the back up:

Keiyo route	13	km
Tokan route	5	km

Figure 2.4 Recommendation of a Shortcut

This attempt succeeded in effective use of the expressways and became popular among drivers. In addition to the length of the back up, the JHPC tried to indicate travel time for both routes, however, the highway police interfered with this and the JHPC postponed this attempt. The police understand that provision of traffic information is under the jurisdiction of the National Police Agency, not of the JHPC or other road administrators. However, historically traffic information on expressways has been provided by the JHPC and the other expressway public corporations, because all expressways in Japan are toll roads and users of expressways have required a high level of traffic information services. This fact constrains the police and makes them resistant to further progress in ATIS implementation. In recent years, urban expressway public corporations started to provide travel time, and they suffered from obstructions by the police.

2.3.2 Traffic Management Systems (TMS)

Road administrators provide road and traffic information that benefits highway users by assuring highway functionality despite impeding factors, such as congestion, accidents, roadwork for maintenance and repairs, snow removal and ice control, falling objects, as well as hazardous driving conditions caused by rain, snow and ice, fog, wind, and earthquakes. The purpose of TMS is to encourage drivers to make appropriate decisions; road administrators also solicit drivers' caution by imposing traffic restrictions that counter the effects of impeding factors. This activity maintains a smooth traffic flow and ensures safety.

Incident detection and follow-up action to remove incidents

The road administrator, such as the JHPC or other urban expressway public corporations, sets up a traffic control center for the TMS. The following is an introduction to the TMS giving the example of the Tomei Expressway. In Figure 2.5, general idea about TMS is shown.

The traffic control center gathers round-the-clock information on road, traffic, and weather conditions, as well as other abnormal situations. On the other hand, the road administrator organizes traffic patrol squads as mentioned above. They collect traffic relevant information by means of regular and special road patrols 24 hours a day. Information on accidents or vehicle breakdowns comes through the emergency telephones installed roadside at one km intervals. The traffic patrol squad is then dispatched and it will take measures to deal with accidents and traffic congestion, such as by imposing traffic restrictions, surveying for recovery work, and for preventing secondary accidents, and giving necessary aid. At the same time, in response to the information, the traffic control center dispatches the highway police squads, the fire department, rescue teams, JAF (Japan Automobile Federation: corresponds to American Automobile Association (AAA)), towing subcontractors as well as traffic patrol squads.

On the operation panel at the traffic control center, data on an incident are entered into a computer. Information for drivers is sent by computer to variable message signs, Highway Radio transmitters, and Highway Telephone information banks to alert drivers to the problem. The traffic control center's computer contains prerecorded message fragments relating to accidents, breakdowns, and weather conditions. The computer pieces together an audio announcement for the Highway Radio and the Highway Telephone explaining the incident from the message fragments. The dispatchers simply enter the lane direction, nearest kilometer marker, and other details of the incident.

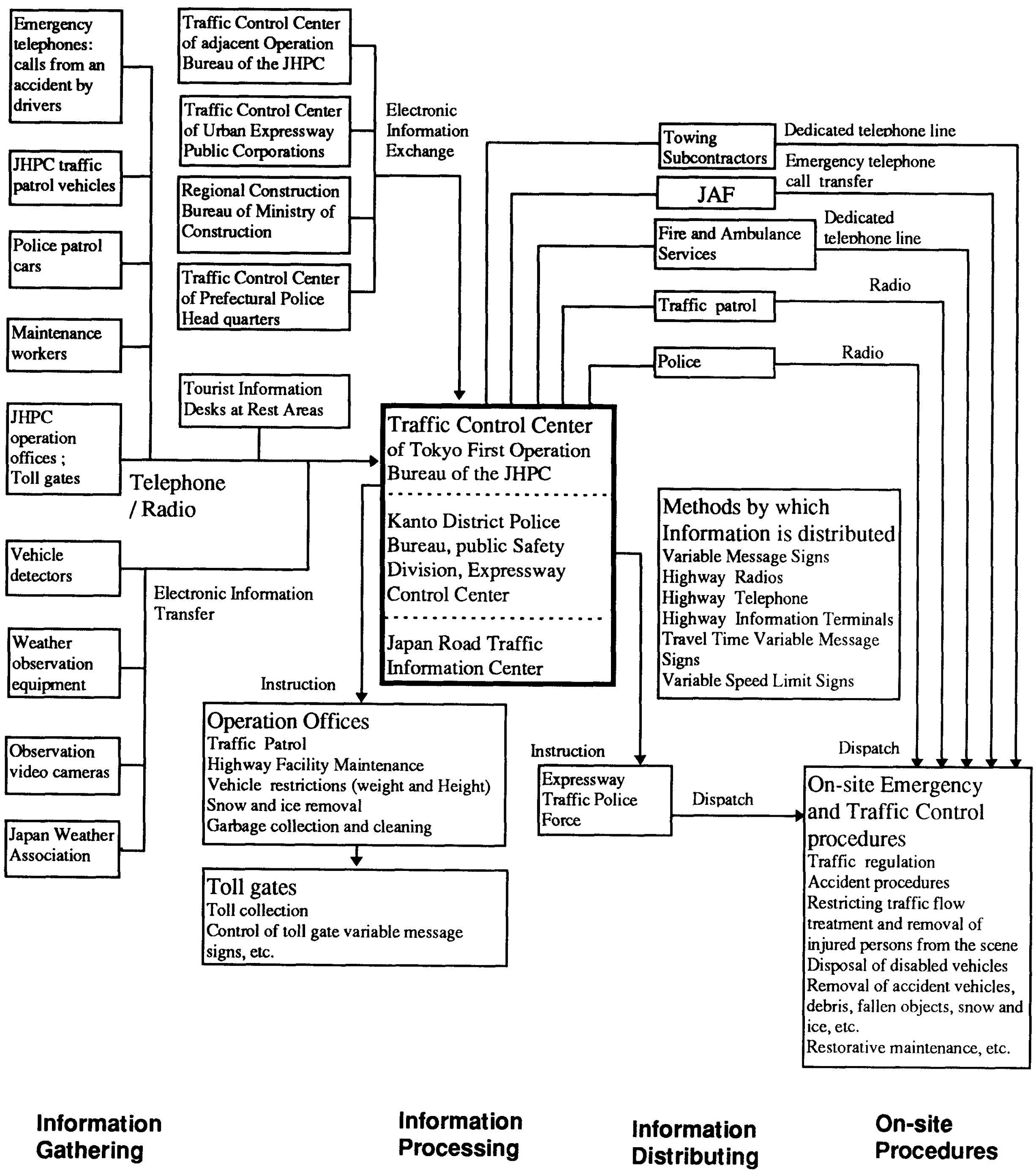


Figure 2.5 Traffic Management Systems

The variable message signs, which can relate traffic congestion information at one km intervals or information on traffic restrictions due to weather or accidents, offer detailed information using characters and pictographs. The whole system is set up to ensure that accurate information is provided to travelers as quickly as possible. When vehicle detectors, which are installed every two km (or every one km in places particularly prone to bottleneck points), detect that the average speed of vehicles has dropped below 40 km/h, the computer decides that congestion has occurred and automatically adjusts the messages on the variable message signs and the information broadcast over the Highway Radio and the Highway Telephone.

2.3.3 ATIS on the Tomei Expressway

The ATIS on the Tomei Expressway use some of the latest computer and fiber optic technologies (see Figure 2.6). Their distinctive features are as follows:

Traffic condition monitoring subsystem

Traffic volume and vehicle speed are measured by detectors installed along the lanes of the expressway at two km intervals (one km interval along stretches of frequent congestion). Using criteria set forth in a manual, average speed data sampled every five minutes are used to determine the length of the back up automatically.

Remote monitoring and control subsystem (see 2.3.2)

This system for monitoring and controlling traffic information consists of equipment for transmitting information, and for integrating and processing it. Whenever an unanticipated event such as an accident occurs, traffic information is entered into the system via the *event control* method: a dispatcher at the traffic control center inputs data of an incident relating to time, location, causes, and current situation (obtained from traffic patrol vehicle reports, emergency telephone calls, etc.), using a video display terminal. These data are then computer-processed according to set procedures to control the number and location of the variable message signs and the messages to be displayed.

Meanwhile, the processed information appears on graphic panels in color-coded display, allowing an instant assessment of what happened and where. The information is then disseminated to the Highway Radio subsystem and other systems, where it is accessible on-line. Thereafter, traffic volume data are automatically processed to determine congestion conditions, and the Variable Message Signs, the Highway Radio broadcasts, and the Highway Information Terminal subsystem are updated every five minutes.

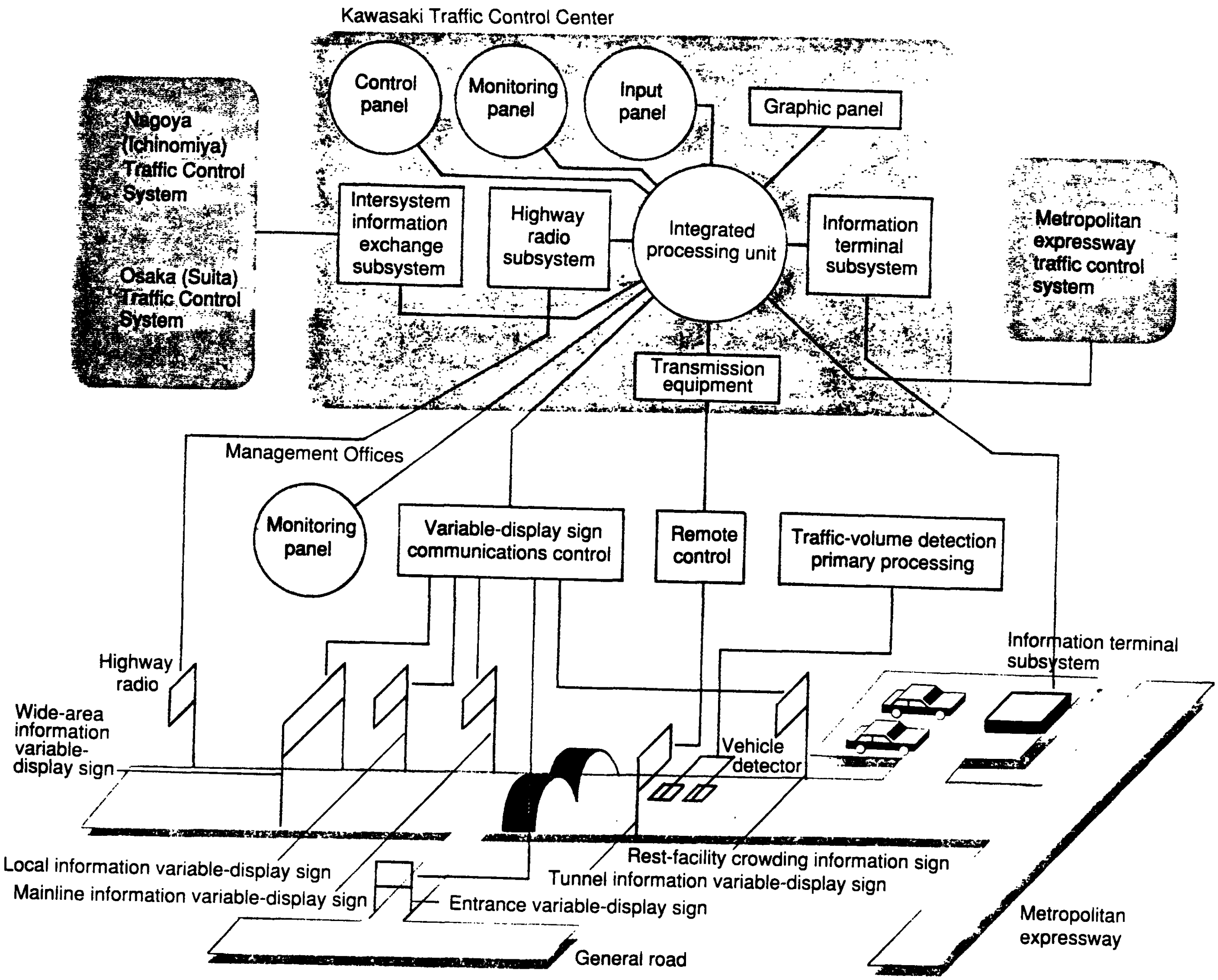


Figure 2.6 ATIS on the Tomei Expressway

Source: Maeda, Y., (1991), "Unanticipated Events on National Expressways," the wheel extended, No. 76, Toyota Motor Corporation, Tokyo.

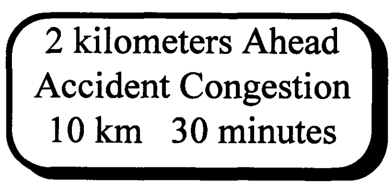
Variable message sign subsystem (see Figure 2.7, 2.8, 2.10)

Variable message signs at critical locations have been upgraded from older light-bulb matrix types to signs using light-emitting diodes (LEDs) for message display. These have the following unique characteristics:

1) They are very effective in terms of visibility and attractiveness for displaying high-definition Chinese characters and graphic information thanks to improved resolution and color display (red, amber, green) provided by the LEDs.

2) They offer several ways to display information, including event control (described above), flexible control of display patterns, preset messages (location, causes, etc. for a total of 255 messages), and text control, which permits a speedy response to different events.

3) They use fiber-optic cable to transfer at high speeds (19,200 bps) the massive amount of data needed to control high resolution LEDs and color data effectively.



The meaning of this variable message sign is "10-km congestion due to an accident is starting 2 km ahead, and it takes 30 minutes to go through the congestion," in compact expression using Chinese characters.

Figure 2.7 Example of a Variable Message Sign

Travel time information subsystem (see Figure 2.9)

Users of inter-city expressways have come to depend on high quality information. To satisfy their requirements, travel time information has recently been provided by LED signs. This continuously operating system automatically provides the drivers with up-to-minute information.

On the Travel Time Variable Message Sign, the name and number of each interchange is written in permanent letters, while the travel time that it takes to reach the interchange is presented on an LED display. Each Travel Time Variable Message sign is located on the roadside after an interchange and a road sign (which lists distances to the three main interchanges).

Time units displayed on the sign vary; travel times under one hour in length are displayed in units of five minutes, times of up to two hours in units of ten minutes, and those longer than two hours display "two hours +." If the traffic is moving normally, times are displayed with green letters. When traffic back ups occur, the times are displayed with amber letters. If the travel times exceed two hours, they are displayed in red letters. Road closure and congestion caused by accidents or road work and so forth, are indicated with a red horizontal line, because it is quite difficult to predict the travel time in such cases.

The Travel Time Graphic Variable Message Sign indicates congested sections graphically Congested sections are displayed with amber stripes on a column graph which repents an approximately 100 km-segment of the Tomei Expressway. Multiple back ups are likely to occur simultaneously in this segment. Travel times to reach several exits are also displayed on the Travel Time Graphic Massage Sign as same as on the Travel Time Variable Message Sign. Drivers can easily understand the location and the length of the back ups and the traffic conditions about accidents or road closures as well as travel times to major interchanges. Two Travel Time Graphic Variable Message Signs (eastbound and westbound) are installed and in operation on the Tomei Expressway at this point.

In order to calculate the travel time, at first the average speed of each segment is calculated by means of vehicle detectors that are installed under the lanes approximately every two km. Then the travel time between locations of vehicle detectors is computed and displayed on the appropriate travel time variable message signs. Travel time information is also updated every five minutes.

■ Mainline Toll Gate Variable Display Sign (high-resolution LED type/caption type)

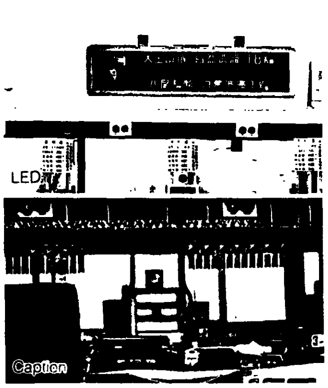
These signs are installed above mainline toll gates providing traffic information for the vicinity as well as for the region (LED type only)

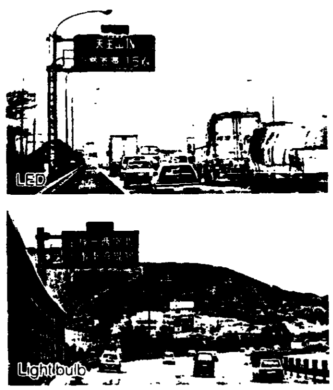
■ Mainline Variable Display Sign (high-resolution LED type/light bulb type)

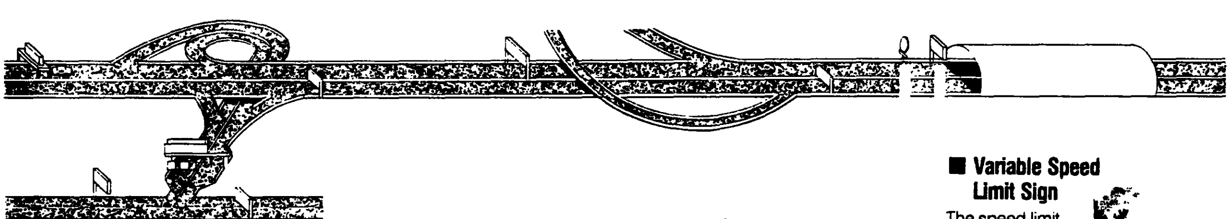
These variable display signs are located above the mainline and are placed near every interchange off ramp. They provide drivers with information for the vicinity.

■ Wide Area Variable Display Sign (light bulb type)

This type of variable display sign is installed above the mainline between major interchanges, and provides the drivers with road and traffic information that covers a broad area.

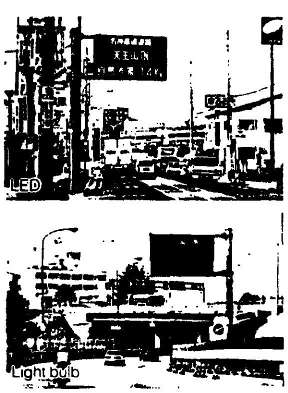


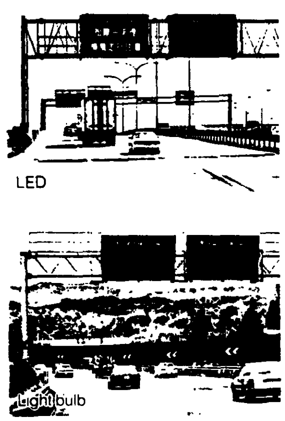




■ Variable Speed Limit Sign

The speed limit may be adjusted in the event of accidents, road work, and poor weather conditions.





■ Interchange Entrance Variable Display Sign (high-resolution LED type/light bulb type)

These are located on general roads near every interchange entrance. They provide information about the immediate vicinity of the mainline and are directed towards drivers who intend to use the expressway

■ Toll Gate Variable Display Sign (high-resolution LED type/caption type)

This type of sign can be seen by the drivers as they arrive at a toll gate, and provides information about road and traffic conditions in the vicinity of the mainline.

■ Junction Variable Display Sign (high-resolution LED type/light bulb type)

These signs are placed above the mainline and can be seen by drivers before they arrive at a junction. They provide information about road and traffic conditions of the region of the junction.

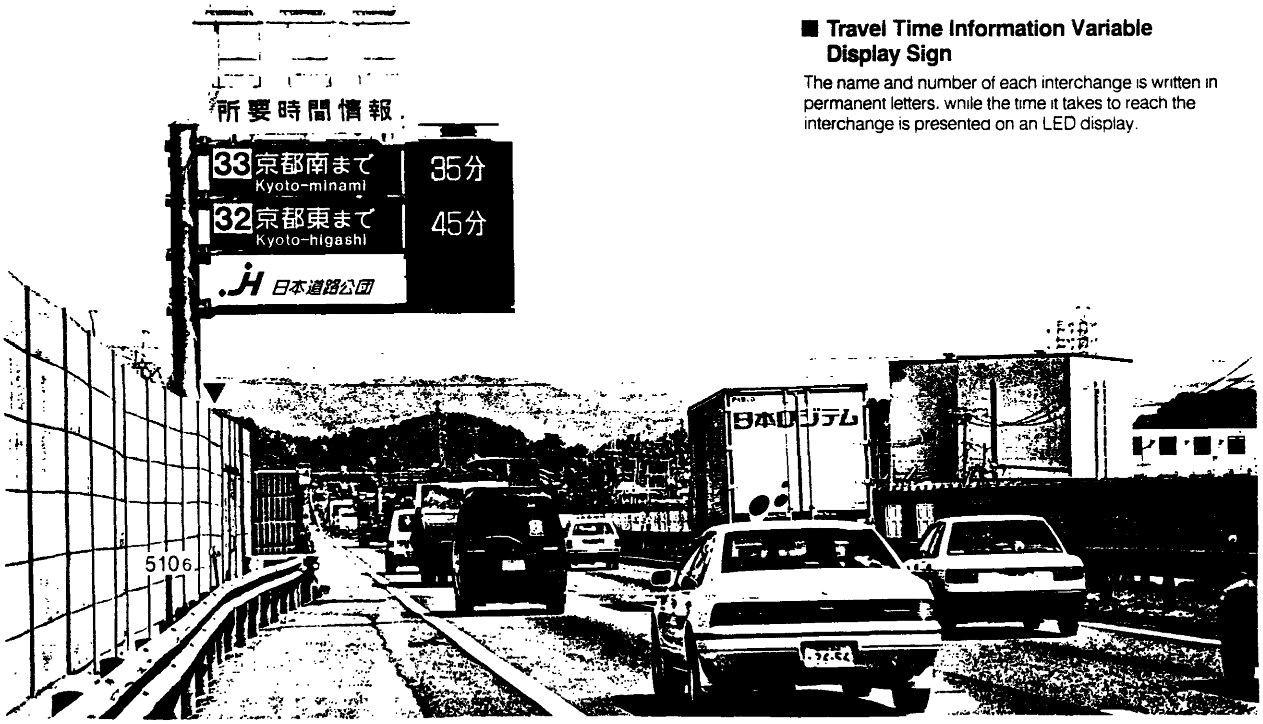
■ Tunnel Variable Display Sign (light bulb type)

Placed above the mainline before the entrance of a tunnel, these signs provide information about road and traffic conditions in the tunnel. In addition, revolving red light and alarm are used to warn of the occurrence of an accident.

Figure 2.8 Variable Message Sign Subsystem

Travel Time Information Variable Display Sign

Highway drivers have many needs and requirements: These LED signs provide information on the travel time. This continuously operating system automatically provides the drivers with up-to-the-minute information.



■ **Travel Time Information Variable Display Sign**

The name and number of each interchange is written in permanent letters, while the time it takes to reach the interchange is presented on an LED display.

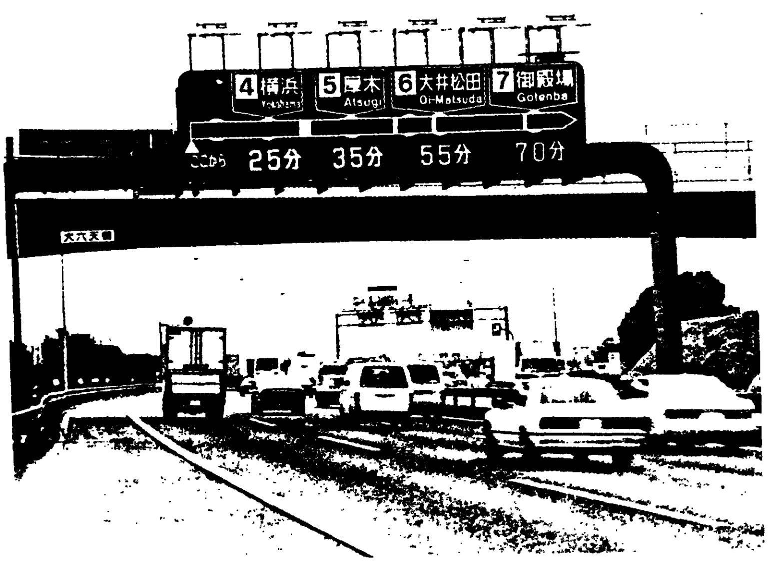


Figure 2.9 Travel Time Information Subsystem

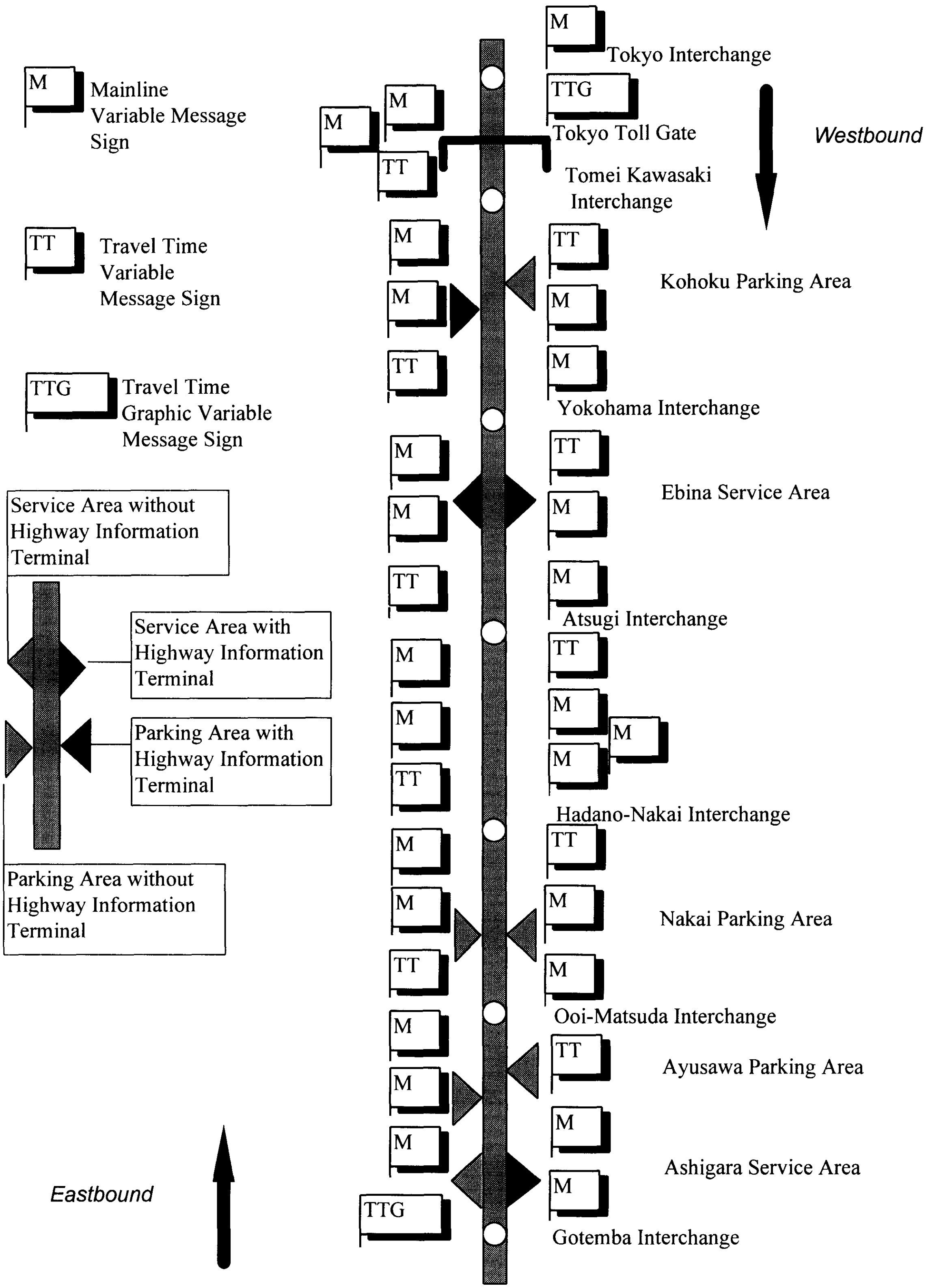


Figure 2.10 Variable Message Signs on the Tomei Expressway

Highway Telephone subsystem

Pre-trip traffic information is important in route choice and making travel plans. The Highway Telephone provides detailed traffic information covering a wide area over the telephone 24 hours a day. This information is processed by linking with the Highway Radio subsystem (see below) and updated every five minutes. Users of this service are charged only for the cost of the call.

Highway Radio subsystem (see Figure 2.11)

The Highway Radio subsystem broadcasts traffic information which can be picked up on car radios at 1620 kHz. Transmitters are placed to cover 3.4-km stretches of the expressway, and the control is adjusted so that the appropriate information reaches drivers in each broadcast sector. Message length is kept to maximum of one minute so the messages can be heard in their entirety at least once by vehicles traveling at 100 km/h. Because voice synthesis is used, no time is lost in drafting and recording, so the system excels in situational adaptability.

Highway Information Terminal subsystem (see Figure 2.12)

Highway Information Terminals are installed at major rest areas to provide drivers with the exact information needed in real time, via information panels, highway television monitors, and videotex. Information panels provide an instant overview of road conditions by indicating sections of roadway that are congested or closed, or have lane restrictions in effect, by means of red, amber, and green LED band displays. Highway television monitors provide more detailed information that is displayed on the information panels, such as location, time, and causes of an incident. Videotex terminals are interactive and provide a wide range of information. By manipulating the terminal's keyboard, drivers can request detailed information on road conditions with specific reference to congestion and weather conditions, as well as details concerning the available routes to their destinations, tolls, and other information.

Highway Radio

Highway radios provide information about traffic and road conditions at 1620KHz AM. Highway radio transmitters are installed before junctions and major interchanges

- A vast amount of detailed information is accurately provided.
- The latest information (updated every five minutes) is constantly available.
- The narration can be easily updated by automatic voice synthesizer, making text writing unnecessary.
- Owing to the on-line link up with the Remote Control System, information from a variety of sources can be compiled and relayed.

■ Radio Information Signs

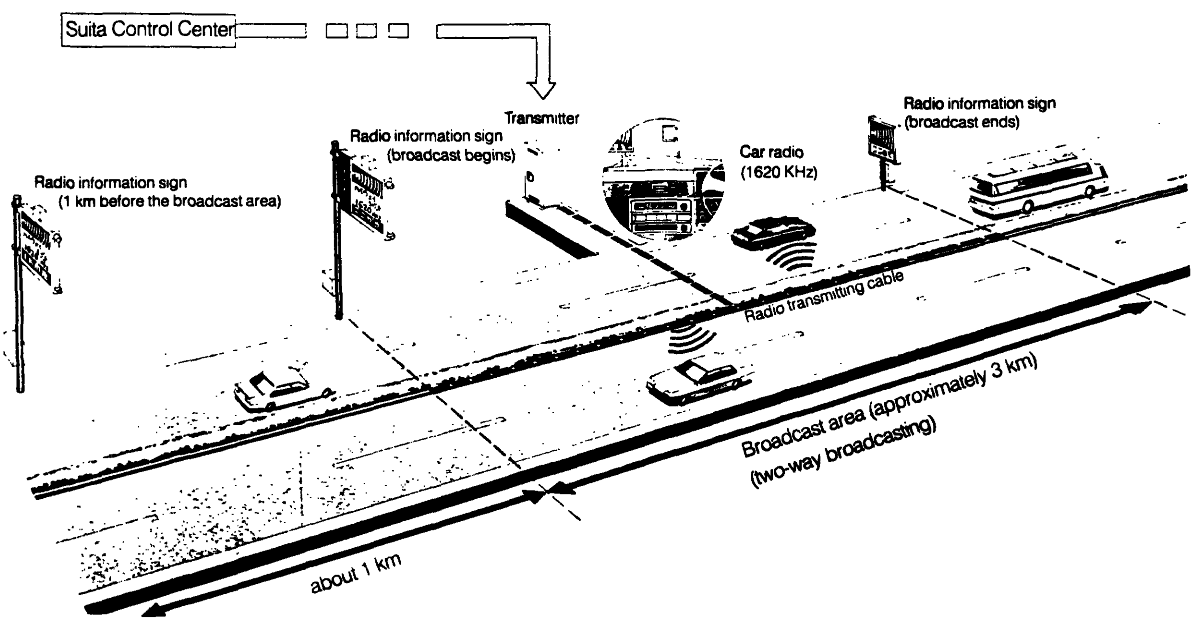


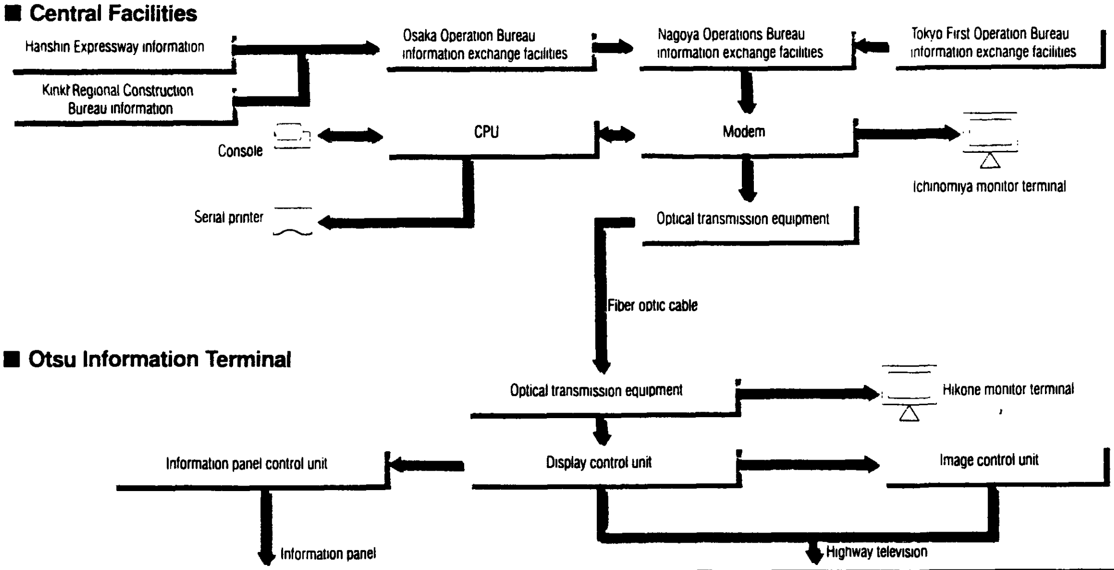
Figure 2.11 Highway Radio Subsystem

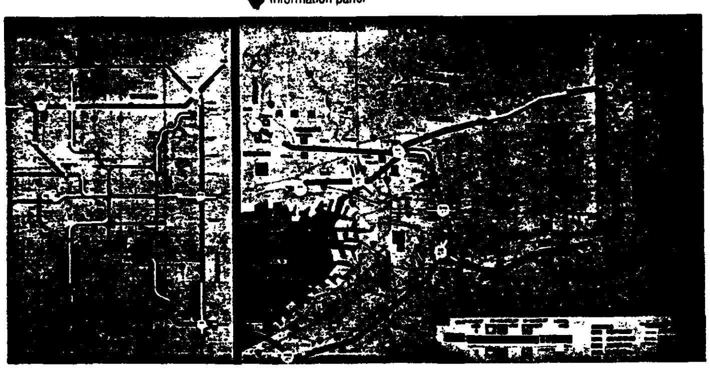
Otsu Traffic Information Terminal
(under jurisdiction of Nagoya Operation Bureau)

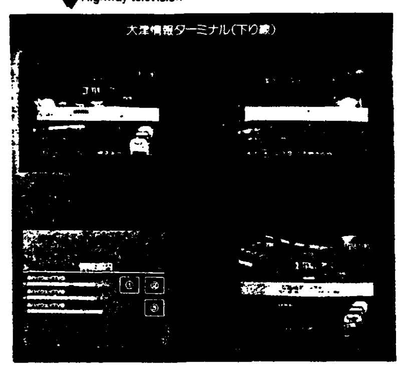
The Otsu Traffic Information Terminal, employing the latest technologies, compiles a wide variety of information such as data on road and traffic conditions from expressways and announcements from the public sectors, and presents it on information panels and highway television. The Traffic Information Terminal operates 24 hours a day, providing information to meet the needs of drivers on a "real-time" basis.

■ **Traffic Information Terminal System**

■ **Central Facilities**







■ **Accidents, road work, road closure, traffic restrictions, and other sorts of road and traffic information are displayed on large information panels.**

The panel employs easy-to-read LEDs to display information. Color coding and different degrees of illumination are used to distinguish different types of information, making it easy to take in a large amount of information at a single glance. The local weather report also makes use of LEDs for its display.

■ **Information on road and traffic conditions and announcements from public sectors are shown on large screen (37") highway television.**

Highway televisions display road and traffic information for tollroads, urban expressways, and major national highways as well as for the expressways. The three television screens display more detailed information than that presented on the information panels.

Figure 2.12 Highway Information Terminal Subsystem

2.3.4 Conventional Traffic News

In the latter half of the 1960's, due to rapid development of motorization, traffic congestion worsened and the number of traffic accidents increased in Japan. Therefore, the needs for traffic information had grown increasingly. In order to respond to these needs, the Japan Road Traffic Information Center (JRTIC) was established in January 1970, just before the opening of the international exposition in Osaka, as a juridical foundation with permission of the National Police Agency and the Ministry of Construction. These two government authorities have been fighting for their jurisdictions about provision of traffic information ever since traffic information services started, however, this time they cooperated in providing traffic information during the international exposition. The antagonism between the two government authorities has kept the JRTIC un-computerized for many years.

Traffic information is collected by personnel assigned to the JRTIC's regional centers and local stations, 145 places altogether nationwide, attached to the traffic control center of road administrators including the JHPC, the Metropolitan Expressway Public Corporation, the Hanshin Expressway Public Corporation, the Ministry of Construction, prefectural government highway departments, prefectural government police headquarters, etc. The traffic information gathered from these sources is then complied and provided to drivers by telephone, radio and TV.

By calling the JRTIC's regional center and local stations, drivers can acquire traffic information from 7 a.m. to 7 p.m. through operators who are watching the graphic panels at the traffic control centers. Some numbers in the Tokyo metropolitan area are using auto-answering tape updated every 30 minutes from 7 a.m. to 7 p.m.

Traffic news on radio is broadcast by the JRTIC personnel once or twice an hour. Traffic news on TV is once or twice a day for each station. These news reports are based on information gathered by the manpower, not by computers.

In the Tokyo metropolitan area, the JRTIC also provides traffic news on teletext TV updated every 30 minutes, from 7 a.m. to 7 p.m. on weekdays, from 7 a.m. to 5 p.m. on holidays.

2.3.5 Other Traffic Information Sources

1) **Personal Communications (Citizen's Band)**

Personal communications are mainly used among professional truck drivers. Using citizen's band in vehicles, they are communicating with each other not only for exchanging traffic information but also for enjoying conversations. Citizen's band is also used to communicate with their home base terminals.

2) **Congestion Forecasting Calendar**

There are several periods during the year when traffic is much heavier than usual. At these times, traffic volume causes massive traffic jams on expressways. In Japan, these holiday seasons include *Golden Week* (between April 29 and May 5), *O-bon* (a Buddhist custom of going back to a home town as Thanks Giving holidays which doubles as a summer break), and a week-long New Year's holidays. All these holidays include a great deal of leisure travel and visit to families in distant areas, especially by urbanites originally from rural areas.

During these seasonal periods of heavy traffic, for locations on expressways that connect urban and rural areas, where congestion is particularly prevalent, congestion forecasting calendars for the upcoming busy periods and sections are made by the JHPC and the result announced to the public through the media and through posters and leaflets.

3) **Car Navigator**

In Japan, the Ministry of Construction (MOC) and the National Police Agency (NPA) have been fighting each other for their jurisdiction of traffic control equipment for many years. As a road administrator, the MOC, in charge of maintaining road structure, says that traffic control equipment is considered to be road-associated facilities, because the road administrator should solicit drivers' caution by imposing traffic restrictions in case of collapse of the road structure. On the other hand, the NPA, in charge of traffic control, insists that traffic control equipment should essentially be under their jurisdiction.

Therefore both the MOC and the NPA have each developed Intelligent Vehicle and Highway Systems (IVHS) separately. The MOC started Road / Automobile Communication System (RACS) in 1986 with 25 private companies, and the NPA started Advanced Mobile Traffic Information and Communication System (AMTICS) in 1987.

RACS and AMTICS are similar systems in terms of their concept, but use different equipment.

Finally in 1991, MOC and NPA reached an agreement to cooperate in developing IVHS. Therefore, RACS and AMTCS started to be integrated into the Vehicle Information and Communication System (VICS) by arbitration of the Ministry of Posts and Telecommunications (MPT), which administrates radio frequency allocation. However, each of these three ministries and agency still insists to use its own individual system. So far, the cooperation in developing VICS has not been achieved yet in the real sense.

In recent years, a field experiment has started to provide dynamic traffic information on the Tokyo metropolitan area as well as on the Tomei Expressways, however most of the drivers are not aware of the experiment. Thus almost all the drivers who own in-vehicle navigators are using them as route guidance equipment. For all that, the number of vehicles which have installed navigators is more than 700,000[1] all over the nation. Owners of the in-vehicle navigators consider them as one piece of optional equipment such as car audio system, air bag, or car telephone.

Regarding provision of dynamic traffic information for in-vehicle car navigators, the Traffic Information Service Inc. (ATiS) started its service this April[2]. The ATiS was founded mainly by the Metropolitan Police Department in 1992 and had conducted a free operational test during last year providing dynamic traffic information in Tokyo. The ATiS has expanded its service area to cover the Tokyo metropolitan area. The dynamic information which consists of traffic conditions, the shortest route and its travel time, is provided to users through telephone lines. The subscription charges of this service consist of enrollment fee (15,000 yen), monthly charge (3,000 yen for up to 50 uses), and a 30 yen charge for additional use (over 50 uses). Car navigators adaptable to this service are provided by Sonny, Sumitomo, etc. and adaptable personal computers are also provided by Panasonic, Mitsubishi, NEC, etc.

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[1] Iguchi, M., (1995), "Doro, Sharyo no Interijentoka no Suisin (Promotion of Intelligent Highway / Vehicle Systems)," Kosokudoro to Jidousha (Expressways and Motor Vehicles), vol. 38, No. 3, pp. 7-10.
[2] Yomiuri Shimbun, April 21, (1995), Japanese Newspaper.

4) **Road Map**

In Japan, JAF (Japan Automobile Federation: corresponds to American Automobile Association (AAA)) does not provide road maps as AAA, and the quality level of road maps in Japan is lower than that of AAA maps. However, some of them illustrate the seasonal traffic congestion and cautions for traffic safety at particular sections. At major rest areas, free maps of the inter-city expressway system are distributed at the tourist information desks.

Chapter 3

Framework for Drivers' Behavior and Model Structure

This chapter presents the general framework for drivers' responses to ATIS. In Section 3.1, drivers' behavior on inter-city expressways in Japan is explained. In Section 3.2, a general framework for drivers' behavioral models is discussed. In Section 3.3, 3.4, and 3.5, the model structure of the acquisition of pre-trip traffic information, the acquisition of en-route traffic information, and response to traffic information are described respectively.

3.1 Introduction to Drivers' Behavior on Inter-City Expressways in Japan

As mentioned in Section 2.1, inter-city expressways carry 40% of freight and 7% of passengers transported by automobiles in Japan. The average trip length of passenger cars on the Tomei Expressways is about 50 km, and that of trucks is 150 km. The commercial vehicles' ratio is about 30%.

Before the departure, drivers might obtain traffic information through traffic news on radio or on TV. As mentioned in Section 2.2.4, traffic news on radio is broadcast irregularly between programs and commercials approximately once or twice an hour. Thus, drivers might not be able to obtain traffic news related to their trips on radio when they need it. Traffic news on TV is just provided in morning news shows only in metropolitan areas. If drivers want to receive real time traffic information, they would call the JRTIC, traffic control center of the JHPC, or the Highway Telephone.

Depending on the traffic conditions based on pre-tip traffic information, drivers might change travel plans, such as departure time, choice of entrance and exit, time spent at rest areas, etc. After the departure, drivers obtain traffic information through Interchange Entrance Variable Message Signs on the access road to the entrance interchange of the Tomei Expressway. Based on this traffic information, they could change entrances or routes to take. At the entrance toll gate, they receive transit passes, and at the same time, they see Toll Gate Variable Message Signs and confirm traffic information. On the Tomei Expressway, they receive traffic information from Mainline Variable Message Signs, Travel Time Variable Message Signs, and Travel Time Graphic Variable Message Signs. Moreover, they can acquire more detailed traffic information from the Highway Radio. According to en-route traffic information, they might change travel plans, such as time spent at rest areas, choice of exit, schedule of activities at destination, or inform someone that they would change travel plans. Even after they are stuck in traffic, Variable Message Signs and the Highway Radio tell them how long it will take to go through the back up, and also they might make the above mentioned responses based on this information. Furthermore, at main rest areas they can confirm traffic conditions by consulting the Highway Information Terminal which provides detailed information covering a wide area.

At each decision making stage, drivers acquire, process, and then respond to traffic information (see Figure 3.1).

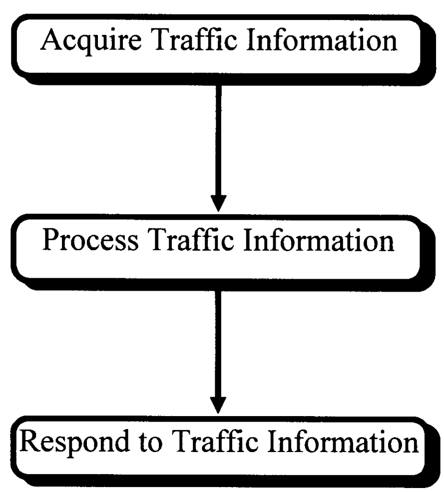


Fig 3.1 Drivers' Decision Making Flow

3.2 General Framework for Drivers' Behavioral Models

In this chapter, three behavioral models, acquisition of pre-trip traffic information, acquisition of en-route traffic information, and response to traffic information, are mainly discussed. The general framework of these behavioral models is shown in Figure 3.2. In this figure, diamonds with heavy outlines present three behavioral models of pre-trip traffic information acquisition, en-route traffic information acquisition,. and response to traffic information, which will be discussed in Section 3.3, 3.4, and 3.5 respectively.

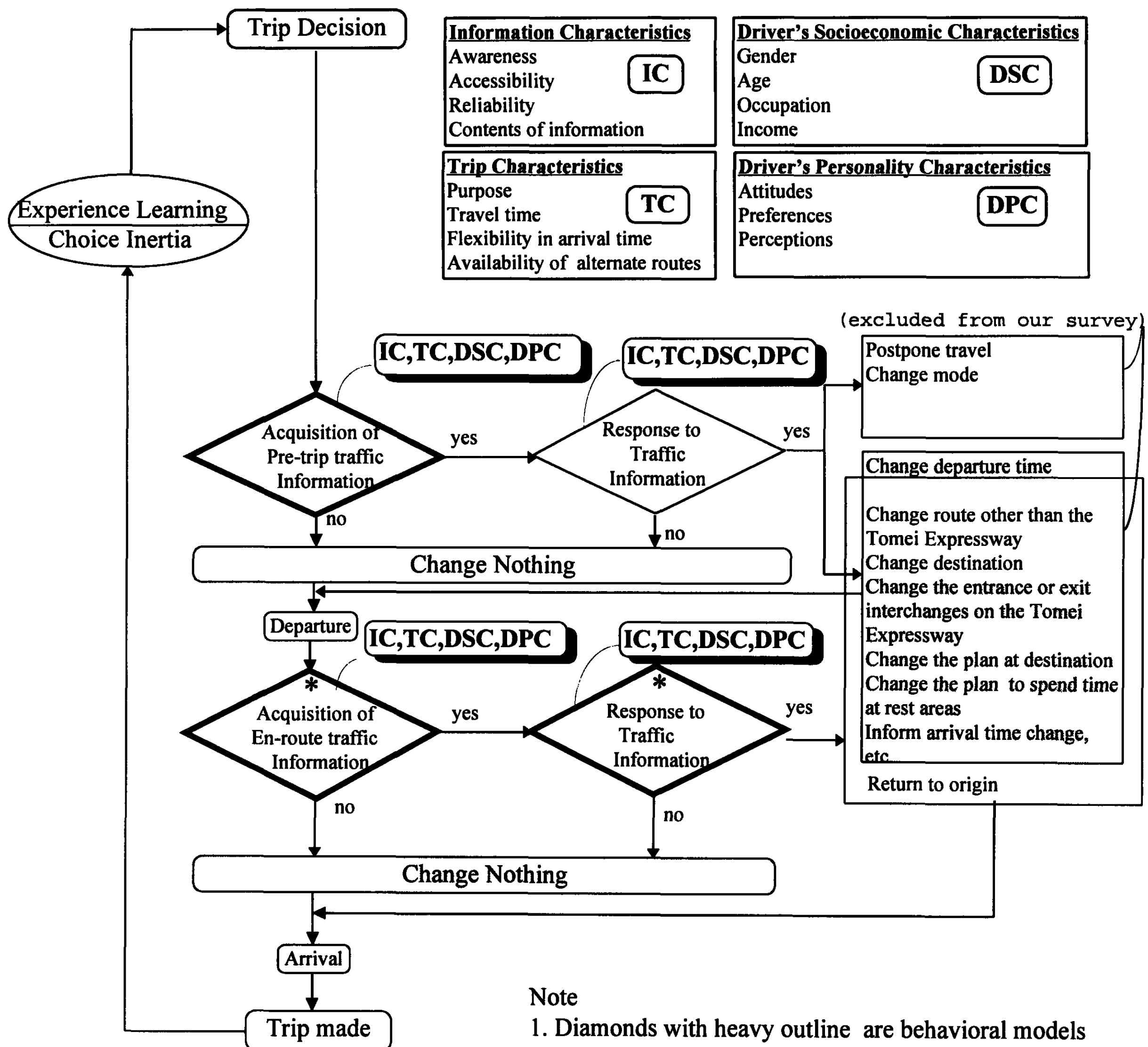
In each model mentioned above, the following factors play important roles as independent (explanatory) variables:

1) **drivers' socioeconomic characteristics**, such as gender, age, occupation, income, etc. (DSC);

2) **drivers' personality characteristics**, such as attitudes and preferences towards driving behavior, driving experiences, familiarity with the road network, etc. (DPC);

3) **trip characteristics**, such as purpose, travel time, flexibility in arrival time, availability of alternate routes, etc. (TC); and,

4) **traffic information characteristics**, such as awareness, accessibility, reliability, and contents of traffic information, etc. (IC).



Note
1. Diamonds with heavy outline are behavioral models discussed later.
2. Shaded areas indicate responses obtained in this survey.

Fig 3.2 General Framework for Drivers' Behavioral Models

3.3 Model Structure of the Acquisition of Pre-Trip Traffic Information

Figure 3.3 shows the model structure of the acquisition of pre-trip traffic information. As mentioned in Section 3.2, this behavior is influenced by the drivers' socioeconomic characteristics, the trip characteristics, and the information characteristics. Drivers process these characteristics and make decisions based on their own personality characteristics. After deciding to acquire pre-trip traffic information or not, they choose information sources they might need. This decision making process is perceived and accumulated by drivers as an experience and learning which will support their decision making the next time.

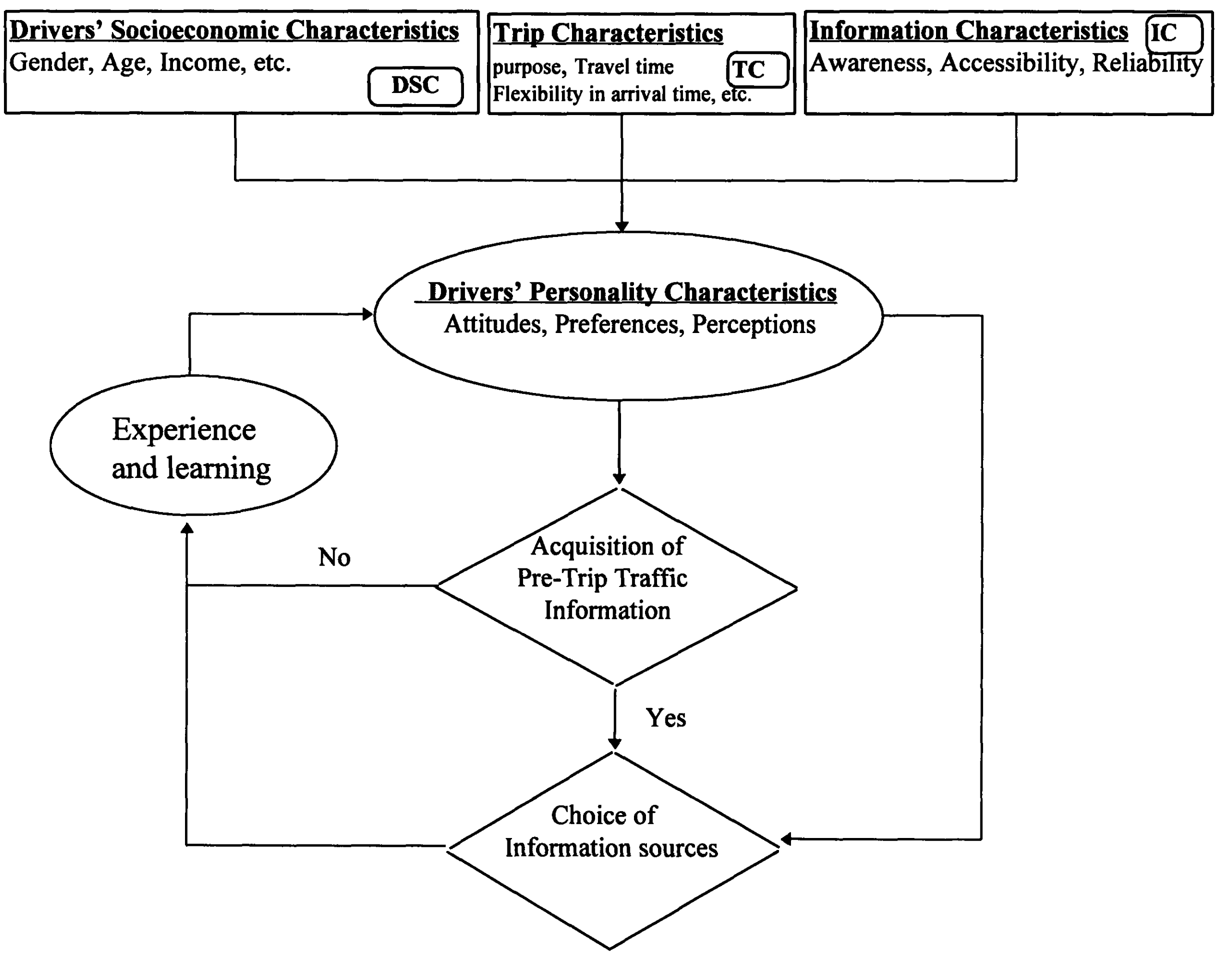


Figure 3.3 Model Structure of the Acquisition of Pre-Trip Traffic Information

3.4 Model Structure of the Acquisition of En-Route Traffic Information

The modeling structure of the acquisition of en-route traffic information is illustrated in Figure 3.4. This behavior is also influenced by the drivers' socioeconomic characteristics, the trip characteristics, and the information characteristics. A drivers' decision making process is the same as that of acquisition of pre-trip traffic information, however, sources and content of pre-trip traffic information have a significant impact on this process.

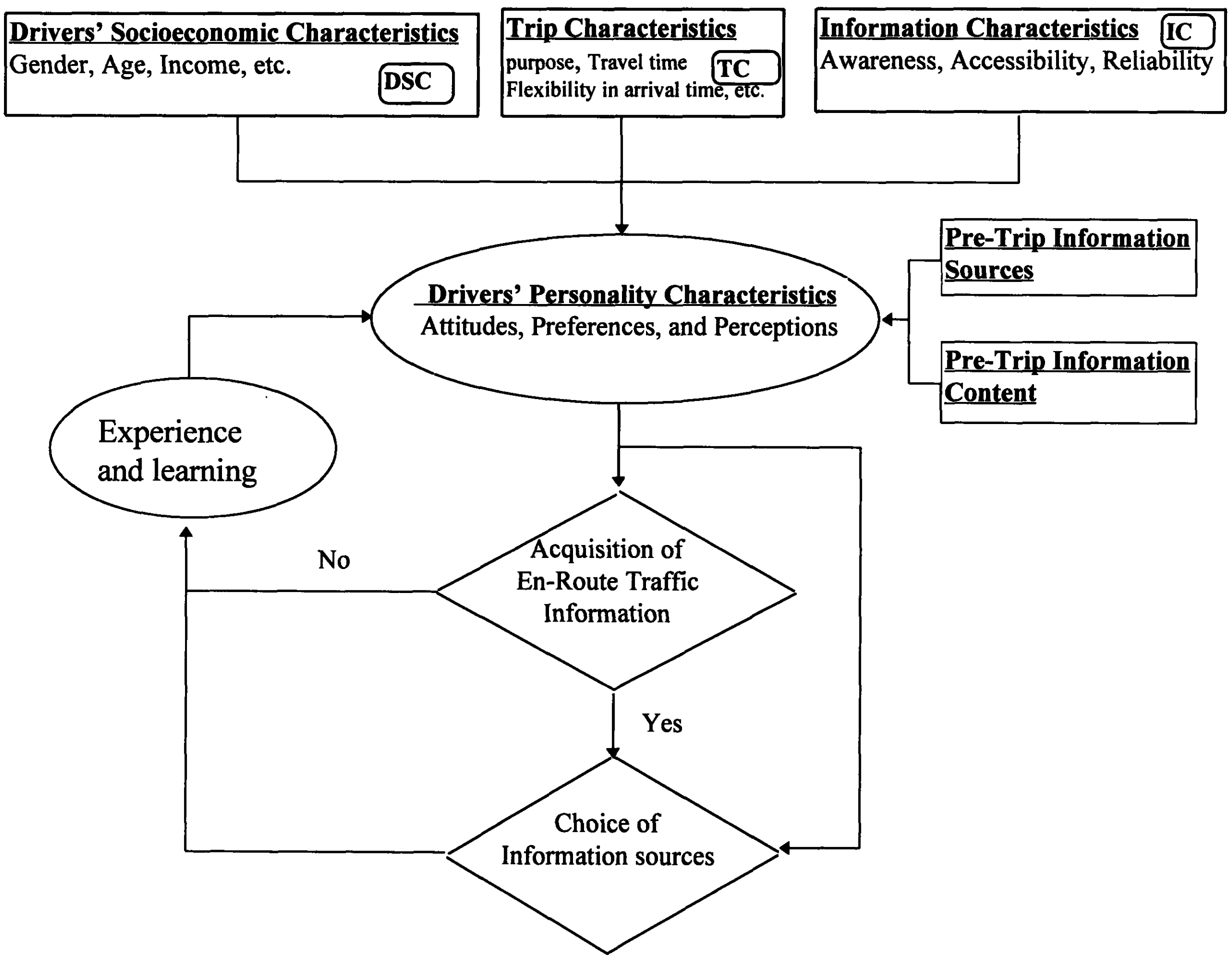


Figure 3.4 Model Structure of the Acquisition of En-Route Traffic Information

3.5 Model Structure of the Response to Traffic Information

For users of inter-city expressways, potential responses to traffic information are the following:

1) Postpone travel
2) Change mode
3) Change departure time
4) Change route other than the Tomei Expressway
5) Change destination
6) Change the entrance interchange
7) Change time spent at rest areas
8) Change exit interchange
9) Change the plan at destination
10) Inform someone arrival time change, etc.
11) Return to origin.

Responses 1) to 10) could be made before departure, and 4) to 10) could be made during the trip. However, responses 1), 2), and 3) must be made before departure, and response 11) must be made during the trip. In our survey, responses 1), 2), 4), 5), and 11) were not obtainable, because all respondents were users of the Tomei Expressway and they were not asked if they changed destination or not. Therefore, this study focuses mainly on the responses 3), 6), 7), and 8). Figure 3.5 illustrates the model structure of the responses to traffic information.

The sequence of travel behavior is thus as follows. The first response to traffic information is to "3) change departure time". This decision depends upon acquisition of pre-trip traffic information. If the driver did not acquire traffic information before the departure, he / she could not change departure time, and would follow planned departure time. The other factors that have influence on changing departure time are the drivers' socioeconomic characteristics, the drivers' personality characteristics, and the trip characteristics.

The second response is to "6) change the entrance interchange." The factors that influence this behavior are the same factors as those for the previous response, plus the previous response itself, "3) change departure time."

The factors that influence the third response, to "7) change time spent at rest areas," are the same factors as those for the previous response plus the previous response itself, "6) change entrance interchange." After entering the Tomei Expressway, almost all drivers recognize variable message signs installed at entrance toll gates and on the expressway every five to ten km, so that almost all drivers receive traffic information about the Tomei Expressway. Thus, contents and sources of en-route traffic information have a significant impact on the third response, to "7) change time spent at rest areas."

The fourth response to traffic information is to "8) change exit interchange," and the factors which influence this behavior are the same as those of the previous response plus the previous response itself "7) change time spent at rest areas."

Considering availability of alternate routes for users of the Tomei Expressway, most drivers would keep going on the Tomei Expressway (change nothing), however, short trip users and frequent users would be likely to change entrances or / and exits, because of their familiarity with alternate routes.

Depending on the trip purpose, responses to traffic information are considered to be different. For example, drivers who have tight schedules would be likely to change their departure times, but drivers who have enough time would be likely to adjust time at rest areas to avoid congestion.

In this study, concerning response to traffic information, we constructed a response to traffic information choice models (MNL), assuming that the choice decision is made simultaneously and that the number of drivers who respond with more than one responses is small (alternatives of MNL models should be mutually exclusive) and four response models (binary logit), for "changed departure time," "changed entrance," "changed time spent at rest areas," and "changed exit."

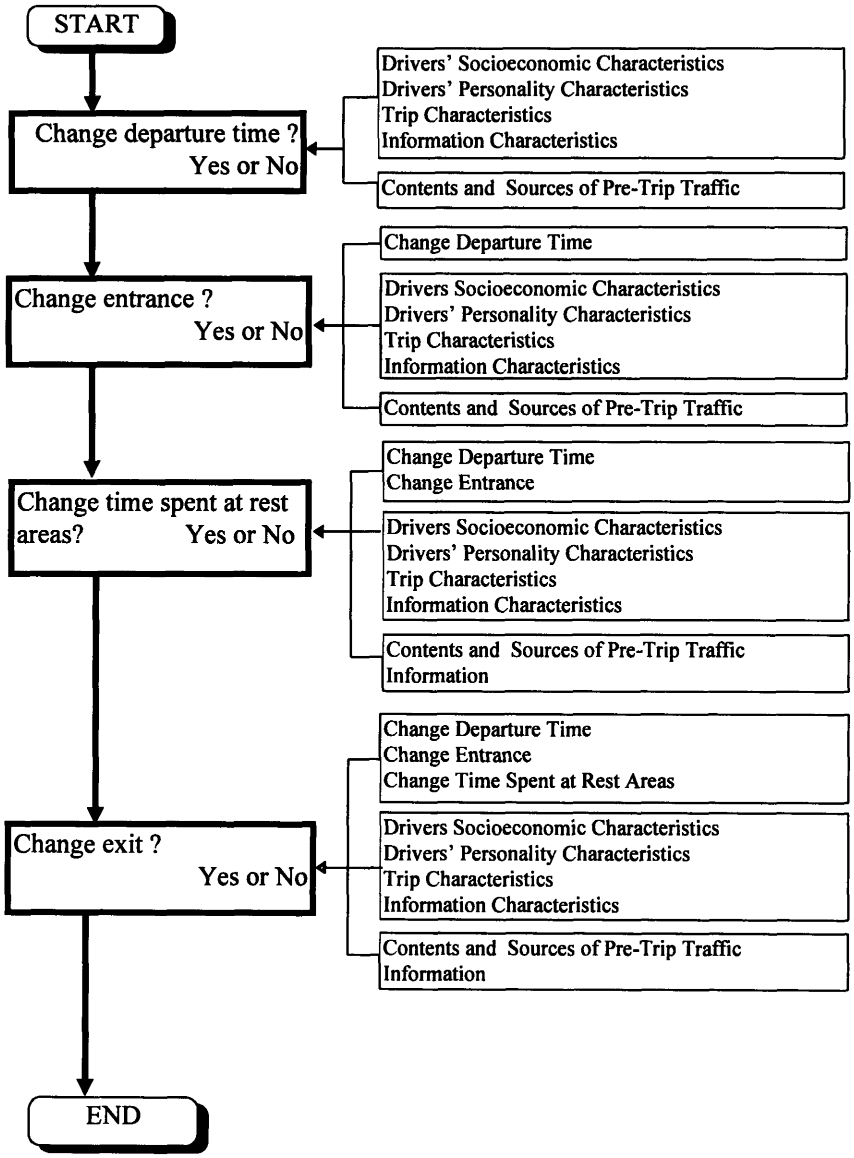


Figure 3.5 Model Structure of the Response to Traffic Information

3.6 Summary of the Behavioral Models

The models estimated in this study are depicted in Figure 3.6. The acquisition of pre-trip traffic information is a nested logit model. The upper level of this model is a binary logit for drivers' decision of "Whether to acquire pre-trip traffic information." The lower level is an MNL for their decision of "Which pre-trip traffic information source to consult."

The acquisition of en-route traffic information is also a nested logit model. However, the acquisition of en-route traffic information is now influenced by the pre-trip traffic information acquisition.

Two types of models for drivers' responses to traffic information are estimated. One is an MNL model for drivers' decision of "which response to choose," assuming that the choice decision is made simultaneously and that the number of drivers who respond with more than one response is small (alternatives of MNL models should be mutually exclusive). The other is a sequential process of four binary logit models for their decision of "Whether to change departure time," "Whether to change entrance," "Whether to change time spent at rest areas," and "Whether to change exit."

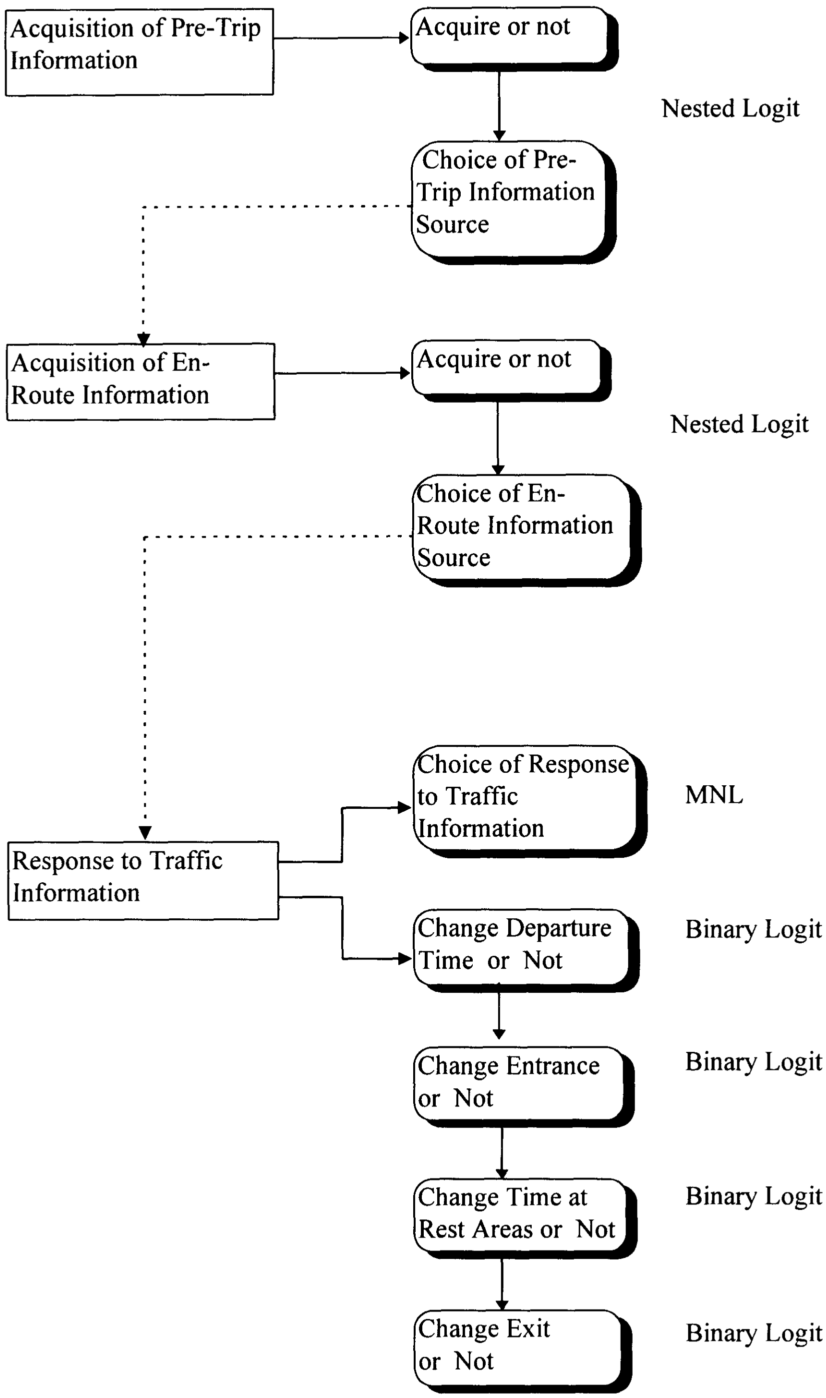


Figure 3.6 Behavioral Models in This Study

Chapter 4

Survey of Evaluation of Traffic Information

In this chapter, the data collection methodologies are discussed. In Section 4.1,4.2 and 4.3, the design of the questionnaire for our survey is explained. Section 4.4 outlines how the questionnaire was distributed and how the responses were collected.

4.1 Questionnaire Design

Many surveys have been designed for collecting data on travelers commuting behavior and response to existing information sources such as radio or TV (see for example Kaysi and Lotan (1992), Khattak (1991)). More recent surveys include stated preference (SP) parts, in which travelers' responses and willingness to pay for hypothetical ATIS scenarios are observed (see Khattak (1993) and Polydoropoulou(1993)). The unique characteristic of our survey is that it was designed to address inter-city travelers' behavior to traffic information provided by already implemented ATIS on the Tomei Expressway in Japan.

The questionnaire for our survey was designed after consulting above mentioned surveys.

In designing the questionnaire, it was important to consider the following points:

(1) Each statement should be clear, with no room for misunderstanding.

(2) Each statement should be concise.

(3) Each question should take in consideration all possible cases.

(4) Each question should be compact, for example, using "yes" or "no" type questions, and "skip to next" instructions where possible.

(5) Questions should be arranged so that each driver's travel behavior and sequence of decisions are followed.

The questionnaire, provided in full in Appendix, consists of the following five parts:

Part A: the trip characteristics

Part B: the driver's evaluation of the traffic information services on the Tomei Expressway

Part C: the driver's choice from among hypothetical routes (stated preference)

Part D: the driver's attitude toward driving behavior

Part E: the driver's socioeconomic characteristics

The whole structure of the questionnaire is shown in Figure 4.1

4.2 Revealed Preference (RP) Survey [Parts A, B, D, and E]

Part A contains questions about the trip characteristics and about the driver's perceptions of the route which s/he actually took and that of an alternate route. The initial questions refer to actual traffic delays, any length of the back up, and to the cause of delays. The latter questions refer to travel time and any length of the back up under optimal traffic conditions, usual traffic conditions, and worst conditions for both the actual route and the best alternate route.

Part B can be separated into four question groups:

1. questions about pre-trip information;
2. questions about en-route information;
3. questions about the response of the driver to traffic information; and,
4. questions about the driver's evaluation of and demand for traffic information.

The questions of the first and the second group attempt to capture sources of traffic information used and also seek the reasons why a driver may not have consulted some particular state-of-the-art sources, that are the Highway Telephone, the Highway Radio, or the Highway Information Terminal. The questions in the third group concern the drivers' expectations of the results from their choices and the actual outcomes of those choices (for example, the traffic delay would decrease or not). Answers to the questions also reveal the contents of the information they received and their responses to traffic information.

Part D consists of questions about the attitudes and preferences of the drivers. The first group of questions is related to the statements that reflect their general attitudes toward diverting the routes, and to the statements that reveal their preferences toward traffic information. The second group of questions investigates which factors are important in choosing the route on the Tomei Expressway, such as travel time, traffic volume, service level of traffic information, weather, etc.

Part E covers the drivers' socioeconomic characteristics, such as age, gender, marital status, occupation, driving experience, driving frequency, and income.

4.3 Stated Preference (SP) Survey [Part C]

In this part, in order to capture the utility of traffic information service on the Tomei Expressway, an SP survey for route choice is deployed.

SP survey data have many advantages for analysis of demand models. Major reason why SP data are frequently used in market research is that the experimenter can control the choice scenarios (Morikawa (1989)). It implies the following advantages of SP data over RP data:

1. choice set can be prespecified
2. range of attributes can be extended
3. multicollinearity among attributes can be avoided
4. attributes that are not easily quantified
5. attributes are free from measurement errors

These advantages enable us to elicit preference with respect to non-existing options. It is also beneficial that experimenter can elicit a preference from the respondent in various ways, such as ranking, rating, and matching, while RP data imply indicate the single preferred alternative.

One reason why SP questions were prepared in our survey is that we set non-existing options as an attribute level, traffic information services on the *future* Tomei Expressway.

Another reason is that we assume people do not answer the willingness to pay for existing free services with accuracy. The toll rate of inter-city expressways in Japan is already the highest in the world (23.0 yen/ km + 150 yen/ usage), drivers never want to pay additional charge for the ATIS which has been provided free as customer services. Moreover the JHPC, the executor of our survey, planned to raise the toll rate in April 1995. People were very nervous about raising charges for public services in this depression, so that the JHPC did not allow us to ask drivers' willingness to pay directly.

This part contains two types of route choice questions: un-customized (see Table 4.1) and customized comparisons (see Table 4.2).

Customization has the following advantages:

1. can make design of experiment more realistic to the respondents by deploying the trip characteristics and drivers' socioeconomic characteristics of RP part into SP part;
2. responses are less biased because of a realistic situation; and,
3. attribute levels can take various values by using actual value for each respondent.

However it also has following disadvantages:

1. require respondents to recall actual values and to calculate them;
2. respondent's attention is concentrated on customized attribute because of the calculation; and,
3. difficult to control the choice scenarios because customized attributes take various values.

Since this customized SP survey, which was mail back survey not using personal computer terminal but using questionnaire sheets, assumed to be the first trial in Japan, we also prepared un-customized SP survey.

In both types of questions, only four attributes are used to simplify the comparison. These four attributes are (1) en-route information service level, (2) traffic delay, (3) travel time, and (4) travel cost.

4.3.1 Building the (Un-Customized) Pairwise Comparison (Table 4.1)

Since the most significant advantage of the pairwise comparison is that it takes a very short time for respondents to make a choice, the smaller number of attributes, the better. In this part, our interest is evaluation of en-route traffic information service level, therefore this attribute comes first. Then traffic delay has an important relation with traffic information. Travel time and travel cost are essential elements of route choice, and necessary to compare the value of en-route traffic information service with the value of time.

In setting the level of each attribute, trip characteristics of typical trip makers are considered. The average trip length is approximately 100 km for passenger cars on the Tomei Expressway in the western suburb of Tokyo. Based on this trip length, the base level of travel time and travel cost are determined. Considering average traffic delay on this section, the levels of maximum traffic delay are set. According to the result of a priori quick survey of new employee of the JHPC in 1993, the value of present en-route traffic information service on the Tomei Expressway was approximately 10% of the toll. Based on this figure, the values of the higher and the lower levels of each attribute are created in order to capture the trade off relations among the attributes.

Table 3.3 indicates four attributes, levels for each attribute, and the value of each level. It is possible to make 144 ($4 \times 3 \times 3 \times 4$) combinations of hypothetical route, however, the 144 combinations contain unrealistic ones. Therefore, using the methodology of experimental design (see Pearmain and Swanson (1991)), 18 combinations of hypothetical route were selected. In order to obtain effective questionnaire results from the limited number of respondents, each pair of routes is selected as follows. First, we designed 19 routes, which have various attribute levels, according to the methodology of experimental design 18 pairs of routes were chosen among 19 routes to be presented to respondents. The routes of each pair were selected to have similar level of attractiveness. Then, 18 pairs of routes were randomly divided into three groups. Thus each questionnaire contained six pairwise comparisons (see Figure 4.1).

4.3.2 Building the (Customized) Quadruple Comparison (Table 4.2)

In order to deploy the trip characteristics and the driver's socioeconomic characteristics of the RP parts into the route choice behavior of the SP part, the customized comparisons are designed. In this context, customization means to use each driver's travel time and travel cost as the values of attributes among comparison routes.

Since the attribute of "en-route traffic information level" contains [Future Tomei Expressway], [Old Tomei Expressway], and [None], this attribute is remained un-customized, because all respondents are [Present Tomei Expressway] users. At the beginning "traffic delay" was also considered to be customized, however, it has remained un-customized. Since most drivers may not encounter traffic delay, the customized traffic delay is no longer an attribute. To simplify the calculation of "travel time" and "travel cost" in customization, only three attribute levels are used (actual travel time or travel cost minus 10%, actual travel time or travel cost, and actual travel time and travel cost plus 10%). Therefore levels of traffic delay are set to be equivalent to the 10% change of travel time (20, 30, and 40 minutes).

As shown in the example question in Table 4.2, each respondent is required to trace the following procedures:

1. in box A (Your Route), fill the parentheses with actual travel time and travel cost;
2. in box B (Alternate Route), fill the left-hand-side parenthesis of travel time row with actual travel time and fill right-hand-side parenthesis with the calculated result (actual travel time plus 10%), then post actual travel cost in the parenthesis of travel cost row;
3. in box C (Alternate Route), post actual travel time in the parenthesis of travel time row, then fill the left-hand-side parenthesis of travel cost row with actual travel cost and fill right-hand-side parenthesis with the calculated result (actual travel cost plus 10%);
4. in box D (Alternate Route), post actual travel time and travel cost; and,
5. take all the values of attribute levels in all boxes (A, B, C, and D) into consideration, rank four routes according to the preference.

Because this SP survey is assumed to be the first attempt in Japan to execute customized comparison which requires respondents to calculate individual attribute levels, an example explained carefully in detail is prepared to help respondents understand the structure of comparison.

Each comparison consists of four alternate routes. Respondents are asked to rank them in preference from one to four. Three quadruple comparison cases are designed for each respondent.

Table 4.1 Example of Pairwise Comparison

Which route do you prefer?

case 1

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up*, *Travel time*, and *Information about alternative routes*	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	10 minutes
3) travel time	80 minutes	90 minutes
4) travel cost	3,200 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 2

attributes	route A	route B
1) en-route traffic information services	none	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	40 minutes
3) travel time	80 minutes	70 minutes
4) travel cost	3,000 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 3

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up*, *Travel time*, and *Information about alternative routes*	none
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	20 minutes
3) travel time	70 minutes	80 minutes
4) travel cost	3,600 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

Table 4.2 Example of Quadruple Comparison

Example Your travel time under optimal traffic condition was (*80*) minutes.
Your travel cost was (*3,000*)yen .

A: Your Route	
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	(*80*) minutes
4) travel cost	(*3,000*) yen

same as Your travel time
same as Your travel cost

B: Alternative Route	
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	(*80*) X1.1=(*88*) minutes
4) travel cost	(*3,000*)yen

Your travel time plus 10%
same as Your travel cost

C: Alternative Route	
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	(*80*) minutes
4) travel cost	(*3,000*) X 1.1=(*3,300*)yen

same as Your travel time
Your travel cost plus 10%

D: Alternative Route	
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**40 minutes**
3) travel time	(*80*) minutes
4) travel cost	(*3,000*)yen

same as Your travel time
same as Your travel cost

Please rank route A, B, C, and D according to your preference

1st	2nd	3rd	4th
B	*A*	*D*	*C*

Case 1 Now try your own case, please.

A: Your Route	
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( ) minutes
4) travel cost	( ) yen

B: Alternative Route	
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( )X1.1=( )minutes
4) travel cost	( )yen

C: Alternative Route	
1) en-route traffic information service	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( ) minutes
4) travel cost	( ) X 1.1=( )yen

D: Alternative Route	
1) en-route traffic information service	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternative routes*
2) traffic delay (maximum delay due to traffic congestion)	**40 minutes**
3) travel time	( ) minutes
4) travel cost	( )yen

1st	2nd	3rd	4th

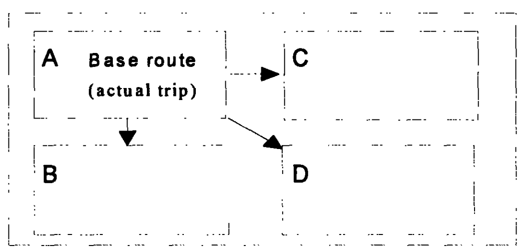
Table 4.3 Attributes of Comparison (un-customized)

attributes	Level 1	Level 2	Level 3	Level 4
1)en-route information service	[**Future** Tomei Expressway] Variable Message Signs and the Highway Radio *Length of the back up, Travel time, and Information about alternative route*	[**Present** Tomei Expressway] Variable Message Signs and the Highway Radio *Length of the back up and Travel time*	[**Old** Tomei Expressway] Variable Message Signs *Length of the back up*	[**none**]
2) traffic delay (maximum traffic delay on the route)	+10 minutes	+20 minutes	+40 minutes	
3) travel time (under usual traffic conditions)	70 minutes	80 minutes	90 minutes	
4) travel cost (mainly for fuel and toll)	3,000 yen	3,200 yen	3,400 yen	3,600 yen

Table 4.4 Attributes of Comparison (customized)

attributes	Level 1	Level 2	Level 3	Level 4
1)en-route information service	[**Future** Tomei Expressway] Variable Message Signs and the Highway Radio *Length of the back up, Travel time, and Information about alternative route*	[**Present** Tomei Expressway] Variable Message Signs and the Highway Radio *Length of the back up and Travel time*	[**Old** Tomei Expressway] Variable Message Signs *Length of the back up*	[**none**]
2) traffic delay (maximum traffic delay on the route)	+20 minutes	+30 minutes	+40 minutes	
3) travel time (under usual traffic conditions)	actual travel time minus 10%	actual travel time	actual travel time plus 10%	
4) travel cost (mainly for fuel and toll)	actual travel cost minus 10%	actual travel cost	actual travel cost plus 10%	

Part A : Trip Characteristics
Part B : Evaluation of the Traffic Information Systems on the Tomei Expressway
Part C : Route Choice (Stated Preference)
(1) Customized
Quadruple Comparison



3 Cases Type a

(2) Un-customized
Pairwise Comparison

6 Cases Type b
6 Cases Type c
6 Cases Type d

Part D : Drivers' Attitude toward Driving Behavior

Part E : Drivers' Socioeconomic Characteristics

Number of Distributed Questionnaires

Type a	1,800
Type b	1,200
Type c	1,200
Type d	1,200

Figure 4.1 Structure of the Questionnaire

4.4 Distribution of the Questionnaires

This travel survey was designed and executed as a joint research of Tokyo Institute of Technology and MIT. The questionnaires were distributed by the JHPC on Dec. 4 (Sun) and Dec. 7 (Wed) at the main rest areas and the Tokyo tollgate (see Figure 4.2). Table 4.5 presents the number of distributed questionnaires. At each distribution site, questionnaires of type a, type b, type c, and type d were prepared in a ratio of 3:2:2:2 respectively (see Table 4.5), and handed out to drivers randomly from 10 a.m. to 6 p.m. on both Sunday and Wednesday. Every 30 minutes, the first 15 to 45 drivers received questionnaires at each distribution site.

In order to raise the response rate of this mail survey, the Highway Cards, which are pre-paid toll cards valid for a 1,000 yen ride on inter-city expressways in Japan, were prepared as an incentive. As a result, 100 of respondents won the premiums. The deadline to mail back the survey was on Dec. 14 (Wed), a week after the last distribution day.

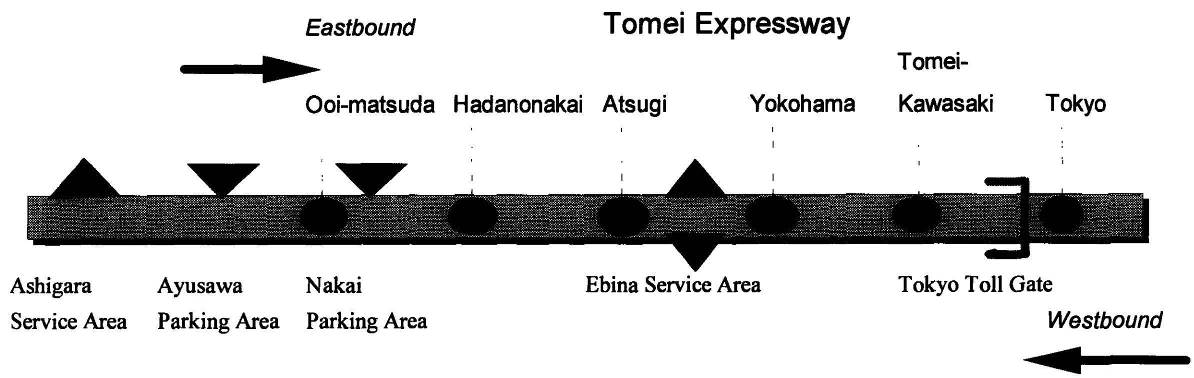


Figure 4.2 Sites of Questionnaire Distribution

4.5 Response Rate

The response rates are shown in Table 4.5. The total response rate is 13%. This is considered to be a typical figure for mail back survey with premiums in Japan. The response rate on Sunday (15%) is higher than that on Wednesday (12%), probably because drivers of pleasure trips are supposed to have more time to answer the questionnaire.

Table 4.5 Response Rate

Date	Direction	Ashigara SA	Ayusawa PA	Nakai PA	Ebina SA	Tokyo TG	Total
Dec. 4 (Sun)	Westbound				15% (70/460)	11% (81/720)	13% (151/1,180)
	Eastbound	21% (101/480)	16% (38/240)	18% (42/240)	13% (70/560)		17% (251/1,520)
Dec. 7 (Wed)	Westbound				14% (64/460)	13% (93/720)	13% (157/1,180)
	Eastbound	13% (63/480)	13% (32/240)	18% (44/240)	5% (29/560)		11% (168/1,520)
Total		17% (164/960)	15% (70/480)	18% (86/480)	12% (233/1,920)	12% (174/1,440)	13% (727/5,400)

Note: Figures in ( ) mean (number of respondents / number of distributed questionnaires).

Chapter 5

Descriptive Statistics

The questionnaire design and the data collection process are explained in the previous chapter. In this chapter, the descriptive statistics are reported. As a result of the survey, we were able to receive 727 valid responses. The complete coverage of the results of the survey is shown in the Appendix.

5.1 Drivers' Socioeconomic Characteristics

The proportion of each attribute of drivers' socioeconomic characteristics is shown in Table 5.1. Before our survey, the JHPC executed a similar survey[1] on the Tomei Expressway on July 26 (Sun.) and 29 (Wed.), 1992. This July 1992 survey consisted of interviews at rest areas and mail back questionnaires distributed at the Tokyo Toll Gate. The number of valid responses was 3,482, and the result of the July 1992 survey is shown in the right column in Table 5.2. Since, in the July 1992 survey, respondents were randomly interviewed at rest areas, and the mail back questionnaire took not so long time to complete, the proportion of each item of the July 1992 survey is considered to represent the average user of the Tomei Expressway better than that of our survey.

Gender

Both in our survey and the July 1992 survey, about 90% of respondents are male, however, in Japan the ratio of male drivers was only 62% in 1991.[2] Since the ratio of commercial vehicles, whose drivers are mostly male, is rather high on inter-city expressways compared with that on ordinary surface roads, response rate of female drivers is lower than that of male drivers.

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[1] Inoue, J. et. al, (1994), "Jikan-joho-teikyo eno Torikumi to sono Hyoka (Provision of Travel Time Information and its Evaluation)," Kosokudoro to Jidosha (Expressways and Motor Vehicles) vol. 37, No. 8, pp. 25-34.

[2] The Chamber of Japan Automobile, Suji de Miru Jidousha (Statistics on Automobiles), Tokyo,

Age

In our survey, the average age is 43, and 43% of the respondents are age 50 and over, but only 19% in the July 1992 survey. This is a very peculiar point of our survey. Since the questionnaire of our survey took quite a long time (it took about 30-50 minutes to answer the questionnaire completely at the trial before the actual implementation of the survey), aged drivers who have enough time to complete the questionnaire would be likely to respond. Moreover, 10% of respondents are age 60 and over.

Occupation

Considering that the share of large sized trucks on the Tomei Expressway is about 29%, the share of professional drivers in the total respondents (10%) is very low. They are assumed to be unfamiliar with paper work such as completing a questionnaire, and do not have enough time to respond.

The share of managerial and executive respondents is 17%. This is considered to be rather high, and reflects income distribution.

Driving Experience

The average driving experience is 20 years. This is rather long because of the high average drivers' age. In Japan, a driver's license can be acquired at the age of 18. 21% of the respondents have at least 30 years of driving experience.

Drive Frequency

59% of respondents drive every day. In the Tokyo metropolitan area, the share of commuters by car is less than 25%[1]. Therefore, many car owners in the Tokyo metropolitan area are assumed to drive on holidays. Thus, in our survey, the share of frequent drivers is rather high.

Income

The average annual household income was 7.67 million yen in 1994[2]. Thus, the respondents to our survey reflects average household in Japan, however, note that 19% of respondents earn 10 million yen and over annually.

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[1] Ministry of Construction, (1992), Doro Poketto-bukku (Road Pocketbook), Tokyo, Zenkoku Doro Riyosha Kaigi (Chamber of All Japan Road users).

[2] The Yomiuri Shimbun. March 18, (1995).

Table 5.1 Drivers' Socioeconomic Characteristics

Attribute		Our Survey Number of respondents	%	July 1992 Survey %
Gender	Male	653	89.8	91.0
	Female	55	7.6	8.3
	N.A.	19	2.6	0.7
Marital Status	Single	156	21.4	
	Married	529	72.8	
	N.A.	42	5.8	
Age	<20	2	0.3	2.6
	20-29	133	18.3	29.3
	30-39	172	23.6	25.1
	40-49	160	22.0	24.0
	50-59	167	23.0	13.7
	60-69	66	9.1	4.9
	70<=	6	0.8	0.0
	N.A.	21	2.9	0.4
Occupation	Self-employed	70	9.6	14.3 (Self-employed, Retail sales)
	Retail sales	12	1.7	
	Professional driver	73	10.0	65.4 (Professional driver through Managerial, Executive)
	Technical employee	136	18.7	
	Administrative employee	106	14.6	
	Professional specialty	33	4.5	
	Managerial, Executive	124	17.1	
	Public employee	55	7.6	7.5
	Student	17	2.3	5.5
	Housewife	25	3.4	2.9
	Other	58	8.0	4.0
	N.A.	18	2.5	0.5
Driving experience	<5	39	5.3	
	5- 9	88	12.1	
	10-14	121	16.7	
	15-19	88	12.1	
	20-24	107	14.7	
	25-29	100	13.8	
	30-34	86	11.8	
	35-39	45	6.2	
	40<=	24	3.3	
	N.A.	29	4.0	
Drive frequency	Every day	426	58.6	
	2-6 times a week	166	22.8	
	Once a week	85	11.7	
	2-3 times a month	24	3.3	
	Once a month	2	0.3	
	1-11 times a year	3	0.4	
	A few times in the past	2	0.3	
	N.A.	19	2.6	
Income	<2,000,000 yen	20	2.8	
	2,000,000-3,999,999 yen	103	14.2	
	4,000,000-5,999,999 yen	190	26.1	
	6,000,000-7,999,999 yen	140	19.3	
	8,000,000-9,999,999 yen	110	15.1	
	10,000,000-11,999,999 yen	54	7.4	
	12,000,000-14,999,999 yen	37	5.1	
	15,000,000-19,999,999 yen	30	4.1	
	20,000,000 yen<=	14	1.9	
	N.A.	29	4.0	

5.2 Trip Characteristics

The proportion of each attribute of trip characteristics is shown in Table 5.2.

Schedule of Activities at Destination

Only 31% of the respondents had schedules of activities at their destination. In other words, They have some restriction on arrival time. This corresponds to the trip purpose. Trips for freight transportation, business, and commuting are 32% of the total trips.

Vehicle Type

The sum of passenger cars (61%) and station wagons (14%) is 75%, and this corresponds to the percentage of passenger cars (75%) of the July 1992 survey. The sum of regular trucks (6%) and delivery vans (6%) also corresponds to the percentage of regular trucks (11%) of the July 1992 survey. As mentioned in Section 5.2, the share of large sized trucks on the Tomei Expressway is 29%, however, the share of large sized trucks in our survey is 4.3% and that of the July 1992 survey was 5.3%. It is not easy to ask drivers of large sized trucks to answer the questionnaire completely.

In-Vehicle Equipment

The level of car telephone ownership is 10.2% in our survey. This figure is considerably high. (The number of vehicles that have installed car telephones in Japan was about 236,000[1] in 1988, and the total number of vehicles exceeded 50 million at that time. Thus the level of ownership of car telephones was 0.5% in 1988. In recent years, the market of cellular phones has grown rapidly and there are 4.33 million cellular phones in Japan as of March 1995[2].)

The level of personal radio communications (Citizen's Band) ownership is 5.0%. (In Japan there were 1.485 million stations of personal radio communications in 1988[1] . The level of personal radio communications ownership was 3.0% in 1988).

The level of in -vehicle navigator ownership is 4.3% in our survey. The total number of vehicles in Japan was about 60 million in 1991[3] , and the current number of in-vehicle

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[1] Koshi, M., (1989), Kurumaga Kawaru Kotsuga Kawaru (Innovation of Automobiles Changes Road Transportation), Tokyo, Nikkan Kogyo Shimbun-sha.

[2] The Yomiuri Shimbun. April 19, (1995).

[3] The Chamber of Japan Automobile, (1993), Suji de Miru Jidosha (Statistics on Automobiles), Tokyo, Japan

navigators is more than 700,000 (see Section 2.3.5). The level of in-vehicle navigator ownership is calculated at 1.2% over the nation.

Although considering that the users of the Tomei Expressway are mostly living in the Tokyo metropolitan area, these levels of in-vehicle equipment ownership in our survey are rather high.

Trip Purpose

Compared with the July 1992 survey, the percentage of trips for recreation (42.6%) is smaller by 7.2 points, and the parentage of freight transportation (10.9%) is almost the half of that of the July 1992 survey (20.4%). However, the percentage of business trips is 19.2%, while that of the July 1992 survey was only 7.2%. The percentage of commuting trips is only 1.4%, while that of the July 1992 survey was 8.1%.

Trip Frequency

In the July 1992 survey, the trip frequency was defined as the frequency of using inter-city expressways; however, in our survey the trip frequency is defined as the frequency of making trips for the same purpose, with the same origin and destination as the trip made on the two days of our survey. Only 13% of respondents make the same trips once a week or more frequently.

Alternate Route

44% of the respondents have never used an alternate route, because 65% of the respondents make the same trip less than once a month. 19% of respondents have used alternate routes that are ordinary surface roads for the entire route. 11% of respondents have used alternate routes that include the Chuo Expressway as parts of the routes 16% of respondents have used alternate routes that are on the Tomei Expressway, but using another entrance or exit. 9% of respondents have used alternate route that are on the Tomei Expressway, but using another entrance or exit of the Metropolitan Expressway.

Table 5.2 Trip Characteristics

Attribute		Our Survey Number of respondents	Our Survey %	July 1992 Survey %
Had a schedule of activities at destination	Yes	222	30.5	
	No	501	68.9	
	N.A.	4	0.6	
Vehicle type	Passenger car	443	60.9	75.1
	Large sized truck	31	4.3	5.3
	Regular truck	41	5.6	11.1
	Delivery van	41	5.6	
	Station wagon	100	13.8	
	Bus	22	3.0	
	Microbus	8	1.1	2.6
	light vehicle	7	1.0	
	Motor bike	3	0.4	3.7
	Other	12	1.7	2.0
	N.A.	19	2.6	0.2
In-vehicle equipment	Car telephone	74	10.2	
	Personal radio communications (Citizens' Band)	36	5.0	
	In-vehicle navigator	25	3.4	
Purpose	Recreation (with family)	140	19.2	
	Recreation (with other)	163	22.4	48.7
	Freight transportation	79	10.9	20.4
	Business (sales, etc.)	140	19.2	7.2
	Commuting	10	1.4	8.1
	Shopping	20	2.8	1.8
	Private business	24	3.3	
	Visiting relatives	33	4.5	4.9
	Other	98	13.5	8.6
	N.A.	20	2.8	0.3
Trip frequency	Every day	16	2.2	11.6
	2-6 times a week	36	5.0	17.4
	Once a week	44	6.1	
	2-3 times a month	73	10.0	35.7
	Once a month	66	9.1	
	1-11 times a year	176	24.2	33.9
	A few times in the past	179	24.5	
	This is the first time	119	16.4	1.1
	N.A.	18	2.5	0.3
Alternate route	Never used alternate routes	323	44.4	
	Ordinary roads for the entire route	140	19.3	
	The Chuo Expressway as a part of the route	82	11.3	
	Using another entrance or exit of the Tomei Exp.	119	16.4	
	Using another entrance or exit of the Metropolitan	68	9.4	
	Other	36	5.0	
	N.A.	43	5.9	

Travel Time on the Chosen Route and on the Best Alternate Route

As shown in Table 5.3, the travel time on the chosen route (the Tomei Expressway) is shorter than that on the best alternate route in each traffic conditions. The differences of the travel time between the routes under the optimal, usual, and worst traffic conditions are respectively 18, 16, and 18 minutes. Generally speaking, these are very close, however, all respondents took the expressway and paid toll in order to shorten their travel time only by 16-18 minutes. On the chosen route, the average travel speed to pass through the congested sections is calculated at 12.9 km/h under the usual traffic conditions, and 14.5 km/h under the worst traffic conditions, while on the best alternate route, it is calculated at 10.3 km/h under the usual traffic conditions, and 9.7 km/h under the worst traffic conditions. Thus, the drivers consider that the congestion on inter-city expressways causes shorter delays than those on ordinary surface roads.

Average actual travel time is 198 minutes which is close to the average travel time on the chosen route, 192 minutes under the usual traffic conditions. The average traffic delays on the actual trip is 38 minutes and the average length of the back up is 8.6 km, so that the average travel speed to pass the congested sections is calculated at 12.0 km/h. Therefore, in general, the actual traffic conditions are considered as the usual traffic conditions on the chosen route.

Table 5.3 Travel Time on the Chosen Route and on the Best Alternate Route

Chosen Route (Tomei Expressway)	Average Travel Time (minutes)	Average Length of the Back up (km)
actual trip	198 (146)	8.6 (12.0)
under *optimal* traffic conditions	155 (129)	-
under *usual* traffic conditions	192 (146)	9.1 (36.4)
under *worst* traffic conditions	264 (176)	20.4 (21.7)
Best Alternate Route		
under *optimal* traffic conditions	173 (117)	-
under *usual* traffic conditions	208 (123)	6.7 (7.3)
under *worst* traffic conditions	282 (160)	19.5 (19.5)

Note: Figures in ( ) mean standard deviation

On the chosen route, the average length of the back up under the usual traffic condition is 9.1 km, and its standard deviation is 36.4 km. On the best alternate route, the average length of the back up under the usual traffic condition is 6.7 km, but its standard deviation is only 7.3 km. This means that the drivers' conception of the usual traffic conditions on inter-city expressways fluctuates much more than their conception of the usual traffic conditions on ordinary surface roads. Because drivers who have experienced heavy traffic congestion due to seasonal leisure travel demand or due to accidents with road closures or lane restrictions are likely to consider the congestion on inter-city expressways very serious once it occurs.

Actual Travel Time

The averages of actual travel time on the Tomei Expressway, access time, and egress time are 119.8, 44.4, and 40.5 minutes respectively. 70% of the drivers stopped at rest areas. (The average number of stops is 1.3 and the average time spent at rest areas is 38 minutes for those who have stopped at rest areas.)

Travel Cost

The average total travel cost for the chosen route is 8,730 yen while for the best alternate route it is 6,856 yen. The difference between these averages comes mainly from different proportions of the expressway to the entire route. Suppose all vehicles were passenger cars, the toll would be approximately 3,300 yen, (120-38=82 minutes, 82÷60X100 km/h =136.7 km, 136,7 X 23.0 yen/km + 150 yen = 3,293 yen) and cost for fuel is calculated at about 1,800 yen (44.4+40.5=84.9 minutes, 84.9÷60[illegible]30 km/h +136.7 = 179.2 km, 179.2 km X 10 km/litter÷100 yen/litter = 1,792 yen). Travel cost for toll and fuel would be 5,100 yen, so that the reported travel cost seems to be overestimated. The respondents might have included expenditure on food at rest areas.

5.3 Traffic Information Services on the Tomei Expressway

Table 5.4 presents drivers' choice of traffic information sources. Before our survey, another survey of traffic information on the Chuo Expressway[1] was executed on November 25 (Thu.) and 28 (Sun.), 1993 by interviewing drivers at rest areas. The total number of respondents was 1,003.

5.3.1 Pre-Trip Traffic Information

Compared with the Nov. 1993 survey on the Chuo Expressway, the proportion of drivers who have acquired pre-trip traffic information is quite high. In our survey, more than 65% of the total respondents acquired traffic information from radio broadcasts before departure, while only 23% of the respondents listened to radio traffic news in the Nov. 1993 survey. This fact shows that the respondents to our survey had an obvious bias toward traffic information. This bias also can be explained by the extremely high level of ownership of in-vehicle navigators (three times as large as the nationwide average).

This fact can be interpreted in another way. Respondents might have confused "before departure" and "during trip." Listening to the radio at home before departure is not common in Japan. Drivers usually leave the TV on, rather than the radio, to confirm morning departure time. However, once they get into a car, they might turn on the car radio out of habit. As mentioned in Section 3.1, traffic news on the radio is irregular, superficial, and irrelevant, so that drivers who just heard the traffic news between commercials and programs might mistakenly think they acquired necessary information not from the Variable Message Signs (almost all drivers recognized Variable Message Signs on the roadside), but from the radio broadcasts. The order of the survey questions which asked about "before departure" behavior first and "during trip" second, might have had an impact on this confusion.

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[1] Express Highway research Foundation of Japan, (1994), Joho-teikyo ni Kansuru Un-yo-kento (The Examination of providing Traffic Information in the area of Tokyo Third Operation Bureau, The JHPC), Tokyo, Japan.

Only 1.5% of respondents called the Highway Telephone, while 1% and 4% of respondents called respectively the JHPC and the JRTIC directly. However, as mentioned in Chapter 2, the service quality of the Highway Telephone is much higher than that of direct calls to the JHPC and the JRTIC. Even though the Highway Telephone service has increased its service areas in recent years, it has not yet caught on among people. Because it only started in 1990. Publicizing this service is necessary for it to be used more effectively.

5.3.2 En-Route Traffic Information

73% of respondents listened to the traffic news on the radio; however, as mentioned above, drivers could not obtain useful information from the radio broadcasts. The percentage of the Highway Radio listeners is 33% and the percentage of the Highway Information Terminal users is 12% in our survey. In the Nov. 1993 survey, 24.3% of respondents always listened to the Highway Radio and 6.4% of respondents always dropped into the Highway Information Terminal.

For Variable Message Signs, the highest percentage of information source is the Travel Time Variable Message Signs (81%). These have been installed since 1991, and now stand between almost every interchange. Travel Time Variable Message Signs are readily understandable and indicate travel time information around the clock, while other Variable Message Signs indicate messages only when incidents occur. The percentage of Travel Time Graphic Variable Message Signs is rather low (39%), because only two (eastbound and westbound) have been installed on the Tomei Expressway at this point. (In the Nov. 1993 survey, the percentage of drivers' awareness of Variable Message Signs was 88%.)

Only 15 respondents (2%) did not acquire traffic information from Variable Message Signs. Moreover, 99% of respondents acquired some traffic information from en-route traffic information sources including Variable Message Signs.

Table 5.4 Traffic Information Sources

Information Sources		Our Survey Number of respondents	Our Survey %	Nov. 1993 Survey %
Pre-Trip	a telephone call to the Japan Road Traffic Information Center	28	3.9	0.9
	a telephone call to the Japan Highway Public Corporation	7	1.0	0.6
	traffic news from radio broadcasts	475	65.3	22.6
	traffic news on TV	59	8.1	2.3
	teletext traffic news on TV	16	2.2	-
	personal radio communications (Citizen's Band)	12	1.7	-
	traffic congestion forecasting calendar	25	3.4	-
	road maps	164	22.6	-
	Highway Telephone	11	1.5	-
	other	132	18.2	2.2
	nothing	108	14.9	71.5
En-Route	a telephone call to the Japan Road Traffic Information Center	10	1.4	-
	a telephone call to the Japan Highway Public Corporation	2	0.3	-
	traffic news from radio broadcasts	528	72.6	-
	car navigator	8	1.1	-
	personal radio communications (Citizen's Band)	14	1.9	-
	traffic congestion forecasting calendar	15	2.1	-
	road maps	122	16.8	-
	Highway Radio	238	32.7	24.3
	Highway Information Terminal	85	11.7	6.4
	other	72	9.9	-
	nothing	103	14.2	-
Variable Message Signs (VMS)	Interchange Entrance	514	70.7	
	Toll Gate	427	58.7	88.1
	Mainline	533	74.0	
	Travel Time	591	81.3	
	Travel Time Graphic	282	38.8	

5.3.3 Drivers' Usage and Awareness of the ATIS

Drivers' usage and awareness of the ATIS is shown in Table 5.5. Drivers' usage of the Highway Telephone, the Highway Radio, and the Highway Information Terminal is 1.5%, 33%, and 12% respectively. Drivers' awareness of the Highway Telephone, the Highway Radio, and the Highway Information Terminal is 49%, 98%, and 84% respectively. Since the Highway Radio has its own signs on the roadside which indicate the broadcast areas and content of information, it shows high usage and awareness. The Highway Information Terminal also has its own pictograph "**i**" on the signs before the rest areas.

The main reasons drivers did not use the Highway Telephone even though they have used it in the past, are "they had enough traffic information already (40%)" and "it was bothersome (18%)." The main reasons drivers did not use the Highway Radio even though they had used it previously, are "they listened to other radio programs or music (52%)" and "they had enough traffic information already (15%)." The main reasons drivers did not use the Highway Information Terminal even though they had used it before, are "they had enough traffic information already (46%)" and "they did not have any time to spare (24%)." The Highway Radio might prevent passengers in the vehicle from enjoying radio programs or music from the car stereo. Dropping into the Highway Information Terminals might take time because they are located far away from restaurants where drivers prefer to stop.

Table 5.5 Drivers' Usage and Awareness of the ATIS

Information Sources		Our Survey Number of respondents	Our Survey %	Nov. 1993 Survey %
Highway Telephone	used Highway Telephone	11	1.5	-
	did not use it, but have used it before	94	12.9	-
	familiar with it, but never used it	230	31.6	-
	not familiar with it	367	50.6	-
	N.A.	25	3.4	-
Why not ?	did not have any time to spare	14	14.9	-
	had enough traffic information already	38	40.4	-
	not useful	4	4.3	-
	bothersome	17	18.1	-
	other	25	26.6	-
	N.A.	5	5.3	-
	always use Highway Radio			24.3
	sometimes use it			66.7
	do not use it			30.0
Highway Radio	used Highway Radio	238	32.7	-
	did not use it, but have used it before	371	51.0	-
	familiar with it, but never used it	83	11.4	-
	not familiar with it	12	1.7	-
	N.A.	23	3.2	-
Why not ?	listened to other radio programs or music	191	51.5	22.3
	had enough traffic information already	106	14.6	45.7
	not useful	12	1.7	11.0
	bothersome	24	3.3	-
	other	78	10.7	21.0
	N.A.	23	3.2	-
	not familiar with Highway Information Terminal			57.1
	always use Highway Information Terminal			6.4
	sometimes use it			13.4
	do not use it			23.1
Highway Information Terminal	used Highway Information Terminal	85	11.7	-
	did not use it, but have used it before	328	45.1	-
	familiar with it, but never used it	169	23.2	-
	not familiar with it	115	15.8	-
	N.A.	30	4.1	-
Why not ?	did not have any time to spare	77	23.5	-
	had enough traffic information already	150	45.7	-
	not useful	10	3.0	-
	bothersome	22	6.7	-
	other	85	25.9	-
	N.A.	8	2.4	-

5.3.4 Content of Traffic Information

The content of traffic information from pre-trip traffic information sources and those from en-route traffic information, and actual traffic conditions are shown in Table 5.6. 225 of the respondents both acquired pre-trip traffic information and were informed of any traffic delays. 290 of the respondents both acquired en-route traffic information and were informed of any traffic delays. 312 of the respondents actually encountered traffic delays. Average traffic delays based on pre-trip traffic information, on en-route information, and that of an actual trip are 51.4, 45.5, and 38.1 minutes respectively. The standard deviations (45.3, 38.5, 38.0 minutes) decrease as time passes. The average length of the back up based on pre-trip traffic information (8.8 km), on en-route traffic information (8.3 km), and that of an actual trip (8.6 km) are very close; however, the standard deviations (7.0 km, 8.6 km, and 12.0 km) are different.

Roughly speaking, the content of en-route information is closer to the actual traffic conditions than that of pre-trip traffic information.

5.3.5 Actual Traffic Conditions

Using data from Traffic Management Systems, it is possible to reproduce actual traffic conditions. (If time permits, it is also possible to reproduce the actual traffic conditions which each respondent encountered on the Tomei Expressway.)

Table 5.7 shows 19 congested sections on a 252 km-stretch of the Tomei Expressway during the two days of our survey. Three of these sections were created by traffic accidents. Eight were a result of road construction work. Six were due to heavy traffic volume at regular bottlenecks. One was rubber neck congestion, and another was due to a disabled vehicle.

Each average length and duration of the back up classified by its cause of delay is shown in Table 5.8. The average length of the back up due to heavy traffic volume was 7.2 km, while that due to road construction work was 3.3 km. The proportion of traffic delays caused by saturation is 58% and that caused by construction is 33%. Since the average length of the back up in total was 4.8 km, respondents encountered more than one congested sections on average (The average length of back up encountered by respondents was 8.6 km).

Table 5.6 Content of Traffic Information

(Based on Respondents' Answers)

		Number of respondents	%
Pre-Trip	did **not** acquire traffic information	108	14.9
	acquired traffic information	590	81.1
	N.A.	29	4.0
	→ the information did **not** tell about traffic delays	365	61.9
	→ the information told about traffic delays	225	38.1
	average traffic delays	51.4 minutes	
	standard deviation	45.3 minutes	
	average length of the back up	8.8 km	
	standard deviation	7.0 km	
	main cause of traffic delays		
	traffic accidents	27	12.0
	road construction work	106	47.1
	congestion due to heavy traffic volume	120	53.3
	weather conditions, such as snow, storm, etc.	1	0.4
	other	1	0.4
En -Route	did **not** acquire traffic information	30	4.1
	acquired traffic information	661	90.9
	N.A.	36	5.0
	→ the information did **not** tell about traffic delays	371	56.1
	→ the information told about traffic delays	290	43.9
	average traffic delays	45.5 minutes	
	standard deviation	38.5 minutes	
	average length of the back up	8.3 km	
	standard deviation	8.6 km	
	main cause of traffic delays		
	traffic accidents	62	21.4
	road construction work	127	43.8
	congestion due to heavy traffic volume	129	44.5
	weather conditions, such as snow, storm, etc.	1	0.3
	other	2	0.7
Actual Trip	did **not** encounter traffic delays	404	55.6
	encountered traffic delays	312	42.9
	N.A.	11	1.5
	average traffic delays	38.1 minutes	
	standard deviation	38.0 minutes	
	average length of the back up	8.6 km	
	standard deviation	12.0 km	
	main cause of traffic delays		
	traffic accidents	52	16.7
	road construction work	154	49.4
	congestion due to heavy traffic volume	128	41.0
	weather conditions, such as snow, storm, etc.	1	0.3
	other	8	2.6

Table 5.7 Actual Traffic Conditions

(Based on Traffic Condition Monitoring Subsystem)

	Date	Direction	Bottleneck Kilometer Post	Maximum length of the back up (km)	Average length of the back up (km)	Time	Duration (Minutes)	Cause of traffic delays
1	Dec. 4	East-	0.0	5.0	3.12	14:50-17:40	170	Saturation
2	(Sun.)	bound	0.0	1.5	0.75	18:00-18:40	40	Saturation
3			24.0	4.5	2.81	9:25-13:20	235	Construction
4			29.6	5.3	4.90	17:02-20:31	209	Saturation
5			47.0	19.3	13.96	15:15-20:31	316	Saturation
6			110.1	2.0	1.35	21:55-23:05	70	Rubber Neck
7			168.0	4.0	2.33	10:40-11:25	45	Disabled Vehicle
8		West-	40.0	2.3	1.71	11:10-13:10	120	Construction
9		bound	44.9	1.9	1.68	17:05-20:00	175	Construction
10			44.9	2.2	1.68	21:30-22:30	60	Construction
11			109.9	6.7	3.18	21:50-23:30	100	Accident
12	Dec. 7	East-	0.0	5.0	2.89	5:50- 8:10	140	Saturation
13	(Wed.)	bound	19.7	12.0	6.57	17:10-19:22	132	Saturation
14			44.3	5.8	3.08	10:15-12:55	160	Construction
15			243.4	9.0	4.97	10:00-13:40	160	Construction
16		West-	14.5	8.0	4.93	6:51- 9:00	129	Accident
17		bound	28.6	8.9	5.19	8:35-14:28	293	Construction
18			132.1	1.9	1.66	10:30-11:10	40	Construction
19			190.0	2.6	2.07	12:45-13:20	35	Accident

Note: Bottleneck Kilometer post indicates the distances of bottlenecks from the Tokyo Interchange.

Table 5.8 Average Traffic Delays

(Based on Traffic Condition Monitoring Subsystem)

Cause of traffic delays	Number of the back ups	Average length of the back up (km)	Average duration of the back up (minutes)	Amount of traffic delays (km-minutes)	%
Accidents	3	3.89	88.0	1,026.42	8.1
Construction	8	3.33	155.4	4,135.42	32.7
Saturation	6	7.22	167.8	7,267.70	57.6
Other	2	1.73	57.5	199.35	1.6
Total	19	4.80	138.4	12,628.89	100.0

5.4 Response to Traffic Information

Table 5.9 presents the average traffic delays based on pre-trip traffic information, en-route traffic information, and actual traffic conditions reported by respondents, classified by drivers' response to traffic information.

In general, the average traffic delay of drivers who have responded to traffic information (26.2 minutes: based on pre-trip traffic information, 30.0 minutes: based on en-route traffic information, 28.6 minutes: based on the actual traffic conditions from respondents' answers), are longer than those of drivers who have not responded (12.8 minutes, 14.5 minutes, 13.6 minutes respectively).

The average traffic delay of drivers who have changed exits, based on pre-trip traffic information is 11.2 minutes, while that based on en-route information is 27.3 minutes This implies that they responded based not on pre-trip traffic information, but on en-route traffic information.

We can be fairly certain that drivers responded based on the length of traffic delays which they were informed of.

In the July 1992 survey, SP data were collected by asking drivers, "How long are the maximum length of the back up and traffic delays that you can endure on the Tomei Expressway?" (The threshold of exiting the Tomei Expressway) Table 5.10 presents the results of this question.

With regard to 50 percentile lengths of the back ups, approximately 10 km, 20 km, and 30 km are for drivers whose trip lengths on expressways are less than 50 km, 50-200 km, and 200 km or over, respectively. Similarly, regarding 50 percentile times to pass through the back ups, approximately 30 minutes, 60 minutes, and 90 minutes are for drivers whose trip lengths on expressways are less than 50 km, 50-200 km, and 200 km or over respectively.

Comparing these results with our survey, only 3% of drivers in our survey exited the Tomei Expressway. In our survey, the average traffic delay based on en-route traffic information for drivers who have diverted is 27.3 minutes, which is equivalent to 34.1 minutes of time necessary to pass through the back up (based on the assumption that the average speed of passing through the back up is 20 km/h), and the average trip length on expressways in our survey is about 200 km. If drivers in our survey behaved according to the results from the July 1992 survey, at least 22% of drivers should have diverted from the Tomei Expressway (50% X 34.1 / 78).

This fact shows that actually drivers are less likely to divert from the inter-city expressway than the results from the SP questions they answered.

Comparing the equivalent time to pass through the back ups which is calculated from "the length of the back ups" (values in the parentheses in Table 5.10) and indicated "time to pass through the back ups," these two values are similar, however the latter is generally smaller than the former. This can be explained by the assumption that "time to pass through the back ups" is direct expression and easier to understand for drivers as a decision making source than "the length of the back ups".

Table 5.9 Response to Traffic Information

Response	Number of respondents	%	Average delay based on pre-trip traffic information (minutes)	Average delay based on en-route traffic information (minutes)	Average delay based on actual traffic conditions (minutes)
changed **nothing**	558	76.8	12.8	14.5	13.6
made a response	133	18.3	26.2	30.0	28.6
changed departure time	57	7.8			
earlier	(42)		33.4	24.7	34.3
later	(6)		24.0	41.2	23.3
N.A.	(9)				
changed entrance	15	2.1	40.0	43.1	14.3
changed exit	22	3.0	11.2	27.3	19.0
changed time spent at rest areas	43	5.9			
longer	(25)		44.3	35.6	40.0
shorter	(18)		30.6	30.3	36.5
changed entire route	13	1.8	19.9	21.8	15.8
planned route was;					
ordinary roads for the entire route	(8)				
the Chuo Expressway as apart of the route	(1)				
other	(3)				
N.A.	(1)				
Changed plans at destination	7	1.0	21.4	23.6	6.7
Informed someone of arrival time change	17	2.3	25.7	30.3	30.6
Other	3	0.4	6.7	16.7	13.3
N.A.	36	5.0			
Total	727	100.0	15.3	17.5	16.3

Note 1) Averages are calculated by omitting respondents who did not acquire pre-trip or en-route traffic information.
2) Actual traffic conditions were reported by respondents.

Table 5.10 Threshold of Diverting from the Tomei Expressway

Trip length on expressways		Length of the back ups (km)	(minutes)	Time to pass through the back ups (minutes)
Less than 50 km	**50** percentile	11.4	(34.2)	30
	85 percentile	44.5	(133.5)	96
50 - 200 km	**50** percentile	21.2	(63.6)	51
	85 percentile	77.3	(231.9)	156
200 km or over	**50** percentile	28.5	(85.5)	78
	85 percentile	not exit		not exit

Note: Figures in ( ) mean times to pass through the back ups at the speed of 20 km/h which is the average velocity in the back ups based on the data collected by a floating-car technique.

5.5 Decision Making Tree

Figure 5.1 illustrates the drivers' decision making process of pre-trip traffic information acquisition, en-route traffic information acquisition, and response to traffic information.

87% of drivers acquired pre-trip traffic information. Then, 93% of drivers who acquired pre-trip information, also acquired en-route traffic information, while only 60% of drivers, who did not acquired pre-trip traffic information, acquired en-route traffic information. This fact shows that drivers who have already acquired traffic information once are more likely to acquire traffic information repeatedly.

The response percentage of drivers who have acquired both pre-trip and en-route traffic information is 19%. That of drivers who have acquired pre-trip or en-route traffic information is 16%. That of drivers who have acquired neither pre-trip nor en-route traffic information is 11%. This implies that acquisition of traffic information has a significantly positive impact on the drivers' response behaviors. Acquisition of traffic information obviously encourages drivers to respond to traffic information.

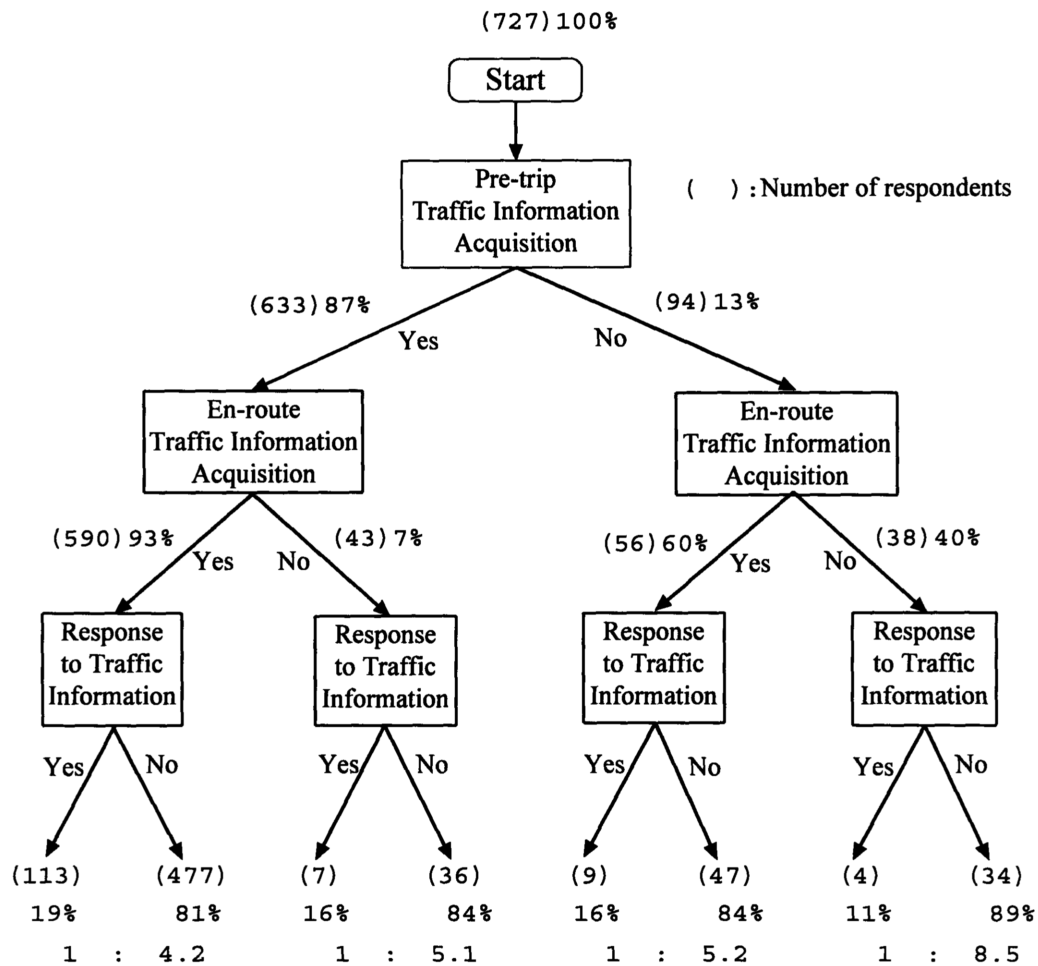

Figure 5.1 Decision Making Tree

5.6 Expectations of Traffic Delays

Table 5.11 presents drivers' expectations of traffic delays.

When drivers decided to respond, 20% of them expected traffic delays would be shorter as the result of their responses compared to the result from "changed nothing," while 32% of them expected traffic delays would be longer. (30% of them expected traffic delays would change little and 17% of them had no idea about traffic delays.) Regarding the length of the back up, 18% of the drivers expected it would be shorter, while 31% of them expected it would be longer. (35% of them would change little and 15% of them had no idea about it.) The number of drivers who have expected traffic delays or the length of the back up would be longer, is larger than that of those who expected they would be shorter

This fact shows that drivers did not respond under the conviction that they could shorten their travel time or length of the back up. This is a very important finding of this survey. Drivers who changed their routes from the Tomei Expressway to ordinary surface roads, had traffic information only about the Tomei Expressway, not about ordinary surface roads. Not knowing traffic information about their alternate routes, they decided to take ordinary surface roads as parts of their routes. This behavior is considered by them to be no better than a gamble. The only motivation to respond to traffic information is information about traffic delays on the Tomei Expressway as mentioned in the previous section.

Drivers were also asked, "Having further information now, what do you think the result of your action was, compared to the result from changing nothing." In this case, 36% of the drivers thought travel time decreased, while 29% of them thought it increased. (36% of them had no idea about it.) Concerning the length of the back up, 22% of them thought it became shorter, while 24% of them thought it became longer. (49% of them had no idea about it) The number of drivers, who thought traffic delays or the length of the back up became shorter by their responses, increased when they had further information after their trips.

5.7 Expectations of Traffic Delays and Response to Traffic Information

Table 5.12 illustrates drivers' expectations of traffic delays classified by their responses to traffic information.

Generally in each response alternative, the number of drivers who have expected that traffic delays would be shorter, is equal to or less than that of those who have expected traffic delays would be longer, and half or more drivers expected traffic delays would change little or had no idea about them. The same thing can be said regarding the length of the back up.

Concerning response, "changed entrance," only two drivers expected traffic delays would be shorter, while eight drivers expected traffic delays would be longer. Concerning responses, "changed exit" and "changed entire route," the situation is quite similar.

Some drivers may think that they could shorten the length of the back up, although they might lengthen traffic delays, by changing entrances or exits. In any case, we lack definite information on the real reason why they responded.

As mentioned in the previous section, however, one thing is certain: drivers responded to traffic information without firm conviction, such as to shorten the traffic delays or the length of the back up. Among those who changed plans at their destinations or informed someone of arrival time change, no one expected that traffic delays or the length of the back up would be shorter.

Table 5.11 Expectations of Traffic Delays

Expectation	Number of respondents	%
When decided to respond	115	100.0
travel time		
would decrease	23	20.0
would increase	37	32.2
change little.	35	30.4
no idea	20	17.4
length of the back up		
would decrease	21	18.3
would increase	36	31.3
change little.	40	34.7
no idea	17	14.8
N.A.	1	0.9
After all	115	100.0
travel time		
decreased	41	35.7
increased	33	28.6
no idea	41	35.7
length of the back up		
decreased	25	21.8
increased	28	24.3
no idea	56	48.7
N.A.	6	5.2

Table 5.12 Expectations of Traffic Delays and Response to Traffic Information

Attributes	Total number of respondents	Travel time would **decrease** (number of respondents	Travel time would **increase** (number of respondents	Travel time would **change little** (number of respondents	**No idea** about Travel time or N.A. (number of respondents	The length of the back up would **decrease** (number of respondents	The length of the back up would **increase** (number of respondents	The length of the back up would **change little** (number of respondents	**No idea** about t he length of th back up or N.A. (number of respondents
changed **nothing**	558								
changed departure time	57								
earlier	(42)	9	8	5	20	7	10	7	18
later	(6)	1		5		1		4	1
N.A.	(9)								
changed entrance	15	2	8	3	2		7	4	4
changed exit	22	3	7	7	5	3	5	9	5
changed time spent at rest areas	43								
longer	(25)	1	8	5	11	4	5	8	8
shorter	(18)	5	3	3	7	2	5	5	6
changed entire route	13	3	6	3	1	1	6	3	3
Changed plans at destination	7		2	1	4		1	1	5
Informed someone of arrival time change	17		2	1	14		2	2	13
Other	3	1		1	1		1	1	1
N.A.	36								

5.8 Satisfaction with Response to Traffic Information

Table 5.13 indicates drivers perceived traffic information and their responses on alleviating frustration.

The percentage of drivers who have felt, "Traffic information alleviated frustration," among those who changed nothing is 73%, while that among those who have made responses is 72%. These percentages are very similar, so that whether drivers responded or not makes no difference to drivers' feelings of "Traffic information alleviated frustration." However, the percentage of drivers who have felt, "Own response alleviated frustration," among those who changed nothing is 63%, while that among those who have made responses is 55%. Moreover, the percentage of drivers who have thought, "I am satisfied with my response," among those who have changed nothing is 84%, while that among those who have made responses is 72%.

Drivers tried to improve something by responding to traffic information, however their responses did not alleviate their frustration enough and they were not satisfied with their responses compared with the response "changed nothing." Drivers certainly made responses depending on the traffic conditions, but they were not sure that the results of their responses would have a good effect on their trips.

A Japanese proverb says that it is a waste of time to think a matter over when one has no good ideas. Besides, a catchline of the Metropolitan Expressway Public Corporation also says that the expressway is literally express no matter how congested it is. In Japan, compared with inter-city expressways, alternate ordinary surface roads are still in the lower service level. Thus, using ordinary surface roads takes almost twice as much time as using inter-city expressways. It would be better to say that the expressway saves time even though it is heavily congested. That is why people use inter-city expressways even during the high season when 100-km back ups occur on inter-city expressways all over the country (see Section 2.3.5).

The percentage of drivers who have felt, "Own response alleviated frustration," in total is 60%, while that of those who have thought, "I am satisfied with my response," is 79%. This implies that some drivers thought, "I am satisfied with my response, but it did not alleviate frustration." These drivers could not but respond to traffic information urged by the traffic conditions. However their responses did not have a good impact on their frustration and they were resigned to the result of their responses.
"Traffic information alleviated frustration," among those who have changed nothing is 73%, while that among those who have made responses is 72%. This fact shows that drivers think traffic information has good effects on their psychology, even though they do not make any responses.

In conclusion, as mentioned Section in 1.1 and 1.3, the major effect of traffic information is considered to be psychological; it alleviates drivers' anxiety and frustration. In fact, 70% of drivers felt that traffic information alleviated frustration, however only 60% of them felt their own responses alleviated frustration. Moreover, concerning drivers who have responded to traffic information, 72% of them felt that traffic information alleviated frustration, however only 55% of them felt that their own responses alleviated frustration. This shows that simply receiving traffic information has a great effect on alleviating drivers' frustration more than changing travel plans.

Table 5.13 Satisfaction with Response to Traffic Information

Attributes	total number of respondents	Traffic information alleviated frustration (number of respondents	%	Own response alleviated frustration (number of respondents)	%	Satisfied with response (number of respondents)	%
changed **nothing**	558	405	73	352	63	466	84
made a response	133	96	72	73	55	96	72
changed departure	57						
earlier	(42)	27	64	19	45	28	67
later	(6)	5	83	4	67	5	83
N.A.	(9)						
changed entrance	15	11	73	8	53	10	67
changed exit	22	16	73	13	59	15	68
changed time spent at rest areas	43						
longer	(25)	19	76	14	56	20	80
shorter	(18)	14	78	10	56	12	67
changed entire route	13	8	62	7	54	11	85
Changed plans at destination	7	6	86	5	71	4	57
Informed someone of arrival time change	17	10	59	8	47	14	82
Other	3	2	67	2	67	3	100
N.A.	36	11	31	11	31	15	42
Total	727	512	70	436	60	577	79

5.9 Evaluation of the ATIS

Table 5.14 shows drivers' evaluation of the ATIS on the Tomei Expressway.

In terms of reliability all three traffic information services receive a high evaluation.

With regard to area coverage, the Highway Information Terminal is more highly evaluated than the others, because its "Information Panels" provide an instant overview of traffic conditions of wide areas.

Concerning relevancy of information, the Highway Information Terminal is also evaluated highly. This is assumed that the Highway Telephone and the Highway Radio announce warning statements about traffic safety requested by the police when the traffic is going smoothly and drivers feel that these announcements are tedious or irrelevant.

Table 5.14 Evaluation of the ATIS

Attribute	Highway Telephone		Highway Radi		Highway Information Terminal	
	Average Score	Standard deviation	Average Score	Standard deviation	Average Score	Standard deviation
reliable	6.17	2.21	6.64	2.10	6.40	2.08
detailed	5.82	2.18	6.05	2.15	6.04	2.06
covers a wide area	5.55	2.13	5.51	2.26	6.25	2.12
relevant	5.45	2.19	5.67	2.25	6.02	2.11
Awareness (%)	51		84		68	

Note: Score 1 indicates "strongly disagree" and 9 indicates "strongly agree."

5.10 General Evaluation of Traffic Information Sources

Table 5.15 presents drivers' general evaluation of traffic information sources.

Among conventional traffic information sources, "Traffic news from radio broadcasts" indicates the highest average score (7.12). It also shows high awareness (91%). Drivers commonly listen to the car radio out of habit. On the other hand, "Teletext traffic news" indicates low evaluation (5.33) and low awareness (21%). Subscribing to teletext is not yet common in Japan, because it requires a special adapter with a TV set. However the quality of information from "Teletext traffic news" is supposed to be rather high compared with "traffic news from radio broadcasts." "Personal communications (Citizen's Band)" shows a relatively high average score (5.91) despite its low awareness (18%). The same observation applies to "In-vehicle car navigator" which still provides only static information, so that drivers could consider it as a map. "Congestion forecasting calendar indicates the lowest average score (5.32), because it is distributed seasonally and provides only static information which tells date, time, and location of expected congestion. "Road maps" shows a comparatively high average score (6.44) supported by high awareness (74%), but they are also static.

Regarding Variable Message Signs, all of them indicate high average scores as well as high awareness. Especially "Mainline Variable Message Signs" shows both the highest average score (7.50) and the highest awareness (99%). These signs are conspicuous among drivers, because they appear most frequently on the inter-city expressways in Japan. "Travel Time Variable Message Signs" indicates the second highest average score (7.34). These Variable Message Signs have been providing travel time information since 1991. This is the first attempt to provide travel time information on inter-city expressways in Japan, and this service is favorably received. "Travel Time Variable Massage Signs" shows a relatively high average score (7.18) in spite of comparatively low awareness (75%). These Variable Message Signs display information visually and graphically so that drivers can easily understand the content.

"Highway Radio" shows a high average score (7.49) compared with "Traffic news from radio broadcasts" even though its awareness is comparatively low (83%). This is only to be expected considering its high information service level. On the other hand, "Highway Telephone" indicates a low average score (6.17) compared with "A telephone call to the Japan road Traffic Information Center." The former is an operator answered system which can provide information according to the caller's inquiry (operation hours: 7:00 a.m.-7:00 p.m.), the latter is an auto-answering system updated every five minutes (24 hours service). The awareness of the former is relatively low (36%) as well as that of the latter (29%).

"Highway Information Terminal" shows a middle level of average score (6.85) and awareness (62%).

It seems reasonable to suggest that there is a correlation between drivers' evaluation (average score) and awareness. Drivers use an information source due to its high level of service, or drivers highly evaluate an information service because they use it frequently. However this argument seems to be circular.

Table 5.15 General Evaluation of Traffic Information Sources

Information Sources	Average Score	Standard deviation	Awareness (%)
a) A telephone call to the Japan Road Traffic Information Center	6.38	2.35	36
b) A telephone call to the Japan Road Highway public Corporation	6.06	2.45	29
c) Traffic news from radio broadcasts	7.12	1.87	91
d) Traffic news on TV	6.01	2.36	69
e) Teletext traffic news on TV	5.33	2.71	21
f) Personal radio communications (Citizens' Band)	5.91	3.09	18
g) Traffic congestion forecasting calendar	5.32	2.43	61
h) Road maps	6.44	2.49	74
i) In-vehicle car navigator	5.73	2.75	18
j) Interchange Entrance Variable Message Signs	7.17	1.86	87
k) Toll Gate Variable Message Signs	7.07	1.92	87
l) Mainline Variable Message Signs	7.50	1.71	99
m) Travel Time Variable Message Signs	7.34	1.86	88
n) Travel Time Graphic Variable Message Signs	7.18	1.90	75
o) Highway Telephone	6.17	2.30	29
p) Highway Radio	7.49	1.74	83
q) Highway Information Terminal	6.85	1.94	62

Note 1) Score 1 indicates "not useful at all" and 9 indicates "very useful."

2) Awareness is a percentage of respondents who have used each traffic information service.

5.11 Attitudes toward Driving Behavior

Table 5.16 shows drivers' attitudes toward driving behavior.

"I like driving." indicates the highest average score. This fact shows that Japanese drivers enjoy driving in spite of poor road infrastructure and severe traffic conditions. "I often take an entrance or exit interchange that is different from the one I had planned to take at the start of the trip" shows low average score (3.71) as well as "I trust my own judgment more than traffic information on expressways" (3.52). This is only to be expected, considering the features of traffic conditions and information services on inter-city expressways in Japan as mentioned above.

Table 5.16 Attitudes toward Driving Behavior

Statement	Average Score	Standard deviation
a) I often take an entrance or exit interchange that is different from the one I ha planned to take at the start of the trip.	3.71	2.60
b) I like discovering new routes.	5.55	2.78
c) I am willing to try new routes to avoid traffic delays.	6.41	2.45
d) I am always trying to acquire traffic information.	6.85	2.24
e) Traffic information on expressways is not sufficient.	5.51	2.55
f) I trust my own judgment more than traffic information on expressways.	3.52	2.16
g) I feel frustrated being stuck in traffic.	6.86	2.35
h) I like driving.	7.08	2.12

Note: Score 1 indicates "strongly disagree" and 9 indicates "strongly agree."

5.12 Importance in Route Choice

The table 5.17 presents drivers' perceptions of route choice.

The most important factor in route choice is "Risk of being stuck in traffic " whose average score is 7.38, while "Travel cost" shows the lowest average score (5.33). This fact represents Japanese inter-city drivers' perceptions of route choice very well. They do not like to be caught in traffic and they are willing to pay for avoiding it. This is one of the reasons they take inter-city expressways even though their toll rate is the highest all over the world. "Travel time"(average score: 7.33) and "Risk of being stuck in traffic" (average score: 7.12) are both related with congestion.

Table 5.17 Importance in Route Choice

Statement	Average Score	Standard deviation
a) Travel time	7.33	2.15
b) Travel cost	5.33	2.57
c) Route length	5.42	2.49
d) Traffic safety	6.64	2.33
e) Habit	6.03	2.24
f) Traffic volume	7.12	1.97
g) Risk of being stuck in traffic	7.38	1.88
h) Existence of traffic lights and intersections	5.82	2.52
i) Service level of traffic information	6.00	2.27
j) Level of difficulty in following the route	7.01	2.12
k) Departure time of day	6.72	2.36
l) Weather	6.07	2.59

Note: Score 1 indicates "not important at all" and 9 indicates "very important."

5.13 Summary of the Descriptive Statistics

1) In our survey, more than 65% of the respondents acquired traffic information from radio broadcasts before departure, while only 23% of the respondents listened to radio traffic news in the Nov. 1993 survey. This is an extremely high percentage of pre-trip traffic information acquisition.

2) If drivers in our survey behaved according to the results from the SP data of the July 1992 survey, at least 22% of them would have diverted from the Tomei Expressway, while only 3% of them actually exited. This demonstrates over-responsiveness of individuals in response to hypothetical route choice.

3) Drivers' awareness of the Highway Telephone, the Highway Radio, and the Highway Information Terminal are 49%, 98%, and 84%, respectively. However, drivers' usage of the Highway Telephone, the Highway Radio, and the Highway Information Terminal are 1.5%, 33%, and 12%, respectively. On the contrary, concerning the Travel Time Variable Message Signs, drivers' awareness is 88% and their usage is 81%.

4) 93% of drivers who acquired pre-trip information, also acquired en-route traffic information, while only 60% of drivers, who did not acquire pre-trip traffic information, acquired en-route traffic information. This fact shows that drivers who have already

acquired traffic information once are more likely to acquire traffic information repeatedly.

5) 19% of drivers who acquired both pre-trip and en-route traffic information responded to traffic information. 16% of those who acquired either pre-trip or en-route traffic information responded. 11% of those who acquired neither pre-trip nor en-route traffic information responded. This implies that acquisition of traffic information has a significantly positive impact on the drivers' travel response behaviors.

6) The number of drivers who have responded to acquired information and have expected traffic delays or the length of the back up would be longer, is larger than that of those who also have responded but have expected it would be shorter. This fact shows that drivers do not always take actions under the conviction that they can shorten their travel time or length of the back up.

7) In fact, 70% of drivers felt that traffic information alleviated frustration, however only 60% of them felt their own responses alleviated frustration. Moreover, concerning drivers who have responded to traffic information, 72% of them felt that traffic information alleviated frustration, however only 55% of them felt their own responses alleviated frustration. This exactly shows that traffic information in itself has better effects on drivers' psychology than their responses to traffic information. In other words, simply receiving traffic information has a greater effect on alleviating drivers' frustration than changing travel plans.

8) Regarding drivers' general evaluation of traffic information sources, Variable Message Signs indicate high evaluation in general. Especially the "Mainline Variable Message Signs" shows the highest evaluation and the "Travel Time Variable Message Signs" indicates the second highest evaluation.

It seems reasonable to suggest that there is a correlation between drivers' evaluation and awareness. Drivers use an information source due to its high quality service, and drivers highly evaluate an information service because they use it frequently.

Chapter 6

Model Estimating Results

This chapter presents the estimation results from the modeling of the acquisition of pre-trip traffic information, acquisition of en-route traffic information, and response to traffic information.

6.1 Estimation Techniques

6.1.1 Logit Model

The assumption underlying discrete choice models is that each decision maker chooses the most desirable alternative that has the highest utility among his/her choice set. Among various discrete choice models, logit models using standard maximum likelihood estimator (MLE) techniques were chosen in this research because of their simplicity and fast computational time in estimating parameters. (see Ben-Akiva and Lerman (1985) for further discussion on discrete choice models.)

6.1.2 Modeling with Fitted Value of Attitudes

In the model estimations, we used the following fitted values as explanatory variables:

1) attitudes toward driving behavior

2) drivers' evaluation of traffic information sources

This two step modeling was used to account for any notions of "circularity" on drivers' actual decision making and the formation of the above attitudinal variables.

These fitted values were acquired by estimating simple regression models. In these models, the dependent variables reflect the attitudes and preferences of the drivers, while the independent variables represent the drivers' socioeconomic characteristics and trip characteristics. Note that the socioeconomic characteristics and the trip characteristics are not very good predictions of the drivers' attitudes and preferences. This implies that there is a large portion of unexplained variability depending on the personality of each driver, which can not be captured by the above factors.

6.2 Traffic Information Acquisition

Nested logit (NL) models were used for estimating traffic information acquisition. Figure 6.1 presents the general structure of these NL models. A driver's decision between "Not acquire traffic information" and "Acquire traffic information" is the upper level of the NL models, and choice among traffic information sources is the lower level.

The upper level is a binary choice ("Not acquire" or "Acquire"), while the lower level is a multinomial choice. The NL models were used because of the a priori hypothesis that at first a driver decides whether to acquire traffic information or not, and then decides which information source to consult. The NL structure was used for both the pre-trip traffic information acquisition and en-route traffic information acquisition.

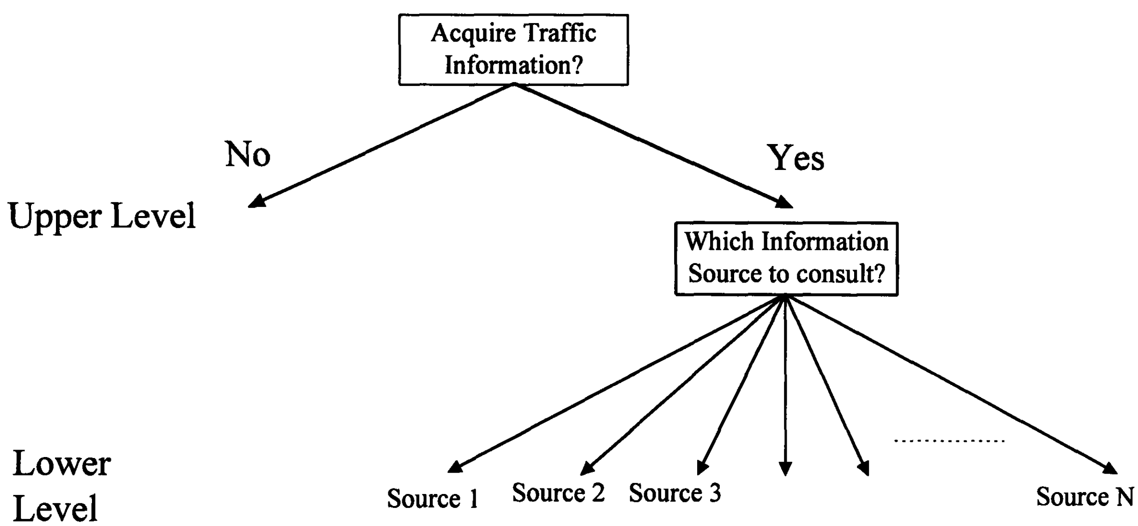

Figure 6.1 General Structure of Traffic Information Acquisition Models

6.3 Pre-Trip Traffic Information Acquisition

The upper level of the pre-trip traffic information acquisition model is a binary logit model in which the dependent variable is: 1 if the driver acquired pre-trip traffic information and 0 otherwise. The lower level is MNL model in which the dependent variable is one of the main pre-trip traffic information sources. Some drivers acquired traffic information from two or more sources because road maps or other sources are included in the information source alternatives. However, the number of drivers who used two or more information sources is not very large. Therefore, they are considered as users of one major information source.

To model the acquisition of pre-trip traffic information, three major groups of independent variables are used: drivers' socioeconomic characteristics, trip characteristics, and drivers' attitudes and perceptions of driving behavior. Results of these models are shown in Table 6.1 and 6.3. The summary with relevant statistics obtained from the estimations are also provided in these Tables. The analysis of the results related to upper level and lower level are as follows.

6.3.1 Pre-Trip Traffic Information Acquisition Model (Binary Logit): Upper Level

Table 6.1 presents the estimation results of this model.

Socioeconomic Characteristics

We tried many socioeconomic characteristics as possible independent (explanatory) variables. However, only "Occupation: subordinate worker" and "Occupation: housewife" appeared to have a significant effect. The negative signs of the coefficients of these variables indicate that subordinate workers and housewives are less likely to acquire pre-trip traffic information. These socioeconomic characteristics are closely related with trip characteristics, such as trip purpose and vehicle type.

In our survey, 91% of the respondents are male, so that subordinate workers are considered to consist of young male workers who do not have enough time to consult traffic information before morning departure time. Housewives are assumed to be unfamiliar with pre-trip traffic information sources because they have few opportunities to make inter-city trips.

Table 6.1 Estimation Results of Pre-Trip Traffic Information Acquisition Model (Binary Logit)

Upper Level (Acquire or Not)

Dependent variable Acquire: 1 n=633

Not acquire: 0 n= 94

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
Socioeconomic characteristics	1	Occupation: subordinate worker	-0.777	0.243	-3.20
	2	Occupation: housewife	-1.583	0.470	-3.37
Trip characteristics	4	Sunday trip	-0.776	0.266	-2.92
	5	had a schedule of activities at destination	0.233	0.287	0.81
	6	Egress time from exit to destination in hundred minutes	0.719	0.376	1.91
	7	Have never used alternate routes	0.445	0.251	1.77
	8	Have used another entrance or exit of the Tomei Expressway	0.766	0.381	2.01
Attitudes and Perceptions	9	"Weather" is important in route choice	0.117	0.042	2.83
	10	Constant for acquire	0.785	0.823	1.42
	11	Inclusive value	0.440	0.269	1.64

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -249.11$

$\rho^2 = 0.506$ $\bar{\rho}^2 = 0.486$

Trip Characteristics

As mentioned in Chapter 2, survey questionnaires were distributed on Sunday and Wednesday (two days). A dummy variable is created for Sunday trips. We can see that Sunday trip makers are less likely to acquire pre-trip traffic information. This can be explained by the assumption that Sunday trips consist more of pleasure trips which do not have definite arrival times and that Sunday drivers have fewer opportunities to make similar inter-city trips than weekday trip makers.

The drivers who have schedules of activities at their destinations are likely to acquire pre-trip traffic information so as to be on time for these schedules.

The longer egress time from exit to destination, the more likely drivers are to acquire pre-trip traffic information. The trips with long egress time include longer ordinary surface roads as parts of the routes which have uncertain factors in travel time.

The drivers who have never used alternative routes are likely to acquire pre-trip traffic information. They might be more curious about traffic conditions on the Tomei Expressway because they cannot but take the expressway.

The drivers who have used another entrance or exit of the Tomei Expressway are likely to acquire pre-trip traffic information. They might also be more curious about traffic conditions on the Tomei Expressway, because they would try to avoid traffic congestion by using another entrance or exit.

Attitudes and Perceptions

We also tried many variables describing drivers' attitudes and perceptions as possible independent (explanatory) variables. However, only "Weather is important in route choice" appeared to have a significant effect. Those who think weather is an important factor in route choice are considered to be likely to consult weather news as well as traffic news. In other words, weather information seekers are also traffic information seekers.

Inclusive Value

The estimated coefficient of inclusive value (0.440), which is the logsum from the lower level model, is between zero and one and is also significantly different from zero and one. Therefore, the nested logit (NL) model, the structure of which is shown in Figure 6.1, can be applied to the parameter estimation.

6.3.2 Pre-Trip Traffic Information Source Choice Model (MNL): Lower Level

Table 6.2 presents the specification of pre-trip traffic information source choice model (MNL) and Table 6.3 presents the estimation results of this model.

To show the difference among information sources, each independent variable is basically applied to all alternatives other than alternative 8 (other information sources), which is the base alternative in this model.

Socioeconomic Characteristics

The only significant socioeconomic characteristic is " Occupation: professional driver." Professional drivers are likely to use personal communications (citizen's band) as a pre-trip traffic information source. Personal communications are mainly used by drivers of commercial vehicles and taxies in Japan.

Table 6.2 Specification of Pre-Trip Traffic Information Source Choice Model (MNL)

	Telephone call	Radio traffic news	TV traffic news	Teletext	Personal communi-cations	Calendar of congestion forecast	Highway Telephone	other
Alternative number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Constant	1	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0
	0	0	1	0	0	0	0	0
	0	0	0	1	0	0	0	0
	0	0	0	0	1	0	0	0
	0	0	0	0	0	1	0	0
	0	0	0	0	0	0	1	0
Occupation: professional driver (pro_driver) =1,0 o.w.	0	0	0	0	pro_driver	0	0	0
Travel cost in thousand yen (travel cost)	travel cost	0	0	0	0	0	0	0
	0	travel cost	0	0	0	0	0	0
	0	0	travel cost	0	0	0	0	0
	0	0	0	travel cost	0	0	0	0
	0	0	0	0	travel cost	0	0	0
	0	0	0	0	0	travel cost	0	0
	0	0	0	0	0	0	travel cost	0
Drive frequency: everyday (everyday) =1,0 o.w.	everyday	0	0	0	0	0	0	0
	0	everyday	0	0	0	0	0	0
	0	0	everyday	0	0	0	0	0
	0	0	0	everyday	0	0	0	0
	0	0	0	0	everyday	0	0	0
	0	0	0	0	0	everyday	0	0
	0	0	0	0	0	0	everyday	0
"Service level of traffic information" is important in route choice (Imp.info)* fitted value =1,2,…,9	0	Imp.info	0	0	0	0	0	0
	0	0	0	Imp.info	0	0	0	0
	0	0	0	0	0	0	Imp.info	0
"Weather" is important in route choice (Imp.weather)* fitted value =1,2,…,9	0	0	0	0	0	Imp.weather	0	0
	0	0	0	0	0	0	Imp.weather	0
Usefulness of each information source (Useful)* fitted value =1,2,…,9	Useful **1**	Useful **2**	Useful **3**	Useful **4**	Useful **5**	Useful **6**	Useful **7**	0
Never used each information source (info.dummy) =1,0 o.w.	info.dummy**1**	info.dummy**2**	info.dummy**3**	info.dummy**4**	info.dummy**5**	info.dummy**6**	info.dummy**7**	0

Table 6.3 Estimation Results of Pre-Trip Traffic Information Source Choice Model (MNL)

Lower Level (Traffic Information Source Choice)

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant 1	-2.284	0.749	-3.85
	2	Constant 2	-1.151	0.721	-1.59
	3	Constant 3	-1.945	0.608	-3.19
	4	Constant 4	-5.990	2.122	-2.82
	5	Constant 5	-4.294	1.008	-4.26
	6	Constant 6	-5.070	1.400	-3.62
	7	Constant 7	-11.968	2.893	-4.14
Socioeconomic characteristics	8	Occupation: professional driver 5	2.603	0.815	3.20
Trip characteristics	9	Had a schedule of activities at destination 1	0.406	0.484	0.84
	10	Had a schedule of activities at destination 2	0.345	0.253	1.36
	11	Had a schedule of activities at destination 3	-0.132	0.415	-0.32
	12	Had a schedule of activities at destination 4	-1.733	1.062	-1.63
	13	Had a schedule of activities at destination 5	1.280	0.765	1.67
	14	Had a schedule of activities at destination 6	0.563	0.516	1.09
	15	Had a schedule of activities at destination 7	1.042	0.720	1.45
	16	Drive frequency: everyday 1	0.856	0.495	1.73
	17	Drive frequency: everyday 2	0.474	0.231	2.05
	18	Drive frequency: everyday 3	0.149	0.358	0.42
	19	Drive frequency: everyday 4	0.637	0.589	1.08
	20	Drive frequency: everyday 5	-0.163	0.850	-0.19
	21	Drive frequency: everyday 6	0.468	0.497	0.94
	22	Drive frequency: everyday 7	-0.048	0.694	-0.07
Attitude and Perceptions	23	"Service level of traffic information" is important in route choice 2	0.104	0.584	1.78
	24	"Service level of traffic information" is important in route choice 4	0.597	0.327	1.83
	25	"Service level of traffic information" is important in route choice 7	0.900	0.481	1.87
	26	"Weather" is important in route choice 6	0.359	0.204	1.76
	27	"Weather" is important in route choice 7	0.497	0.399	1.25
	28	Usefulness of each information source 1-7	0.236	0.094	2.53
	29	Never used each information source (Dummy) 1-7	0.024	0.648	0.04

Dependent variable

1	Telephone call	n= 24
2	Radio traffic news	n=395
3	TV traffic news	n= 47
4	Teletext	n= 16
5	Personal communications	n= 10
6	Calendar of congestion forecast	n= 22
7	Highway Telephone	n= 11
8	Other	n=108

Summary Statistics

Number of observations = 633

$L(0) = -1316.3$ $L(\bar{\beta}) = -726.03$

$\rho^2 = 0.448$ $\bar{\rho}^2 = 0.426$

Trip Characteristics

We also tried many trip characteristics as possible independent (explanatory) variables. However, only "Had a schedule of activities at destination" and "Drive frequency" appeared to have a significant effect.

Generally, drivers who have schedules of activities at their destinations are likely to use pre-trip traffic information sources so as to be on time, except for TV traffic news and teletext traffic news. As mentioned in Section 2.3.4, traffic news on TV is broadcast once or twice a day by each station and is very short. Subscription to teletext is not yet common in Japan, because it requires a special adapter with a TV set. Only 16 drivers (2.2% of the total respondents) have chosen teletext traffic news as their pre-trip traffic information sources. Therefore, negative coefficients of these alternatives are considered to be accidental.

Frequent drivers are more likely to acquire pre-trip traffic information in general. Especially, they are likely to make phone calls and consult traffic news on the radio, since they are considered to be familiar with traffic information sources.

Attitudes and Perceptions

Those who think "Service level of traffic information is important in route choice" are considered to be traffic information seekers. They are likely to use radio traffic news, teletext traffic news, and the Highway Telephone which provides a high quality of traffic information.

Those who think "Weather is important in route choice" are also considered to be traffic information seekers. They are likely to use congestion forecasting calendars, which are similar to weather forecast, as well as the Highway Telephone.

Drivers' perceptions of usefulness of each information source appear significant independent variables in this model. Drivers who evaluate an information source as "Very useful" are more likely to use this information source. This is easy to understand intuitively.

To exclude the bias of those who have not used the information source, we introduced a dummy variable. The coefficient of this dummy variable should be negative, because respondents, who have not used a traffic information source, are naturally considered not to have consulted the information source on their trips. However, it appeared to be positive in this model. The reason for this is assumed to be as follows:

In our survey questionnaire, drivers were asked "If you have not used a particular information service, please skip the corresponding question of evaluating each information service." However, there were as many as 75 respondents (10.3% of the total respondents) who skipped the question evaluating an en-route traffic information service, but actually used the same information service.

6.3.3 Summary of the Pre-Trip Traffic information Acquisition Models

The nested logit (NL) model can be applied in pre-trip information acquisition behavior.

In the upper level model (acquire or not), drivers' socioeconomic characteristics, such as gender, age, or income have little significance in general. The only significant socioeconomic characteristic is occupation, however, occupation is closely related with trip characteristics, such as trip purpose and vehicle type. Trip characteristics also do not play important roles in pre-trip traffic information acquisition behavior in general. "Sunday trip," "Egress time," and "Have used another entrance or exit" are exceptions. Drivers' Attitudes and Perceptions are not significant either. "Weather is important in route choice" is also an exception.

In the lower level model (information source choice), socioeconomic characteristics have little significance in general. "Occupation: professional driver" is an exception. Trip characteristics are not significant either. Generally speaking, Attitudes and Perceptions also do not play important roles, however, "Usefulness of each information source" is significant for choosing each information source. This is quite obvious, but a very important finding. When drivers perceive that a traffic information source is useful to their needs, they will use it. Therefore, it is important to publicize how to use it and how it is relevant to drivers' needs, in introducing a new information service.

Furthermore, by improving the quality of a traffic information service, we can improve drivers' attitudes and perceptions of it and increase their usage of it. For example, as mentioned in Section 5.10, the Highway Telephone indicates lower awareness (29%) than the Highway Radio (83%) and the Highway Information Terminal (62%). The JHPC has been trying to publicize these state-of-the-art ATIS by sending news letters to regular customers and publishing all kinds of brochures, however the awareness of the Highway Telephone is still rather low. The Highway Radio shows higher awareness thanks to the roadside signs which indicate broadcast areas and contents of traffic information (see Figure 2.11). The Highway Information Terminal also shows rather high awareness thanks to the roadside signs before the rest areas which indicates existence of the Highway Information Terminal by the pictograph "I".

Given the circumstances mentioned above, there is no significant independent (explanatory) variable which can explain pre-trip traffic information acquisition behavior clearly, other than the perceived "Usefulness of each information source."

6.4 En-Route Traffic Information Acquisition

In estimating en-route traffic information acquisition, a nested logit (NL) model is also used in the same way as in estimating pre-trip traffic information acquisition. The upper level is a binary logit model in which the dependent variable is: 1 if the driver acquired en-route traffic information and 0 otherwise. The lower level is an MNL model in which the dependent variable is one of the main en-route traffic information sources.

To model the acquisition of en-route traffic information, four major groups of independent variables are used: socioeconomic characteristics, trip characteristics, drivers' attitudes and perceptions of driving behavior, and pre-trip traffic information characteristics. The results of these models are shown in Table 6.4 and 6.6. The analyses of the results related to upper level and lower level are as follows.

6.4.1 En-Route Traffic Information Acquisition Model (Binary Logit): Upper Level

Table 6.4 presents the estimation results of this model.

Socioeconomic Characteristics

We investigated many socioeconomic characteristics as possible independent (explanatory) variables. However, only "Occupation: housewife" appeared to have a significant effect. As mentioned in Section 6.3.1, housewives are assumed to be unfamiliar with en-route traffic information sources and indifferent to traffic information. Actually 84% of their trip purposes are recreation, shopping, private business, and visiting relatives. Trips for these purposes are considered to have large flexibility in arrival time.

Table 6.4 Estimation Results of En-Route Traffic Information Acquisition Model (Binary Logit)

Upper Level (Acquire or Not)

Dependent variable **Acquire: 1 n=646**

Not acquire: 0 n= 81

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
Socioeconomic characteristics	1	Occupation: housewife	-0.922	0.572	-1.61
Trip characteristics	2	Vehicle type: bus and micro-bus	-2.326	0.478	-4.86
	3	Have used the Chuo Expressway as a part of the route	0.865	0.582	1.49
Attitudes and Perceptions	4	I am always trying to acquire traffic information	0.116	0.056	2.06
	5	"Service level of traffic information" is important in route choice	0.109	0.058	1.87
Pre-trip traffic information characteristics	6	Acquired pre-trip traffic information	2.092	0.301	6.96
	7	Length of the back up based on pre-trip traffic information (km)	0.032	0.032	0.98
	8	Constant for acquire	-4.829	1.092	-4.42
	9	Inclusive value	0.822	0.226	3.64

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -188.15$

$\rho^2 = 0.627$ $\bar{\rho}^2 = 0.609$

Trip Characteristics

Drivers of buses or microbuses are less likely to acquire en-route traffic information. According to the results of the Nov. 1993 survey, 45% of bus drivers did not listen to the Highway Radio, while only 28% of other professional drivers and 30% of passenger car drivers did not listen to the Highway Radio. 46% of bus drivers who did not listen to the Highway Radio, answered that they were afraid passengers felt radio broadcasts were noisy, as the reason why they did not listen to the Highway Radio. Thus, in our survey, bus drivers are also less likely to listen to it, which is the main en-route traffic information source.

Drivers who have used the Chuo Expressway as parts of their routes, are more likely to acquire en-route traffic information, because they should catch traffic conditions on the Tomei Expressway if they want to switch to the Chuo Expressway.

Attitudes and Perceptions

Drivers who think "I am always trying to acquire traffic information" are more likely to acquire en-route traffic information. This is easy to understand intuitively. As mentioned in Section 6.3.2, drivers who think "Service level of traffic information is important in route choice" are considered to be information seekers who are likely to acquire en-route traffic information as a matter of course.

Pre-Trip Traffic Information Characteristics

Drivers who acquired pre-trip traffic information are more likely to acquire en-route traffic information. Those who acquired pre-trip traffic information are considered to be information seekers and are always trying to acquire traffic information during the trip rather than being satisfied with pre-trip traffic information. This is a very significant variable.

The longer the length of the back up based on pre-trip traffic information, the more likely drivers are to acquire en-route traffic information. This can be explained by the assumption that pre-trip traffic information about long back ups makes drivers curious about traffic conditions during the trip, although this variable is not so significant.

Note that drivers will be informed of the length of the back ups and traffic delays through Variable Message Signs during their trips before they actually encounter the back ups.

Inclusive Value

In the same way as mentioned in Section 6.3.1, the estimated coefficient of inclusive value (0.822), which is the logsum of the utilities of the lower level model, is between zero and one and is significantly different from zero and one. Therefore, the nested logit (NL) model can be applied to the parameter estimation.

6.4.2 En-Route Traffic Information Source Choice Model (MNL): Lower Level

Table 6.5 presents the specification of en-route traffic information source choice model (MNL) and Table 6.6 presents the estimation results of this model.

To show the difference among information sources, in the same way as in Section 6.3.2, each independent variable is applied to all alternatives other than alternative 8 (other information sources), which is the base alternative in this model.

Socioeconomic Characteristics

The only significant socioeconomic characteristic is also "Occupation: professional driver." Professional drivers are likely to use personal communications as an en-route traffic information source, however, the significance of "Occupation: professional driver" in this model is rather lower than that in the pre-trip information source choice model.

Trip Characteristics

Drivers of long travel time trips are likely to acquire en-route traffic information in general. Especially, they are more likely to use the Highway Radio and the Highway Information Terminal, which are the ATIS on the Tomei Expressway providing a high quality of traffic information. In general, drivers who have schedules of activities at their destinations are likely to use en-route traffic information sources other than car navigators and congestion forecasting calendars. Since these information sources are not so common, the numbers of respondents who have chosen these alternatives are 8 (1.1% of the total respondents) and 11 (1.5% of the total respondents) respectively.

Attitudes and Perceptions

We tried many socioeconomic characteristics as possible independent (explanatory) variables. However, only the drivers' perceptions of usefulness of each information source, appear as a significant independent variable in this model. Drivers who evaluate an information source as "very useful" are more likely to use this information source as a matter of course.

To exclude the bias of those who have not used the information source, we introduced dummy variable in the same way as in Section 6.3.2. The coefficient of this variable should be negative, however, it appeared to be positive in this model. The reason for this is assumed to be as follows:

In the questionnaire of our survey, drivers were asked "If you have not used a particular information service, please skip the corresponding question." However, there were as many as 91 respondents (12.5% of the total respondents) who skipped the question evaluating an en-route traffic information service, but actually used the same information service.

Table 6.5 Specification of En-Route Traffic Information Source Choice Model (MNL)

	Telephone call	Radio traffic news	In-vehicle navigator	Personal communi-cations	Calendar of congestion forecast	Highway Radio	Highway Information Terminal	other
Alternative number	1	2	3	4	5	6	7	8
Constant	1	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0
	0	0	1	0	0	0	0	0
	0	0	0	1	0	0	0	0
	0	0	0	0	1	0	0	0
	0	0	0	0	0	1	0	0
	0	0	0	0	0	0	1	0
Occupation: professional driver (pro-driver) =1,0 o.w.	0	0	0	pro_driver	0	0	0	0
Travel time in thousand yen (travel cost)	travel time	0	0	0	0	0	0	0
	0	travel time	0	0	0	0	0	0
	0	0	travel time	0	0	0	0	0
	0	0	0	travel time	0	0	0	0
	0	0	0	0	travel time	0	0	0
	0	0	0	0	0	travel time	0	0
	0	0	0	0	0	0	travel time	0
Had a schedule of activities at destination (schedule) =1,0 o.w.	schedule	0	0	0	0	0	0	0
	0	schedule	0	0	0	0	0	0
	0	0	schedule	0	0	0	0	0
	0	0	0	schedule	0	0	0	0
	0	0	0	0	schedule	0	0	0
	0	0	0	0	0	schedule	0	0
	0	0	0	0	0	0	schedule	0
Usefulness of each information source (Useful)* fitted value =1,2,...,9	Useful 1	Useful 2	Useful 3	Useful 4	Useful 5	Useful 6	Useful 7	0
Never used each information source (info.dummy) =1,0 o.w.	info.dummy 1	0 info.dummy2	0 info.dummy3	0 info.dummy4	0 info.dummy5	0 info.dummy6	0 info.dummy7	0 0
Pre-trip traffic information source (used the same information source as pre-trip information)	pr_inf 1	0	0	0	0	0	0	0
	0	pr_inf 2	0	0	0	0	0	0
	0	0	0	pr_inf 4	0	0	0	0
	0	0	0	0	pr_inf 5	0	0	0
	0	0	0	0	0	0	0	pr_inf 8

Table 6.6 Estimation Results of En-Route Traffic Information Source Choice Model (MNL)

Lower Level (Traffic Information Source Choice)

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant **1**	-4.930	1.210	-4.07
	2	Constant **2**	-0.917	0.850	-1.08
	3	Constant **3**	-3.181	1.049	-3.03
	4	Constant **4**	-5.394	1.353	-3.99
	5	Constant **5**	-2.337	1.038	-2.25
	6	Constant **6**	-1.161	0.877	1.32
	7	Constant **7**	-1.722	0.843	-2.04
Socioeconomic characteristics	8	Occupation: professional driver **4**	1.070	0.991	1.08
Trip characteristics	9	Travel time (hundred minutes) **1**	0.378	0.282	1.34
	10	Travel time (hundred minutes) **2**	0.208	0.148	1.41
	11	Travel time (hundred minutes) **3**	0.520	0.256	2.03
	12	Travel time (hundred minutes) **4**	0.625	0.264	2.37
	13	Travel time (hundred minutes) **5**	-0.407	0.467	-0.87
	14	Travel time (hundred minutes) **6**	0.488	0.146	3.33
	15	Travel time (hundred minutes) **7**	0.519	0.154	3.38
	16	Had a schedule of activities at destination **1**	0.989	0.806	1.23
	17	Had a schedule of activities at destination **2**	0.475	0.349	1.36
	18	Had a schedule of activities at destination **3**	-0.777	1.119	-0.69
	19	Had a schedule of activities at destination **4**	1.698	0.993	1.71
	20	Had a schedule of activities at destination **5**	-0.516	0.897	0.57
	21	Had a schedule of activities at destination **6**	0.261	0.366	0.71
	22	Had a schedule of activities at destination **7**	0.459	0.404	1.13
Attitudes and	23	Usefulness of each information source **1-7**	0.332	0.108	3.08
Perceptions	24	Never used each information source (Dummy) **1-7**	0.974	0.787	1.23
Pre-trip traffic information characteristics	25	Pre-trip information source was telephone call **1**	4.56	0.836	5.42
	26	Pre-trip information source was radio traffic news **2**	0.899	0.201	4.48
	27	Pre-trip information source was personal communications **4**	5.680	1.122	5.06
	28	Pre-trip information source was calendar of congestion forecast **5**	3.657	0.693	5.28
	29	Pre-trip information source was other **8**	1.739	0.318	5.47

Dependent variable

1	Telephone call	n= 11
2	Radio traffic news	n=274
3	In-vehicle navigator	n= 8
4	Personal communications	n= 14
5	Calendar of congestion forecast	n= 11
6	Highway Radio	n=187
7	Highway Information Terminal	n= 82
8	Other	n= 59

Summary Statistics Number of observations = 646

$L(0) = -1343.3$ $L(\bar{\beta}) = -789.88$

$\rho^2 = 0.412$ $\bar{\rho}^2 = 0.390$

Pre-Trip Traffic Information Characteristics

Drivers who have used a pre-trip information service are more likely to use the same information service as an en-route traffic information source. For example, drivers who have used radio traffic news before the departure are more likely to use radio traffic news during the trip. These independent variables are very significant, because they indicate a sort of adherence to a certain traffic information source. This adherence points to individual's habitual behavior in the choice of traffic information source.

6.4.3 Summary of the En-Route Traffic information Acquisition Models

The nested logit (NL) model can be applied in en-route information acquisition behavior. In the upper level model (acquire or not), drivers' socioeconomic characteristics, such as marital status, gender, age, or income have little significance in general. The only significant socioeconomic characteristic is occupation, however, as mentioned in Section 6.3.1, occupation is closely related with trip characteristics, such as trip purpose or vehicle type. Trip characteristics also do not play important roles in pre-trip traffic information acquisition behavior in general. "Vehicle type," and "Have used the Chuo Expressway as a part of the route" are exceptions, not common. Drivers' attitudes and perceptions are not significant either. "I am always trying to acquire traffic information" and "Service level of traffic information is important in route choice" are also exceptions. The only significant independent variables of the upper level model are pre-trip traffic information characteristics. "Acquired pre-trip traffic information" has very important influence on en-route traffic information acquisition behavior.

In the lower level model (information source choice), socioeconomic characteristics have little significance in general. "Occupation: professional driver" is an exception. Trip characteristics, other than travel time, are not significant either. Long commercial trip makers are more likely to acquire en-route traffic information from major sources (radio traffic news, personal communications, the Highway Radio, and the Highway Information Terminal). Generally speaking, attitudes and perceptions also do not play important roles, however, "Usefulness of each information source" is significant for choosing each information source as a matter of course. The major significant independent variables are pre-trip traffic information characteristics. Drivers who have used a pre-trip information service are more likely to consult the same information service as an en-route traffic information source.

Given the circumstances mentioned above, the major significant independent (explanatory) variables, which can clearly explain en-route traffic information acquisition behavior, are perceived usefulness of en-route traffic information services and pre-trip traffic information characteristics.

6.5 Response to Traffic Information

As mentioned in Section 3.5, we estimated one simultaneous response model (MNL) versus four sequential response models (binary logit) for "change departure time or not," "change entrance or not," "change time spent at rest areas or not," and "change exit or not." (see Figure 3.2, 3.5, and 3.6) The results of the MNL model are shown in Table 6.8 and the results of the binary logit models are shown in Table 6.9, 6.10, 6.11, and 6.12. The MNL model is constructed based on the assumption that drivers will choose only one main response (including "change nothing"). Drivers can respond with two or more responses, however the number of drivers who have responded with two or more is negligibly small. Thus, these drivers are considered to make one major response to traffic information. Therefore the MNL model is applied in this section. Four binary logit models are constructed by following drivers' decision making procedures. The analysis of the estimation of each model are as follows.

6.5.1 Response to Traffic Information Choice Model (MNL)

Table 6.7 presents the specification of response to the traffic information choice model (MNL) and Table 6.8 presents the estimation results of this model in which the dependent variables are the main responses to traffic information.

To show the difference among responses, in the same way as in Section 6.3.2 and 6.4.2, each independent variable is basically applied to all alternatives other than alternative 1 ("changed nothing"), which is the base alternative in this model.

In this model, we investigated possible combinations of socioeconomic characteristics as significant independent variables, however we could not find any significant socioeconomic characteristics. To model the response to traffic information choice, four major groups of independent variables are used: trip characteristics, drivers' attitudes and perceptions of driving behavior, traffic information characteristics, and drivers' expectations about traffic delay.

Table 6.7 Specification of Response Model (MNL)

	Changed Nothing	Changed Departure Time	Changed Time Spent at Rest Areas	Change Route (entrance, exit , or in entire)	Other
Alternative number	1	2	3	4	5
Constant	0	1	0	0	0
	0	0	1	0	0
	0	0	0	1	0
	0	0	0	0	1
Had a schedule of	0	schedule	0	0	0
activities at destination	0	0	schedule	0	0
(schedule)	0	0	0	schedule	0
=1,0 o.w.	0	0	0	0	schedule
Have used another entrance or exit of the	0	alternate	0	0	0
Tomei Expressway	0	0	alternate	0	0
(alternate)	0	0	0	alternate	0
=1,0 o.w.	0	0	0	0	alternate
"I am always trying to acquire traffic information"(Info.seeker)* fitted value =1,2,…,9	Info.seeker	0	0	0	0
Traffic delay in hundred minutes	0	delay	0	0	0
(delay)	0	0	delay	0	0
	0	0	0	delay	0
	0	0	0	0	delay
Expected that traffic delay would be shorter	0	expTshort	0	0	0
as the result of response to traffic information	0	0	expTshort	0	0
(expTshort)	0	0	0	expTshort	0
=1,0 o.w.	0	0	0	0	expTshort
Did not expect that traffic delay would change : changed nothing (exp.dummy) =1,0 o.w.	0	exp.dummy	exp.dummy	exp.dummy	exp.dummy

Table 6.8 Estimation Results of Response Model (MNL)

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant **2**	-2.462	0.896	-2.75
	2	Constant **3**	-3.215	0.924	-3.48
	3	Constant **4**	-2.356	0.898	-2.62
	4	Constant **5**	-3.533	0.955	-3.70
Trip characteristics	5	Had a schedule of activities at destination **2**	0.648	0.402	1.61
	6	Had a schedule of activities at destination **3**	0.898	0.493	1.82
	7	Had a schedule of activities at destination **4**	0.022	0.460	0.05
	8	Had a schedule of activities at destination **5**	0.989	0.570	1.74
	9	Have used another entrance or exit of the Tomei Expressway **2**	0.579	0.459	1.26
	10	Have used another entrance or exit of the Tomei Expressway **3**	0.126	0.630	0.20
	11	Have used another entrance or exit of the Tomei Expressway **4**	1.018	0.463	2.20
	12	Have used another entrance or exit of the Tomei Expressway **5**	0.305	0.709	0.43
Attitudes and Perceptions	13	"I am always trying to acquire traffic information" **1**	-0.367	0.131	-2.80
Traffic information characteristics	14	Traffic delay in hundred minutes **2**	2.109	0.495	4.26
	15	Traffic delay in hundred minutes **3**	2.497	0.532	4.69
	16	Traffic delay in hundred minutes **4**	0.871	0.698	1.24
	17	Traffic delay in hundred minutes **5**	2.055	0.712	2.88
Expectations	18	Expected that traffic delay would be shorter as the result of response **2**	1.564	1.110	1.41
	19	Expected that traffic delay would be shorter as the result of response **3**	0.861	1.242	0.69
	20	Expected that traffic delay would be shorter as the result of response **4**	1.670	1.117	1.49
	21	Expected that traffic delay would be shorter as the result of response **5**	0.257	1.478	0.17
	22	Did not expect that traffic delay would change: changed nothing (Dummy) **2-4**	-4.625	0.366	-12.64

Dependent variable	**1 Changed Nothing**	**n=594**
	2 Changed Departure Time	**n= 51**
	3 Changed Time Spent at Rest Areas	**n= 25**
	4 Changed Route	**n= 41**
	5 Other	**n= 16**

Summary Statistics Number of observations = 727

$L(0) = -1170.1$ $L(\bar{\beta}) = -332.98$

$\rho^2 = 0.715$ $\bar{\rho}^2 = 0.697$

Trip Characteristics

We tried many trip characteristics as possible independent (explanatory) variables, However, only "Had schedule of activities at destination" and "Have used another entrance or exit of the Tomei Expressway" appeared to have a significant effect.

Drivers who have schedules of activities at their destinations are likely to change their departure times, time spent at rest areas, routes (including changing entrances and exits), and make other responses, because they are traveling under restriction of time.

Drivers who have used other entrances or exits on the Tomei Expressway in the past are more likely to respond to traffic information in general. More specifically, they are likely to change their departure times and change routes (including changing entrances and exits). This is easy to understand intuitively.

Attitudes and Perceptions

We also tried many significant drivers' attitudes and perceptions as possible independent (explanatory) variables. However, only "I am always trying to acquire traffic information" appeared to have a significant effect.

Drivers who think "I am always trying to acquire traffic information" are less likely to change nothing. In other words, these drivers are more likely to respond to traffic information. They are considered to be information seekers who tend to respond based on the information they acquired.

Traffic Information Characteristics

Generally speaking, the more traffic delay, the more likely drivers are to respond to traffic information. Drivers who encountered longer traffic delay are more likely to change their departure times, change time spent at rest areas, and make other responses. "Traffic delay" plays an important role in the response to the traffic information choice model.

Expectations

Drivers who have expected "traffic delay will be shorter as the result of response" are likely to change their departure times and change their routes. However expectations of traffic delays are not so significant as mentioned in Section 5.7.

To exclude the bias of those who did not expect that traffic delay would change as the result of response (respondents who changed nothing were asked to skip the question about the expectation of traffic delay, so we assumed that they did not expect traffic delay would change as the result of response), we introduced a dummy variable in the same way as in Section 6.3.2 and 6.4.2. The coefficient of this variable is negative as a matter of course, because these drivers obviously changed nothing.

6.5.2 Response Model: Changed Departure Time (Binary Logit)

Table 6.9 presents the estimation results of this model.

Socioeconomic Characteristics

We tried many drivers' socioeconomic characteristics as possible independent (explanatory) variables. However, only "Occupation: retail sales" appeared to have a significant effect. Drivers whose occupations are in retail sales, are likely to change their departure times, because most make business trips, which have time restrictions.

Table 6.9 Estimation Results of Response Model: Changed Departure Time (Binary Logit)

Dependent variable Changed: 1 n= 57
Not changed: 0 n=670

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant for Change	-4.286	1.101	-3.89
Socioeconomic characteristics	2	Occupation: retail sales	1.660	0.845	1.97
Trip characteristics	3	Trip on Sunday	-0.527	0.324	-1.63
	4	Had a schedule of activity at destination	0.360	0.315	1.14
	5	Trip purpose: recreation (with family)	0.738	0.366	2.02
	6	Trip purpose: commuting	1.488	0.856	1.74
	7	Vehicle type: passenger car	0.855	0.370	2.31
	8	Vehicle type: bus	1.346	0.733	1.84
	9	Have used another entrance or exit of the Tomei Expressway	0.661	0.350	1.89
Attitudes and Perceptions	10	"I like discovering new routes"	-0.123	0.053	-2.31
	11	"I feel frustrated being stuck in traffic	-0.077	0.055	-1.41
	12	"Travel time" is important in route choice	0.082	0.058	1.42
	13	"Departure time of day" is important in route choice	0.132	0.063	2.09
Pre-trip traffic information characteristics	14	Telephone call as pre-trip information source	0.835	0.573	1.46
	15	Radio traffic news as pre-trip information source	0.377	0.341	1.11
	16	Pre-trip traffic information told traffic delay due to accidents	1.244	0.543	2.29
	17	Pre-trip traffic information told traffic delay due to construction	0.402	0.388	1.04
	18	Pre-trip traffic information told traffic delay due to saturation	0.587	0.340	1.73

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -176.21$

$\rho^2 = 0.651$ $\bar{\rho}^2 = 0.612$

Trip Characteristics

Sunday drivers are less likely to change their departure times, because their driving often includes pleasure trips, which have a higher degree of flexibility in arrival time.

Drivers who have schedules of activities at their destinations are likely to change their departure times so as to be on time for these schedules.

Drivers whose trip purposes are recreation with families are likely to change their departure times. They have a high degree of flexibility in arrival time, but also in their entire travel plans. They might change their departure times not for the purpose of being on time but for other reasons, such as a delay when getting ready to go out. (In terms of time restrictions, drivers whose trip purposes are recreation with people other than family members are considered to be different from those with family members. The latter trips include tours with coworkers, or golf tours with business counterparts. These tours are considered parts of business and have time restrictions in Japan.) Commuting drivers are likely to change their departure times under time pressure as a matter of course.

Drivers of passenger cars and buses are likely to change departure. As mentioned above, drivers of passenger cars are assumed to make trips with a higher degree of flexibility in their travel plans than business trips, such as freight transportation. Bus drivers are also likely to change their departure times. Most buses on the inter-city expressways in Japan are considered to be sightseeing buses which have time restrictions in picking up passengers.

Drivers who have used other entrances and exits of the Tomei Expressway in the past, are likely to change their departure times. They are considered flexible in their travel plans.

Attitudes and Perceptions

Drivers who think, "I like discovering new routes," are less likely to change their departure times, because they seem not to plan ahead. Drivers who think, "I feel frustrated being stuck in traffic," are also less likely to change their departure times, because they also appear to lose their presence of mind easily and to travel casually.

Drivers who think, "Travel time is important in route choice," are likely to change their departure times under time pressure. Drivers who think, "Departure time of day is important in route choice," are likely to change their departure times as a matter of course.

Pre-Trip Traffic Information Characteristics

Drivers whose pre-trip traffic information sources are telephone calls and radio traffic news, are more likely to change their departure times responding to traffic information they have acquired.

Drivers who have been informed that traffic delays would occur, are more likely to change their departure times. In the case of traffic delays due to accidents and saturation, drivers are much more likely to change their departure times than in the case of traffic delays due to construction. In general, the back ups due to accidents take a much longer time to pass through in Japan.

Pre-trip traffic information characteristics are comparatively significant.

6.5.3 Response Model : Changed Entrance (Binary Logit)

Table 6.10 presents the estimation results of this model.

Socioeconomic Characteristics

Drivers whose occupations are professional drivers, technical employees, and professional specialties, are likely to change entrances. They are considered to be pro-information based in their occupation attributes.

Very experienced drivers are less likely to change entrances, because they are considered to be older drivers resistant to change.

Trip Characteristics

In the same way as in Section 6.3.1 and 6.5.2, Sunday drivers are less likely to change entrances.

Drivers who have schedules of activities at their destinations, are less likely to change entrances. This result is opposite of our initial expectations. However, it can be explained by a tendency to follow rigid travel plans.

Recreation trip makers have few opportunities to make similar trips, and therefore they are less likely to change entrances. Sales persons should follow their planned sales routes, thus they are less likely to change.

Drivers of passenger cars are more likely to change entrances, because they are considered as having a higher degree of flexibility in their travel plans than drivers of commercial vehicles.

Drivers who have used other entrances and exits of the Tomei Expressway in the past are likely to change entrances as a matter of course. They are considered flexible in their travel plans.

Table 6.10 Estimation Results of Response Model: Changed Entrance (Binary Logit)

Dependent variable Changed: 1 n= 15
Not changed: 0 n=712

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant for Change	-11.509	3.086	-3.73
Socioeconomic characteristics	2	Occupation: professional driver	2.877	1.326	2.17
	3	Occupation: technical employee	1.936	0.935	2.07
	4	Occupation: professional specialty	4.044	1.271	3.18
	5	Drive year	-0.037	0.032	-1.13
Trip characteristics	6	Trip on Sunday	-1.871	0.956	-1.96
	7	Had a schedule of activity at destination	-0.882	0.773	-1.14
	8	Trip purpose: recreation (with family)	-2.325	1.193	-1.95
	9	Trip purpose: business (sales, etc.)	-3.623	1.501	-2.41
	10	Vehicle type: passenger car	4.038	1.449	2.79
	11	Have used another entrance or exit of the Tomei Expressway	1.260	0.744	1.69
Attitudes and Perceptions	12	"I often use another entrance or exit	0.402	0.135	2.97
	13	"I am always trying to acquire traffic information	0.764	0.321	2.38
	14	"I like driving"	-0.312	0.157	-1.99
	15	"Travel time" is important in route choice	-0.295	0.141	-2.10
pre-trip traffic information characteristics	16	Pre-trip traffic information told traffic delay due to accidents	1.857	1.094	2.62
	17	Pre-trip traffic information told traffic delay due to construction	2.095	0.837	2.50
	18	Pre-trip traffic information told traffic delay due to saturation	2.150	0.827	2.60
Previous responses	19	Changed departure time	2.540	0.938	2.71

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -37.15$

$\rho^2 = 0.926$ $\bar{\rho}^2 = 0.889$

Attitudes and Perceptions

Those who think, "I often use another entrance or exit," and, "I am always trying to acquire traffic information," are more likely to change entrances as a matter of course. Those who think, "I like driving," are less likely to change entrances, because they are supposed to think switching routes is troublesome and just want to enjoy driving.

Drivers who think, "Travel time is important in route choice," are also less likely to change entrances. This can be explained by assuming that they really know that switching routes from inter-city expressways to ordinary surface roads does not shorten actual travel time.

Pre-Trip Traffic Information Characteristics

Drivers who have been informed that traffic delays would occur are more likely to change entrances. Pre-trip traffic information characteristics are considered significant.

Previous Responses to Traffic Information

Drivers who have changed their departure times are more likely to change entrances. As mentioned in Section 3.5, in each response step, the factors which influence drivers' behaviors are the same factors that influenced the previous response, plus the previous response itself. In this model, the previous response is "Changed departure time," and this appears to be a significant variable.

6.5.4 Response Model: Changed Time Spent at Rest Areas (Binary Logit)

Table 6.11 presents the estimation results of this model.

Socioeconomic Characteristics

Student drivers are likely to change time spent at rest areas. 65% of their trip purposes was recreation with people other than family members (in this case with their friends, not with coworkers), so that they should have a high degree of flexibility in travel plan.

Trip Characteristics

Sunday drivers are more likely to change time spent at rest areas, because their driving often includes pleasure trips, which have a higher degree of flexibility in their travel plans.

Freight transportation trip makers are more likely to change time spent at rest areas, because they (large sized truck drivers) usually wait at rest areas for food markets or factories to open in the morning due to just-in-time logistic systems in Japan.

Table 6.11 Estimation Results of Model Response: Changed Time Spent at Rest Areas (Binary Logit)

Dependent variable Changed: 1 n= 42
Not changed: 0 n=685

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant for Change	- 4.640	0.594	-7.81
Socioeconomic characteristics	2	Occupation: student	1.632	0.812	2.01
Trip characteristics	3	Trip on Sunday	0.278	0.388	0.72
	4	Had a schedule of activity at destination	0.310	0.373	0.83
	5	Trip purpose: Freight transportation	0.961	0.509	1.89
Attitudes and Perceptions	6	"weather" is important in route choice	0.120	0.071	1.68
Pre-trip traffic information characteristics	7	Traffic news on TV as pre-trip information source	0.811	0.486	1.67
	8	Highway Telephone as pre-trip information source	1.209	0.874	1.38
	9	Pre-trip traffic information told traffic delay due to accidents	1.295	0.574	2.25
Previous response	10	Changed departure time	1.769	0.412	4.30
	11	Changed entrance	1.946	0.645	3.02

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -131.34$

$\rho^2 = 0.739$ $\bar{\rho}^2 = 0.718$

Attitudes and Perceptions

Attitudes and perceptions do not appear very significant. Those who think, "Weather is important in route choice," are more likely to change time spent at rest areas. They are considered to be information seekers and they might try to adjust time at rest areas so as not to be stuck in traffic.

Pre-Trip Traffic Information Characteristics

Drivers whose pre-trip traffic information sources are the Highway Telephone, are likely to change time spent at rest areas responding to the high quality of traffic information.

Drivers who have been informed that traffic delays would occur, are more likely to change time spent at rest areas. Especially in the case of traffic delays due to accidents, drivers are more likely to change time spent at rest areas.

Pre-trip traffic information characteristics are considered to be significant variables

Previous Responses to Traffic Information

Drivers who have changed their departure times, are more likely to change time spent at rest areas. This appears to be very significant. Drivers who have changed entrances are also likely to change time spent at rest areas. Previous responses to traffic information are considered to be significant variables.

6.5.5 Response Model : Changed Exit (Binary Logit)

Table 6.12 presents the estimation results of this model.

Socioeconomic Characteristics

Drivers whose occupations are in retail sales and professional drivers are likely to change exits as mentioned in Section 6.5.2 and 6.5.3. Most of these drivers make business trips and tend to respond to traffic information under time pressure.

Trip Characteristics

Sunday drivers are more likely to change exits. This is assumed as follows. Sunday trips include more east-bound trips than trips on Wednesday. Most of the east-bound trips have destinations in the Tokyo metropolitan area and drivers use exits of the Metropolitan Expressways. The distance between exits on the Metropolitan Expressways is very short (1-3 km) compared with that (10-15 km) of inter-city expressways. Users of the Metropolitan Expressways are considered to change exits more frequently than inter-city expressway users. Therefore, Sunday drivers, who are likely to use exits on the Metropolitan Expressways and to use entrances on the Tomei Expressway, are more likely to change exits, while they are less likely to change entrances.

Drivers who have used other entrances or exits of the Tomei Expressway in the past are more likely to change exits as a matter of course.

Table 6.12 Estimation Results of Response Model: Changed Exit (Binary Logit)

Dependent variable Changed: 1 n= 22
Not changed: 0 n=705

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
	1	Constant for Change	-6.359	0.821	-7.74
Socioeconomic characteristics	2	Occupation: retail sales	2.863	0.891	3.21
	3	Occupation : professional driver	0.923	0.745	1.24
Trip characteristics	4	Trip on Sunday	1.693	0.655	2.58
	10	Have used another entrance or exit of the Tomei Expressway	1.235	0.509	2.42
Attitudes and Perceptions	11	" I often use another entrance or exit"	0.137	0.084	1.63
En-Rote Traffic information characteristics	13	En-route traffic information told traffic delay due to accident	0.632	0.661	0.96
	14	En-route traffic information told traffic delay due to construction	0.667	0.587	1.13
Previous response	17	Changed departure time	0.200	0.689	0.29
	18	Changed entrance	2.407	0.736	3.27
	20	Changed time spent at rest areas	0.824	0.726	1.13

Summary Statistics Number of observations = 727

$L(0) = -503.92$ $L(\bar{\beta}) = -76.159$

$\rho^2 = 0.849$ $\bar{\rho}^2 = 0.827$

Attitudes and Perceptions

Those who think, "I often use another entrance or exit," and ,"I am always trying to acquire traffic information," are more likely to change exits as a matter of course.

En-Route Traffic Information Characteristics

Drivers, who have been informed that traffic delays due to accidents or construction would occur, are more likely to change exits in order to avoid these traffic delays.

En-route traffic information characteristics are considered to be significant variables in this model.

Previous Responses to Traffic Information

Drivers who have responded to traffic information are more likely to change entrances. More specifically, drivers who have changed entrances are more likely to change exits.

Previous responses to traffic information are also considered to be significant variables in this model.

6.5.6 Summary of the Response to Traffic Information Models

In the MNL model, drivers' socioeconomic characteristics, such as marital status, gender, age, or income have little significance in general. The only significant socioeconomic characteristic is occupation. As mentioned in Section 6.3.1, occupation is closely related with trip characteristics, such as trip purpose or vehicle type. Attitudes and perceptions are not significant either except for "I am always trying to acquire traffic information." Trip characteristics also do not play important roles in response to the traffic information choice model (MNL) in general. In terms of traffic information characteristics, "Traffic delay" is the only significant factor in this model. Expectations of traffic delays are not significant.

In the binary logit model (changed departure time), socioeconomic characteristics have little significance in general. "Occupation: retail sales" is an exception. Trip characteristics are not significant either. Attitudes and perceptions are also insignificant and inconsistent. The only significant and stable variables are pre-trip traffic information characteristics.

In the binary logit model (changed entrance), socioeconomic characteristics have little significance in general. "Occupation: professional driver, technical employee, and professional specialty" are exceptions. Trip characteristics are not significant either. Attitudes and perceptions are also insignificant and inconsistent. The only significant and stable variables are pre-trip traffic information characteristics and previous responses to traffic information. "Changed departure time" has a significant influence on this model.

In the binary logit model (changed time spent at rest areas), socioeconomic characteristics have little significance in general. "Occupation: student" is an exception. Trip characteristics are not significant either. "Trip purpose: freight transportation" is an exception. Attitudes and perceptions are also insignificant and inconsistent. The only significant and stable variables are pre-trip traffic information characteristics and previous responses to traffic information. "Changed departure time" and "Changed entrance" have a significant influence on this model.

In the binary logit model (changed exit), socioeconomic characteristics have little significance in general. "Occupation: retail sales and professional driver" is an exception. Trip characteristics other than "Sunday trip" are not significant either. Attitudes and perceptions are also insignificant and inconsistent. The only significant and stable variables are en-route traffic information characteristics and previous responses to traffic information. "Changed entrance" has a significant influence on this model.

Given the circumstances mentioned above, the only significant independent variables which can clearly explain response to traffic information behavior, are "Traffic information characteristics" and "Previous responses to traffic information."

As mentioned in Section 6.5, we consider that the number of drivers who give one or more responses is small, so as to apply an MNL model. However, in binary logit models, previous responses have a significant positive influence (e.g. drivers who have changed their departure times are more likely to change time spent at rest areas, or drivers who have changed entrances are more likely to change exits). This can be explained as follows:

Only 18% of drivers responded to traffic information. The number of drivers who have chosen each alternative is very small, so that even though the number of drivers who have chosen one or more alternative is small, the percentage of such drivers in each alternative is not so small. Thus, drivers who have responded to traffic information are likely to respond repeatedly.

In conclusion, in the MNL model, only "Traffic information characteristics." has a significant effect on the drivers' decision making. In the binary logit models, only "Traffic information characteristics" and "Previous responses to traffic information" have a significant effect on drivers' responses.

6.6 Summery of the Model Estimation Results

Drivers who have acquired traffic information before the departure are most likely to acquire information during the trip. These drivers also tend to consult the same traffic information sources before and during the trip. Users of the Tomei expressway have a choice among multiple pre-trip and en-route traffic information services. The modeling results have shown that the most important factor affecting the choice among information sources is their perceived usefulness.

Furthermore, drivers' responses to the acquired traffic information are represented by the following sequence. The first response is the choice of departure time. The second is the choice of an entrance to the inter-city expressway. The third is the choice of time spent at rest areas, and finally the fourth is the choice of an exit. Each of these decisions is strongly affected by the content of the acquired traffic information as well as their previous decisions (e.g., drivers who have changed entrances are more likely to change exits).

Chapter 7

Route Choice (Stated Preference) Model

In this Chapter, stated preference (SP) data from the survey are used to assess the drivers' evaluation of old, present, and future ATIS on the Tomei Expressway. As mentioned in Chapter 1, drivers on inter-city expressways in Japan have few possibilities for choosing alternate routes to minimize traffic delays.

We are interested in the trade-off between quality of ATIS and tolls, however we cannot infer it from the RP data. Therefore we generated hypothetical route choice situations, which enabled us to estimate route choice models and analyze the trade-off among various attributes, such as travel time, travel cost (mainly for fuel and the toll), traffic delay, and quality of information services. The value of traffic information was then calculated using the coefficients of travel cost and en-route information services in the same way that value of time is calculated.

7.1 Analysis and Interpretation of the Estimation Results

As mentioned in Section 4.3, the SP part of our survey consists of two types of route choice questions. One is customized and the other is un-customized. From the estimation results of customized SP data, we cannot avoid the conclusion that customized route choice questions did not work well (this is a point that will be considered later). Therefore, estimation results in this chapter are based on un-customized data. Nevertheless, 517 respondents (71% of the total respondents) completed 6 pairs of un-customized route choice questions. Thus, the total number of observations is 3,102, which is enough for estimations. Table 7.1 shows the Estimation results of the route choice model.

In this model, the dependent variable is whether to choose route A or not. Since route A is shown on the pairwise comparison question as the left-hand-side route, the dependent variable has no label or name, such as bus, rail, or car in a mode choice model. Therefore, in this route choice model, we do not have an alternative specific constant.

All the attributes included in the SP experiment have significant effects on the respondents' route choice. Drivers are more likely to choose a route that has a higher quality of information services. Furthermore, a route becomes less attractive as its traffic delay, travel time or travel cost increases.

Table 7.1 Estimation Results of Un-Customized Route Choice Model (Binary Logit)

Dependent variable **Choose route A: 1 n=1,909**

Choose route B: 0 n=1,193

	Variable Number	Variable name	Estimated Coefficient	Standard Error	t-statistics
Traffic information service level	1	***Future*** Tomei Expressway	1.816	0.387	4.69
	2	***Present*** Tomei Expressway	1.205	0.286	4.21
	3	***Old*** Tomei Expressway	0.559	0.162	3.45
Traffic delay	4	maximum traffic delay in hundred minutes	-9.690	2.332	-4.16
Travel time	5	travel time under usual traffic conditions in hundred minutes	-9.081	4.874	-1.86
Travel cost	6	travel cost in thousand yen	-3.463	1.465	-2.36

Summary Statistics Number of observations = 3,102

$L(0) = -2{,}150.1$ $L(\bar{\beta}) = -1{,}794.5$

$\rho^2 = 0.165$ $\bar{\rho}^2 = 0.163$

7.2 Forecasting Willingness to Pay for the ATIS

Based on the estimation results of route choice model (Table 7.1), the value of traffic information service, maximum traffic delay, and travel time are calculated as follows (In terms of traffic information services, level "*none*" is set as a base case, in other words the utility of traffic information service level "*none*" is set zero.):

1) traffic information services on the ***future*** Tomei Expressway	524.2 yen
2) traffic information services on the ***present*** Tomei Expressway	347.9 yen
3) traffic information services on the ***old*** Tomei Expressway	161.4 yen
4) maximum traffic delay,	28.0 yen/minute
5) travel time	26.2 yen/minute

Concerning the value of travel time, 26.2 yen / minute is rather small compared with 38.2 yen / minute for passenger cars as of 1982[1]. Hato et al. (1995) reported the value of travel time based on SP data of route choice model between the Metropolitan Expressway and an ordinary surface road. In case of commuting trips, the value of travel time was found to be 33.0 yen / minute for drivers without any experience to drive the routes, 50.6 yen / minute for drivers with experience and 58.6 yen / minute for driver with much experience. The corresponding results for shopping trips were 50.6 yen / minutes for drivers without any experience, 31.7 yen / minute for drivers with experience and 58.6 yen / minute for driver with much experience. These figures are higher than ours but approximately similar.

The value of maximum delay (28.0 yen / minute) is a little larger than that of travel time (26.2 yen / minute). Because the former includes uncertainty in that drivers did not know how long the actual traffic delay would be, and drivers evaluated this uncertainty more significantly than usual travel time.

Since, one of hypothetical conditions of route choice model is that trip length on the Tomei expressway is assumed to be 100 km (toll rate is 2,450 yen), the value of traffic information services on the *future* Tomei Expressway, *present* Tomei Expressway, and *old* Tomei Expressway, are 21%, 14%, and 7% of the toll respectively. As mentioned in

[1] Ministry of Construction, (1986), Doro-Gyosei 61 (Road Administration 1986), Tokyo, Zenkoku Doro Riyosha Kaigi (Chamber of All Japan Road Users). The value of time was calculated based on labor cost.

Chapter 4 (see Table 4.3 and 4.4), traffic information services of the *old* Tomei Expressway provided the length of the back up and its cause using Variable Message Signs. The traffic information services of the *present* Tomei Expressway provide the services of the *old* Tomei expressway plus travel time to main exits and time to pass through the confronting congestion using Variable Message Signs and the Highway Radio. The traffic information services of the *future* Tomei Expressway will provide the services of the *present* Tomei Expressway plus traffic information about alternate ordinary surface roads using Variable Message Signs and the Highway Radio. Thus, drivers' valuation of traffic information is the following:

1) Information about the length of the back up and its cause is worth 7% of the toll.

2) Information about travel time to main exits and time to pass through the confronting congestion is worth 7% of the toll.

3) Information about alternate ordinary surface roads is worth 7% of the toll.

In march 1992 at the Ashigara Service Area and the Hamanako Service Area on the Tomei Expressway, the JHPC executed a survey[2] in which drivers were asked "How much are you willing to pay as a telephone charge for one-minute information provided by the Highway Telephone?" According to the results of the survey, the average charge drivers were willing to pay for the Highway Telephone was 44 yen. In Japan, a city call charge is 10 yen for 90 seconds. Therefore drivers perceived that the information from the Highway Telephone was worth 34 yen. Compared with this figure, 347.9 yen (value of traffic information services on the *present* Tomei Expressway) is 10 times the value of the information from the Highway Telephone.

In fiscal 1992, the JHPC spent 211,405 million yen (5.6% of the total expenditure: 37,963 billion yen) for maintenance and improvement of 5,404.4 km of inter-city expressway network in Japan. 16.5% of this maintenance and improvement cost was invested in traffic information services. This investment amounts to 34,882 million yen. On the other hand, toll revenue was 14,290 billion yen in fiscal 1992. Based on the estimation results, traffic information services on the *old* Tomei Expressway are worth

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[2] Express Highway Research Foundation of Japan, (1993), Odawara-chiku Kotsu-kansei Shisutemu Kento (Study for Traffic Control Systems in Odawara Area), Tokyo.

7% of the toll and those on the *present* Tomei Expressway are worth 14% of the toll. In nationwide inter-city expressway network, average service level of traffic information systems is considered to be nearly equal to that of the *old* Tomei Expressway. Therefore, the total benefit of traffic information services is supposed to be at least 7% of the total toll, and this amounts to 100,030 million yen. Thus, annual benefit of traffic information services on inter-city expressways (100,300 million yen) surpasses the annual investment in traffic information services (34,822 million yen). Investing in traffic information services has a cost-benefit ratio of about 1 : 3.

We would like to focus attention on the Tomei Expressway. In the past years, the JHPC has invested 10,304 million yen in improving traffic information services on the Tomei Expressway (252 km section: between Tokyo and Mikkabi) from the *old* level to the *present* level. On the other hand, the total toll revenue of the Tomei Expressway (252 km section) was 211,925 million yen in fiscal 1992. Therefore, the total investment in traffic information services in the past seven years is equivalent to only 5% of the total toll revenue of single year. This shows that the benefits of the ATIS improvement significantly exceeded its costs.

7.3 Influence of the RP Characteristics on the SP Choice

In this section we investigate the influence of socioeconomic characteristics and trip characteristics on the SP responses.

Table 7.2 presents the value of traffic information services classified according to drivers' incomes. These values are calculated based on the estimation results of route choice models applied for each respondents' group, which are segmented by drivers' income. The higher drivers' incomes are, the more highly they evaluate traffic information services. In total, a proportion of value of traffic information services of the *future* Tomei Expressway, the *present* Tomei Expressway, and the *old* Tomei Expressway is 3 : 2 : 1. However, in the category of drivers whose incomes are 10,000,000 yen or more, the proportion is 4 : 2 : 1. High income drivers highly evaluate the *future* level of traffic information services which includes information about alternate surface roads.

The value of traffic information services classified by trip purpose is shown in Table 7.3. In the same way as above, these values are calculated based on the estimation results of route choice models applied for each respondents' group, which are segmented by their trip purpose. Drivers whose purposes were freight transportation highly valued en-route traffic information services because travel costs for the freight transportation trips are larger than those for other trips. Drivers whose trip purposes were visiting relatives valued low in general. Drivers whose trip purposes were recreation (with other than family) valued more highly than those whose trip purposes were recreation (with family) This can be explained by the assumption that the latter includes tours with coworkers, or golf tours with business counterparts. These tours are considered to be parts of business and thus price inelastic.

In conclusion, high income drivers' highly valued traffic information services. Drivers whose trip purposes were freight transportation and business also highly valued traffic information services.

7.4 Summary of the Route Choice (SP) Model

1) All the attributes included in the SP experiment have significant effects on the respondents' route choice. Drivers are more likely to choose a route that has a higher quality of information services. Furthermore, a route becomes less attractive as its traffic delay, travel time or travel cost increases.

2) Current en-route traffic information services on the Tomei Expressway are valued by the drivers to be worth 14% of the toll. This finding implies that the benefits of the existing ATIS significantly exceeds costs.

10) High income drivers highly value en-route traffic information services. Drivers making price inelastic trips (such as freight transportation or business trips) also highly value information services.

Table 7.2 Value of Traffic Information Services (Classified by Drivers' Income)

Monetary Value	less than 6,000,000 yen	6,000,000 - 9,999,999 yen	10,000,000 yen or more	Total
1) Traffic Information Services of the ***Future*** Tomei Expressway (yen)	404.3 (3.38)	1,530.4 (3.09)	2,926.9 (4.32)	524.2 (3.25)
2) Traffic Information Services of the ***Present*** Tomei Expressway (yen)	269.1 (2.25)	1,065.6 (2.15)	1,366.2 (2.02)	347.9 (2.16)
3) Traffic Information Services of the ***Old*** Tomei Expressway (yen)	119.5 (1.00)	494.7 (1.00)	677.9 (1.00)	161.4 (1.00)
4) Maximum Traffic Delay (yen / minute)	21.2	72.9	172.5	28.0
5) Travel Time (yen / minute)	27.7	8.9	19.9	26.2

Table 7.3 Value of Traffic Information Services (Classified by Trip Purpose)

Attributes	recreation (with family)	recreation (with other than family)	freight trans-portation	business (sales, etc.)	private business	visiting relatives
1) Traffic Information Services of the ***Future*** Tomei Expressway (yen)	507.6	656.6	810.7	414.6	502.3	360.2
2) Traffic Information Services of the ***Present*** Tomei Expressway (yen)	344.8	413.3	683.5	292.8	90.3	256.3
3) Traffic Information Services of the ***Old*** Tomei Expressway (yen)	194.6	145.3	305.3	106.1	144.7	149.2
4) Maximum Traffic Delay (yen / minute)	27.1	40.3	36.1	25.4	23.1	18.8
5) Travel Time (yen / minute)	26.1	18.0	20,9	32.5	35.5	29.8

Chapter 8

Conclusions

8.1 Contributions

The major contributions of our work are in the following areas:

Framework for ATIS Analysis Proposition in Japan

A general framework was formulated for drivers' behaviors, which are acquisition of pre-trip and en-route traffic information and response to traffic information. Drivers' socioeconomic characteristics, trip characteristics, drivers' personality characteristics, and traffic information characteristics are the principal factors affecting drivers' behaviors.

Model Formulation

The modeling framework was developed for analysis of pre-trip and en-route traffic information acquisition and response to traffic information. We adopted nested logit (NL) models for pre-trip and en-route traffic information acquisition models and confirmed statistically that NL models are acceptable. One of the unique features of these models is the choice among alternative available sources of traffic information.

Data Collection

We developed a data collection methodology to collect detailed information about usage, attitudes, perceptions, and travel responses for alternative and competing traffic information sources.

Evaluation of the results

Through the estimation of parameters of behavioral models and descriptive statistics of the survey, this case study provided insights into acquisition of pre-trip and en-route traffic information, and the influence of traffic information on drivers' responses.

Assessment of the drivers' evaluation of the ATIS

Through the development and analysis of an SP experiment, we were able to evaluate the quality of information services on inter-city expressways. More specifically, the following traffic information service levels were evaluated:

1) Future Tomei Expressway: traffic information regarding *the length of the back up, travel time, and information about alternate ordinary roads* is provided to drivers

2) Present Tomei Expressway: traffic information regarding *the length of the back up and travel time* is provided to drivers

3) Old Tomei Expressway: traffic information regarding *the length of the back up*s is provided to drivers

Uniqueness

As mentioned above, the most important point of this study is that the survey questioned the users of the ATIS which has been in actual operation. Users of inter-city expressways have used the ATIS for more than 20 years, so they have sufficient familiarity and knowledge about them. Therefore these drivers have a rich choice set of pre-trip and en-route traffic information sources.

Furthermore, this research focuses on the inter-city expressway, which does not have an alternate expressway, and investigates how the users of the ATIS on the inter-city expressway evaluate and respond to the ATIS, whereas most previous research has focused on commuting trips or trips on urban expressways where drivers have alternate routes to switch to.

8.2 Major Findings

The major findings of our study are given below:

Estimation Results of the Behavioral Models

1) Drivers' socioeconomic characteristics do not have significant effect on inter-city travelers' behaviors.

2) In general, trip characteristics also do not play important roles in the behavioral models.

3) Generally, drivers' perceptions are not significant either, however," Usefulness of each information source" is a significant factor for choosing among information sources.

4) "Acquired pre-trip traffic information" has a very important positive influence on en-route traffic information acquisition behavior.

5) "Pre-trip traffic information source choice" significantly affects the en-route traffic information source choice. In other words, drivers who have used a specific information service before the departure are more likely to consult the same information service during the trip.

6) In the response to traffic information models, traffic information characteristics are significant. Specifically, "Traffic delay" has significantly positive effects on responding to traffic information.

7) Drivers' responses to the acquired traffic information are represented by the following sequence. The first response is the choice of departure time. The second is the choice of an entrance to the inter-city expressway. The third is the choice of time spent at rest areas, and finally the fourth is the choice of an exit. Each of these decisions is strongly affected by the content of the acquired traffic information as well as drivers' previous decisions (e.g., drivers who have changed entrances are more likely to change exits).

The model estimation results indicate that drivers can be divided into two groups: information seekers and non-seekers. Information seekers always try to acquire traffic information regardless of traffic conditions and trip characteristics. This inherent tendency to acquire information is indicated by drivers' personality characteristics, such as "Weather is important in route choice" or "I am always trying to acquire traffic information."

Drivers tend to consult the same information sources both pre-trip and en-route. This implies the presence of the inherent or habitual tendency to choose particular information sources.

The key factors affecting drivers' responses are the acquisition of traffic information and content of the acquired information. Therefore, information seekers are assumed to be likely to respond to traffic information that has announced significant traffic delay. These drivers are assumed to have an inherent propensity to respond, even though they do not have a firm conviction that traffic delay or the length of the back up will be shorter as the result of their responses.

8) Concerning drivers' who responded to traffic information, 72% of them felt that traffic information alleviated frustration, however only 55% of them felt that their own

responses alleviated frustration. This shows that simply receiving traffic information has a greater effect on alleviating drivers' frustration than changing travel plans. Therefore the major effect of traffic information is considered to be psychological; it alleviates drivers' anxiety and frustration.

Assessment of the Drivers' Valuation of the ATIS

9) From the results of the SP experiment, drivers' valuation of traffic information services is the following:

- Information about the length of the back up and its cause is worth 7% of the toll.
- Information about travel time to main exits and time to pass through the confronting congestion is worth 7% of the toll.
- Information about alternate ordinary surface roads is worth 7% of the toll.
- Current traffic information services on the Tomei Expressway are worth 14 % of the toll.
- Therefore the benefits of the ATIS improvement significantly exceed its costs.

10) High income drivers highly value en-route traffic information services. Drivers making price inelastic trips (such as freight transportation or business trips) also highly value information services.

8.3 Future Work

As mentioned in Section 5.4.1, the percentage of the drivers who have acquired traffic information is extremely high compared with the previous interview survey. We collected data from a mail back survey and prepared pre-paid toll cards valid for 1,000 yen in order to raise the response rate. However this might have caused a pro-information bias. In any case, it may be safely assumed that our sample group was composed of people who showed an interest in our survey. Therefore, the sample itself has a bias in that it is made up of people sharing a higher rate of interest in traffic information than the general public. Thus, we cannot apply the results of our survey directly to an aggregate analysis such as a nationwide demand forecast for the ATIS in

Japan. The use of sampling techniques such as stratified sampling is one way to solve this problem.

Moreover, it took a long time to answer completely the entire questionnaire which was too long and too varied. Thus, this might cause respondents' confusion of pre-trip behaviors with en-route behaviors.

Thanks to the Traffic Management Systems on the Tomei Expressway, data concerning actual traffic conditions and content of the traffic information that was announced on the two days of our survey are available. Using these data, we can simulate the actual traffic conditions encountered by each respondent and identify the actual traffic information content provided to each respondent. Then, we can compare the actual traffic conditions and the actual content of traffic information with the reported drivers' responses in order to analyze their behaviors more accurately and precisely.

We also conducted a stated preference (SP) survey using two types of questions: customized questions and un-customized ones. In this study we focused on modeling un-customized data set. Future research will involve the analysis of the customized data set.

One way to improve the quality of SP data would be to use portable personal computer terminals at interview sites. Respondents would be requested simply to input their actual data, after which the attribute levels could be automatically calculated and displayed on the screens of the terminals. Regarding the attributes of SP experiments and improvement of the quality of the estimation results, computer aided surveys provide:

1) an easier, faster, and less tiresome methodology for collecting data with an automatic questionnaire branching function; and

2) an automatic data creation system which can avoid tabulation errors caused by transferring responses from the paper survey to a statistical package.

As mentioned earlier (Section 2.3.5), the installation of in-vehicle car navigators has increased in Japan, and the number of cars equipped with these navigators is continuing to grow. Since this April, dynamic traffic information service for in-vehicle navigators and personal computers have been in operation through telephone lines. It will be useful to investigate further drivers' usage of this latest service and to learn their evaluation of this system.

Appendix   Questionnaire and Descriptive Statistics of the Survey

This questionnaire is designed by ***the Tokyo Institute of Technology and the Center for Transportation Studies at MIT***. Our aim is to obtain a customer evaluation of Traveler Information Systems. By completing this questionnaire, you will help us to provide useful, reliable, and driver-friendly traffic information on expressways in the Tokyo area.

Thank you in advance for your cooperation.

This questionnaire consists of part A, B, C, D, and E.
The following questions concern <u>the trip you made using the Tomei Expressway on which we distributed this questionnaire to you</u>.

A. Trip Characteristics

1. Was your trip on the way to your destination or on the return?
   (242)❑ on the way (481)❑ on the return (4) N.A.
2. Where did your trip begin (**origin**) and end (**destination**)?
   origin _____ prefecture _____ ward / city / town / village *(circle one)*
   destination _____ prefecture _____ ward / city / town / village *(circle one)*

3. Please answer the questions about your departure and arrival time.
a) What was your actual departure time and arrival time of your trip?
   actual departure time ____ : ____ AM / PM *(circle one)* (10) N.A.
   actual arrival time ____ : ____ AM / PM *(circle one)* (18) N.A.
b) Before you received any traffic information, what time did you plan to start your trip and arrive at your destination?
   planed departure time ____ : ____ AM / PM *(circle one)* (37) N.A.
   expected arrival time ____ : ____ AM / PM *(circle one)* (36) N.A.

4. Did you have to arrive at your destination at a certain time, such as for a meeting, delivery, or concert?
(501)❑ no
(222)❑ yes ➪ How much **late** could you arrive at your destination? _____ minutes
$n=200$ $\mu=30.25$ $\sigma=70.16$
➪ How much **earlier** did you want to arrive before the time limit? _____ minutes
$n=215$ $\mu=47.20$ $\sigma=42.18$
➪ Were you on time? (25)❑ no (196)❑ yes (1) N.A.

5. Please check both **entrance** and **exit** interchanges.
❑ north of the Metropolitan Expressway *(please specify)*______ expressway ______ interchange

❑ Metropolitan-expressway	❑ Tokyo (Youga)	❑ Tomei-Kawasaki	❑ Yokohama
	❑ Atsugi	❑ Hadano-Nakai	❑ Ooi-Matsuda
❑ Gotemba	❑ Susono	❑ Numazu	❑ Fuji
❑ Shimizu	❑ Shizuoka	❑ Yaizu	❑ Yoshida
❑ Sagara-Makinohara	❑ Kikugawa	❑ Kakegawa	❑ Fukuroi
❑ Hamamatsu	❑ Hamamatsu-Nishi	❑ Mikkabi	❑ Toyokawa

❑ West of Toyokawa *(please specify)*______ expressway ______ interchange

6. How long did it take you to drive **on the Tomei Expressway** (excluding time spent at rest areas)? ___ hour(s) ___ minutes

n=709 μ=119.82 σ=116.91

7. Did you experience **traffic delay** on the Tomei Expressway?

(312) ❑ Yes (404) ❑ no ⇨ *(skip to question* 10*)* (11) N.A.

8. How long was the **traffic delay** on the Tomei Expressway?

___ hour(s) ____ minutes, the length of the back up: ___ km

n=307 μ=38.06 σ=38.00 n=283 μ=8.55 σ=11.97

9. What was the **main cause** of the traffic delay? (29) N.A.

(52) ❑ congestion due to heavy traffic volume
(154) ❑ road construction work
(128) ❑ traffic accidents
(1) ❑ weather conditions, such as snow, storm, *etc.*
(8) ❑ other *(please specify)*________________

10. How long did it take you to drive **from your origin to the entrance interchange** and **from the exit interchange to your destination**?

from your origin to the entrance interchange: ___ hour(s) ___ minutes n=691 μ=44.41 σ=58.82
from the exit interchange to your destination: ___ hour(s) ___ minutes n=673 μ=40.50 σ=46.28

11. Did you make any stops at rest areas?

(162) ❑ no ⇨ (*skip to question* 14)
(565) ❑ yes ⇨ Which rest area(s) did you stop

(29) ❑ Kouhoku	(263) ❑ Ebina	(74) ❑ Nakai	(61) ❑ Ayusawa
(179) ❑ Ashigara	(10) ❑ Komakado	(10) ❑ Ashitaka	(27) ❑ Fujigawa
(6) ❑ Yui	(9) ❑ Nihondaira	(8) ❑ Nihonzaka	(25) ❑ Makinohara
(4) ❑ Ogasa	(3) ❑ Iwatabara	(3) ❑ Mikatagahara	(29) ❑ Hamanako

(23) ❑ other *(please specify)*___________ ___

12. How many stops did you make? ___ stop(s) n=487 μ=1.33 σ=0.85

13. How much time did you spend at rest areas in total? ___ hour(s) ____ minutes

n=484 μ=38.01 σ=67.38 (3) N.A.

14. What **type of vehicle** did you drive? (19) N.A.

(443) ❑ passenger car	(31) ❑ large sized truck	(41) ❑ regular truck	(41) ❑ delivery van
(100) ❑ station wagon	(22) ❑ bus	(8) ❑ microbus	(7) ❑ light vehicle
(3) ❑ motor bike	(12) ❑ other *(please specify)*________		

15. What type of equipment do you have in your vehicle? (19) N.A.

(74) ❑ car telephone
(36) ❑ personal radio communications (Citizens' Band)
(25) ❑ in-vehicle navigator
(102) ❑ other *(please specify)*________.

16. Including yourself, how many people were in your vehicle? ___ people n=676 μ=2.30 σ=1.41

17. What was the **purpose** of your trip? (20) N.A.

(140) ❑ recreation (with family) (163) ❑ recreation (with others) (79) ❑ freight transportatio
(140) ❑ business (sales, *etc.*) (10) ❑ commuting (20) ❑ shopping
(24) ❑ private business (33) ❑ visiting relatives
(98) ❑ other *(please specify)*________

18. What is the travel cost (mainly for fuel and toll) for the trip you made on the expressway?

_____ yen_ n=677 μ=8,729.61 σ=8,072.691

19. How **often** do you make a trip for the same purpose, with the same origin and destination as the trip you made on the Tomei Expressway? (18) N.A.

(16) ❑ approximately every day (36) ❑ 2-6 times a week
(44) ❑ approximately once a week (73) ❑ 2-3 times a month
(66) ❑ approximately once a month (176) ❑ 1-11 times a year
(179) ❑ a few times in the past (119) ❑ this is the first time

20. How much time does it take you to drive the route using the Tomei Expressway from your origin to destination under the following traffic conditions?

➪ under optimal traffic conditions (There is no congestion and you can drive smoothly)
___ hour(s) ____ minutes n=700 μ=154.55 σ=129.42
➪ under usual traffic conditions ___ hour(s) ____ minutes, the length of the back up: ___ km
n=646 μ=192.34 σ=145.74 n=593 μ=9.10 σ=36.35
➪ under worst traffic conditions ___ hour(s) ____ minutes, the length of the back up: ___ km
n=646 μ=264.07 σ=176.44 n=592 μ=20.41 σ=21.71

21. Which of the following describes your **alternate route(s)**? (43) N.A.
(Please check all that apply)

(323) ❑ I have not used any alternate routes. ➪ *(skip to next part* B*)*
(140) ❑ ordinary roads for the entire route
(82) ❑ the Chuo Expressway as a part of the route
➪ What is the exit interchange on the Chuo Expressway? ________ interchange
(119) ❑ the Tomei Expressway, but using another entrance or exit interchange(s)
➪ What are the entrance and exit interchanges?
entrance ________ interchange, exit ________ interchange
(68) ❑ the Tomei Expressway, but using the another entrance or exit interchange(s) on the Metropolitan Expressway
(36) ❑ other *(please specify)*________

22. In question 19, for what percentage of the trips mentioned do you use **alternate route**(s)?

___% n=352 μ=30.78 σ=24.19 (52) N.A.

23. How much time does it take you to drive the route using **your best alternate route** from your origin to destination under following traffic conditions?

➪ under optimal traffic conditions (There is no congestion and you can drive smoothly)
___ hour(s) ____ minutes n=359 μ=173.01 σ=116.53
➪ under usual traffic conditions ___ hour(s) ____ minutes, the length of the back up: ___ km
n=340 μ=208.38 σ=122.68 n=291 μ=6.65 σ=7.25
➪ under worst traffic conditions ___ hour(s) ____ minutes, the length of the back up: ___ km
n=326 μ=281.81 σ=159.67 n=280 μ=19.48 σ=19.47

24. Assuming typical traffic conditions what is the travel cost of **your best alternate route**?

________ yen
n=331 μ=6,856.40 σ=9,038.93

B. Traffic Information Services on the Tomei Expressway

The following questions concern your knowledge and usage of traffic information before your departure and during your trip.

Before your departure

1. From the following traditional traffic information sources, which one did you use to acquire information about the trip **before your departure?**
(Please check all that apply)
- (28) ❑ a telephone call to the Japan Road Traffic Information Center
- (7) ❑ a telephone call to the Japan Highway Public Corporation
- (475) ❑ traffic news from radio broadcasts
- (59) ❑ traffic news on TV
- (16) ❑ teletext traffic news on TV
- (12) ❑ personal radio communications (Citizens' Band)
- (25) ❑ traffic congestion forecasting calendar in newspapers , magazines, and brochures
- (164) ❑ road maps

Highway Telephone is a 24 hour auto-answering telephone service that provides up-to-the-minute traffic information about the Tomei Expressway

2. Are you familiar with the Highway Telephone? (25) N.A.
(335) ❑ yes
(367) ❑ no ➪ *(skip to question 4)*

3. Did you use the Highway Telephone just before your departure? (0) N.A.
(11) ❑ yes ➪ When did you call Highway Telephone? ____ : ____ AM / PM *(circle one)*
➪ Which station did you call? (1) N.A.
(3) ❑ Tokyo (4) ❑ Kawasaki (2) ❑ Yokohama ❑ Gotemba
(1) ❑ Fuji ❑ Shizuoka ❑ Hamamatsu
(324) ❑ no ➪ Have you ever used it? (230) ❑ no ➪ *(skip to question 4)*
(94) ❑ yes ➪ Why didn't you use it? (5) N.A.
(Please check all that apply)
- (14) ❑ I did not have any time to spare.
- (38) ❑ I had enough traffic information already.
- (4) ❑ Highway Telephone is not so useful.
- (17) ❑ It is bothersome.
- (25) ❑ other *(please specify)*____________

4. If you consulted any other traffic information source before your departure, please specify.
other traffic information source: __________________ (132)

During your trip

5. From the following traditional traffic information sources, which did you use to acquire information about the trip **during your trip?**
(Please check all that apply)

(10) ❑ a telephone call to the Japan Road Traffic Information Center
(2) ❑ a telephone call to the Japan Highway Public Corporation
(528) ❑ traffic news from radio broadcasts
(8) ❑ in -vehicle car navigator
(14) ❑ personal radio communications (Citizens' Band)
(15) ❑ traffic congestion forecasting calendar in newspapers , magazines, and brochures
(122) ❑ road maps

There were many kinds of ***Variable Message Signs*** on your trip.
6. From which Variable Message Signs did you receive information during your trip? (15) N.A.

(Please check all that apply)

Variable Message Signs	Location and Function
(514) ❑ Interchange Entrance	placed on ordinary roads near every interchange entrance, and helps drivers decide to take the expressway or not.
(427) ❑ Toll Gate	placed at every toll gate, and provides information about the mainline of the expressway.
(533) ❑ Mainline	placed near every exit and mid point of exits, and provides information ahead of drivers.
(591) ❑ Travel Time	placed on mainline and provide travel time for next major three interchanges.
(282) ❑ Travel Time Graphic	placed above the mainline, and indicates travel time and displays congesting section graphically.

The Highway Radio service provides up-to-the-minute traffic information between interchanges 24 hours a day through your car radio at 1620 kHz, AM. At least one broadcast area is placed between interchanges which are approximately 15 km apart.

7. Are you familiar with the Highway Radio? (23) N.A.

(692) ❑ yes

(12) ❑ no ➪ *(skip to question 9)*

8. Did you use the Highway Radio during your trip?

(238) ❑ yes ➪ When and where did you use the Highway Radio? (1) N.A.

(123) ❑ at ____ : ____ AM / PM *(circle one)* in ______________

and (at ____ : ____ AM / PM *(circle one)* in ______________)

(68) ❑ almost every broadcasting section on the Tomei Expressway

(46) ❑ I do not remember when and where exactly

(454) ❑ no ➪ Have you ever used it? (83) ❑ no ➪ *(skip to question 9)*

(371) ❑ yes ➪ Why didn't you use it? (5) N.A.

(191) ❑ I listened to other radio programs or music.

(106) ❑ I had enough traffic information already.

(12) ❑ Highway Radio is not so useful.

(24) ❑ It is bothersome.

(78) ❑ other *(please specify)*______________

The Highway Information Terminals are installed at major rest areas, providing real time traffic information 24 hours a day on the graphic panels and video monitors. The graphic panels show an instant overview of road conditions by indicating sections of roadway that are congested or closed, or have lane restrictions in effect. The video monitors provide more detailed information, such as location, time, and causes of an incident, as well as tolls, details of available routes after getting off the expressway, or tourist information on request.

9. Are you familiar with the Highway Information Terminal? (30) N.A.

(582) ❑ yes

(115) ❑ no ➪ *(skip to question 11)*

10. Did you use the Highway Information Terminal during your trip?

(85) ❑ yes ➪ When did you use the Highway Information Terminal?

at ____ : ____ AM / PM *(circle one)* (and at ____ : ____ AM / PM *(circle one)*)

➪ Where did you use the Highway Information Terminal? (5) N.A.

(7) ❑ Kouhoku (60) ❑ Ebina (18) ❑ Ashigara

(5) ❑ other *(please specify)*______________

(497) ❑ no ➪ Have you ever used it? (169) ❑ no ➪ *(skip to question 11)*

(328) ❑ yes ➪ Why didn't you use it? (8) N.A.

(Please check all that apply)

(77) ❑ I did not have any time to spare.

(150) ❑ I had enough traffic information already.

(10) ❑ Highway Information Terminal is not so useful.

(22) ❑ It is bothersome.

(85) ❑ other *(please specify)*______________

11. If you consulted any other traffic information source during your trip, please specify.
other traffic information source: ____________________ (72)

The following questions concern your expectation about travel time before your trip and during your trip.

Before your departure

12. Did you received any traffic information before your departure? (29) N.A.
(108) ❑ no➪ (*skip to question* 16)
(590) ❑ yes

13. Did the information tell you about any traffic delays?
(365) ❑ no➪ (*skip to question* 16)
(225) ❑ yes

14. How long did you **expect** the traffic delay on the Tomei Expressway to be? (9) N.A.
___ hour(s) ____ minutes, the length of the back up: ____ km
n=211 μ=51.36 σ=45.31 n=208 μ=8.76 σ=6.99

15. What was the **main cause** of the traffic delay, according to the information you received?
(27) ❑ traffic accidents
(106) ❑ road construction work
(120) ❑ congestion due to heavy traffic volume
(1) ❑ weather conditions, such as snow, storm, *etc.*
(1) ❑ other *(please specify)*________________

During your trip

16. Did you receive any traffic information during your trip? (36) N.A.
(30) ❑ no➪ (*skip to question* 20)
(661) ❑ yes

17. According to the information you received, were there any traffic delays?
(371) ❑ no➪ *(skip to question* 20)
(290) ❑ yes

18. How long did you **expect** the traffic delay on the Tomei Expressway would be? (17) N.A.
___ hour(s) ____ minutes, the length of the back up: ____ km
n=278 μ=45.46 σ=38.48 n=270 μ=8.32 σ=8.59

19. What was the **main cause** of the traffic delay, according to the information you received?
(62) ❑ traffic accidents
(127) ❑ road construction work
(129) ❑ congestion due to heavy traffic volume
(1) ❑ weather conditions, such as snow, storm, *etc.*
(2) ❑ other *(please specify)*________________

20 What was your **response** to the traffic information you received or your own observations? *(Please check all that apply)* (36) N.A.

(558) ❑ I changed nothing

(57) ❑ I changed my departure time for an earlier/ later time *(circle one)*
(42) (6) (9) N.A.

(15) ❑ I changed the **entrance** interchange ⇨ originally I planned to use ________ interchange

(22) ❑ I changed the **exit** interchange ⇨ originally I planned to use ________ interchange

(25) ❑ I spent **more** time at __________ rest area by ___ hour(s) ____ minutes longer
n=21 μ=56.42 σ=86.51

(and at __________ rest area by ___ hour(s) ____ minutes longer)
n=6 μ=32.5 σ=16.05

(18) ❑ I spent **less** time at __________ rest area by ___ hour(s) ____ minutes shorter
n=14 μ=24.29 σ=8.52

(and at __________ rest area by ___ hour(s) ____ minutes shorter)
n=1 μ=20.00 σ=0.00

(13) ❑ I changed the entire route ⇨ What kind of route had you planned to use previously? (1) N.A.

(8) ❑ ordinary roads for the entire route

(1) ❑ the Chuo Expressway as a part of the route

(3) ❑ other *(please specify)*________________

(7) ❑ I changed my plans at the destination.

(17) ❑ I informed someone that my arrival would be later/earlier*(circle one*).
(14) (0) (3) N.A.

(3) ❑ other *(please specify)*________________

21. When you decided to respond, what did you think the result of your action would be, compared to the result from changing nothing? (18) N.A.

about travel time (excluding the time spent at rest areas)

(23) ❑ It would decrease by ____ hour(s) ____ minutes.
n=22 μ=40.00 σ=26.90

(37) ❑ It would increase by ____ hour(s) ____ minutes.
n=37 μ=46.08 σ=23.66

(35) ❑ It would change little.

(20) ❑ I had no idea about travel time at that time.

about the length of the back up (in total)

(21) ❑ It would decrease by ____ km.
n=19 μ=18.42 σ=17.40

(36) ❑ It would increase by ____ km.
n=34 μ=13.23 σ=15.06

(40) ❑ It would change little.

(17) ❑ I had no idea about the length of the buck up at that time.

22. Having further information now, what do you think the result of your action was, compared to the result from changing nothing?

about travel time (excluding the time spent at rest areas)

(41) ❑ It decreased by ____ hour(s) ____ minutes.
n=40 μ=35.50 σ=17.28

(33) ❑ It increased by ____ hour(s) ____ minutes.
n=32 μ=45.63 σ=32.89

(41) ❑ I have no idea about travel time.

about the length of the back up (in total)

(25) ❑ It decreased by ____ km.
n=23 μ=18.00 σ=13.13

(28) ❑ It increased by ____ km.
n=27 μ=18.68 σ=23.06

(56) ❑ I have no idea about the length of the back up.

23. How do you think your response, based on traffic information / or, if you did not acquire any information, based on your own decision?

Did the traffic information in itself alleviate your anxiety or frustration?	(96) N.A.	(512) ❑ yes	(119) ❑ no
Did your response alleviate your anxiety or frustration?	(126) N.A.	(436) ❑ yes	(165) ❑ no
Are you satisfied with your response?	(82) N.A.	(577) ❑ yes	(68) ❑ no

The following questions concern your evaluation of and demand for traffic information.

24. On a scale of 1 to 9, where 1 indicates "strongly disagree" and 9 indicates "strongly agree," please indicate your level of agreement with the following statements regarding the Highway Telephone, Highway Radio and Highway Information Terminal. *(If you have not used a particular information service, please skip the corresponding question.)*

	strongly disagree							strongly agree		
Highway Telephone	1	2	3	4	5	6	7	8	9	NA
It provides reliable information.	10	19	29	18	82	23	85	49	71	341
It covers detailed information on important incidents.	14	15	33	29	87	38	63	43	52	353
It covers a wide area and most incidents.	19	14	33	32	98	42	66	28	41	354
It provides relevant information.	22	22	30	28	108	37	61	34	38	347
Highway Radio	1	2	3	4	5	6	7	8	9	NA
It provides reliable information.	17	12	32	32	94	57	133	101	152	97
It covers detailed information on important incidents.	17	18	44	63	125	59	98	83	103	117
It covers a wide area and most incidents.	37	34	50	56	139	68	95	60	71	117
It provides relevant information.	31	28	57	51	144	66	90	68	85	107
Highway Information Terminal	1	2	3	4	5	6	7	8	9	NA
It provides reliable information.	14	10	23	27	113	46	90	77	102	225
It covers detailed information on important incidents.	14	13	33	31	127	60	80	68	71	230
It covers a wide area and most incidents.	16	14	23	31	113	54	77	82	88	229
It provides relevant information.	18	14	34	27	128	54	88	63	76	225

25. In what situation would you use the Highway Telephone, Highway Radio, and / or Highway Information Terminal? *(Please check all that apply.)*

Highway Telephone	Highway Radio	Highway Information Terminal	
(328) ☐	(555) ☐	(303) ☐	When I am in a hurry and can not be late
(362) ☐	(541) ☐	(394) ☐	When congestion due to heavy traffic volume is expected during holiday seasons.
(356) ☐	(563) ☐	(403) ☐	When road or lane closures due to construction work are expected.
(403) ☐	(573) ☐	(415) ☐	When road or lane closures or traffic restrictions due to weather conditions, or an earthquake are expected.
(46) ☐	(98) ☐	(59) ☐	Other ______________________*(please specify)*

26. On a scale of 1 to 9, where 1 indicates "not useful at all" and 9 indicates "very useful," please indicate the overall usefulness of the following information sources in determining your response. If you have not used the information source, please skip.

Information Sources	1 (not useful at all)	2	3	4	5	6	7	8	9 (very useful)	NA
a telephone call to the Japan Road Traffic Information Center	12	11	12	15	45	19	38	46	61	468
a telephone call to the Japan Road Highway public Corporation	15	9	10	16	43	13	32	31	45	513
traffic news from radio broadcasts	10	2	24	22	77	68	126	126	203	69
traffic news on TV	30	22	31	28	94	62	75	62	96	227
teletext traffic news on TV	23	9	11	6	31	19	13	15	27	573
personal radio communications (Citizens' Band)	21	8	8	3	17	7	6	14	46	597
traffic congestion forecasting calendar in newspapers, magazines, and brochures	39	23	51	41	84	57	45	42	59	286
road maps	31	22	28	23	93	48	50	70	171	191
in-vehicle car navigator	13	11	6	11	20	10	9	18	30	599
Interchange Entrance Variable Message Signs	9	7	13	18	88	57	107	137	198	93
Toll Gate Variable Message Signs	7	13	19	20	82	55	109	141	183	98
Mainline Variable Message Signs	4	8	9	14	65	41	100	164	234	88
Travel Time Variable Message Signs	10	4	16	26	56	47	112	136	231	89
Travel Time Graphic Variable Message Signs	7	5	20	21	55	44	103	112	175	185
Highway Telephone	11	6	15	18	29	17	45	34	37	515
Highway Radio	9	5	7	18	41	46	116	138	225	122
Highway Information Terminal	7	8	13	21	67	47	87	85	113	279

[Customized questions]

C. Route Choice

Imagine you are driving from the same origin to the same destination, for the same purpose, using the same vehicle, with the same members as the trip you made.

Assume that you have four routes to go to your destination.
Each route has some characteristics under consideration.
Those characteristics are:

1) **en-route traffic information services**: en-route traffic information service level

1.[**Future** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
Information Contents: *Length of the back up, Travel time,* and *Information about alternate routes*

2.[**Present** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
Information Contents: *Length of the back up, Travel time,*

3.[**Old** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
Information Contents: *Length of the back up*

4.[none] No Traffic Information

2) **traffic delay**: maximum traffic delay on the route you may choose, however you are not able to know how much time you may delay before you make a decision to choose a route.

3) **travel time**: travel time under optimal traffic conditions (There is no congestion and you can drive smoothly) For the following questions, please answer again your ravel time under optimal traffic condition in minutes. _______ minutes

4) **travel cost**: travel cost mainly for fuel and toll
For the following questions ,please answer again your travel cost. _________ yen

Example Your travel time under optimal traffic condition was (*80*) minutes. Your travel cost was (*3,000*)yen .

Question type A

A: Your Route

1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	(*80*) minutes → same as Your travel time
4) travel cost	(*3,000*) yen → same as Your travel cost

B: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	(*80*) X1.1=(*88*) minutes → Your travel time plus 10 %
4) travel cost	(*3,000*)yen → same as Your travel cost

C: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	30 minutes
3) travel time	(*80*) minutes → same as Your travel time
4) travel cost	(*3,000*) X 1.1=(*3,300*)yen → Your travel cost plus 10%

D: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	40 minutes
3) travel time	(*80*) minutes → same as Your travel time
4) travel cost	(*3,000*)yen → same as Your travel cost

Please rank route A, B, C, and D according to your preference

1st	2nd	3rd	4th
B	*A*	*D*	*C*

Case 1 Now try your own case, please.

A: Your Route

1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( ) minutes
4) travel cost	( ) yen

B: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( )X1.1=( )minutes
4) travel cost	( )yen

C: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	**30 minutes**
3) travel time	( ) minutes
4) travel cost	( ) X 1.1=( )yen

D: Alternate Route

1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up ,Travel time, and Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	**40 minutes**
3) travel time	( ) minutes
4) travel cost	( )yen

1st	2nd	3rd	4th

Question type A

Case 2

A: Your Route	
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( ) minutes
4) travel cost	( ) yen

B: Alternate Route	
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( )X0.9=( )minutes
4) travel cost	( )yen

Your travel time minus 10 %
same as Your travel cost

C: Alternate Route	
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( )minutes
4) travel cost	( )X0.9=( )yen

same as Your travel time
Your travel cost minus 10%

D: Alternate Route	
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	**20** minutes
3) travel time	( )minutes
4) travel cost	( )yen

same as Your travel time
same as Your travel cost

(C: same as Your travel time; same as Your travel cost — from A)

Please rank route A, B, C, and D according to your preference

1st	2nd	3rd	4th

Case 3

A: Your Route	
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up and Travel time*
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( ) minutes
4) travel cost	( ) yen

B: Alternate Route	
1) en-route traffic information services	[None]
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( )X0.9=( )minutes
4) travel cost	( )yen

C: Alternate Route	
1) en-route traffic information services	[None]
2) traffic delay (maximum delay due to traffic congestion)	**30** minutes
3) travel time	( ) minutes
4) travel cost	( )X0.9=( )yen

D: Alternate Route	
1) en-route traffic information services	[None]
2) traffic delay (maximum delay due to traffic congestion)	**20** minutes
3) travel time	( ) minutes
4) travel cost	( )yen

1st	2nd	3rd	4th

C. Route Choice

[Un-Customized Questions]

Imagine you are driving approximately 100 km (for example, between Tokyo and Hakone), for the same purpose, using the same vehicle, with the same members as the trip you made.

Assume that you have two routes to go to your destination.
Each route has some characteristics under consideration
Those characteristics are;

1) **en-route traffic information services**: en-route traffic information service level
   1. [**Future** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
      Information Contents: *Length of the back up*, *Travel time*, and *Information about alternate routes*
   2. [**Present** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
      Information Contents: *Length of the back up*, *Travel time*,
   3. [**Old** Tomei Expressway] Information System: Variable Message Signs and Highway Radio
      Information Contents: *Length of the back up*
   4. [none] No Traffic Information
2) **traffic delay**: maximum traffic delay on the route you may choose, however you are not able to know how much time you may delay before you make a decision to choose a route
3) **travel time**: travel time under usual traffic conditions
4) **travel cost**: travel cost mainly for fuel and toll

Question type B

Which route do you prefer?

case 1

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up, Travel time*, and *Information about alternate routes*	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	10 minutes
3) travel time	80 minutes	90 minutes
4) travel cost	3,200 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 2

attributes	route A	route B
1) en-route traffic information services	none	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	40 minutes
3) travel time	80 minutes	70 minutes
4) travel cost	3,000 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 3

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up, Travel time*, and *Information about alternate routes*	none
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	20 minutes
3) travel time	70 minutes	80 minutes
4) travel cost	3,600 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

Question type B

Which route do you prefer?

case 4

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	none
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	40 minutes
3) travel time	90 minutes	70 minutes
4) travel cost	3,600 yen	3,600 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 5

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	40 minutes
3) travel time	80 minutes	90 minutes
4) travel cost	3,400 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 6

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	[**Future** Tomei Expressway] *Length of the back up, Travel time*, and *Information about alternate routes*
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	40 minutes
3) travel time	80 minutes	90 minutes
4) travel cost	3,600 yen	3,400 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

Question type C

Which route do you prefer?

case 1

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up*, *Travel time*, and *Information about alternate routes*	none
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	10 minutes
3) travel time	80 minutes	80 minutes
4) travel cost	3,200 yen	3,400 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 2

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	none
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	40 minutes
3) travel time	90 minutes	80 minutes
4) travel cost	3,200 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 3

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	none
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	20 minutes
3) travel time	70 minutes	80 minutes
4) travel cost	3,400 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

Question type C

Which route do you prefer?

case 4

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	[**Old** Tomei Expressway] *Length of the back up*
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	40 minutes
3) travel time	90 minutes	90 minutes
4) travel cost	3,600 yen	3,000 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 5

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	none
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	20 minutes
3) travel time	80 minutes	90 minutes
4) travel cost	3,400 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 6

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	none
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	20 minutes
3) travel time	90 minutes	90 minutes
4) travel cost	3,600 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

Question type D

Which route do you prefer?

case 1

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	none
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	10 minutes
3) travel time	90 minutes	80 minutes
4) travel cost	3,200 yen	3,400 yen

definitely route **A** — probably route **A** — probably route **B** — definitely route **B**

1 — 2 — 3 — 4

case 2

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up*, *Travel time*, and *Information about alternate routes*	none
2) traffic delay (maximum delay due to traffic congestion)	10 minutes	40 minutes
3) travel time	90 minutes	80 minutes
4) travel cost	3,400 yen	3,000 yen

definitely route **A** — probably route **A** — probably route **B** — definitely route **B**

1 — 2 — 3 — 4

case 3

attributes	route A	route B
1) en-route traffic information services	[**Future** Tomei Expressway] *Length of the back up*, *Travel time*, and *Information about alternate routes*	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	40 minutes
3) travel time	70 minutes	70 minutes
4) travel cost	3,600 yen	3,200 yen

definitely route **A** — probably route **A** — probably route **B** — definitely route **B**

1 — 2 — 3 — 4

Question type D

Which route do you prefer?

case 4

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	none
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	20 minutes
3) travel time	90 minutes	90 minutes
4) travel cost	3,000 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 5

attributes	route A	route B
1) en-route traffic information services	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*	none
2) traffic delay (maximum delay due to traffic congestion)	40 minutes	40 minutes
3) travel time	80 minutes	70 minutes
4) travel cost	3,400 yen	3,600 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

case 6

attributes	route A	route B
1) en-route traffic information services	[**Old** Tomei Expressway] *Length of the back up*	[**Present** Tomei Expressway] *Length of the back up* and *Travel time*
2) traffic delay (maximum delay due to traffic congestion)	20 minutes	40 minutes
3) travel time	70 minutes	70 minutes
4) travel cost	3,400 yen	3,200 yen

definitely route **A**	probably route **A**	probably route **B**	definitely route **B**
1	2	3	4

D. The following questions concern your attitude toward driving behavior.

1. On scale of 1 to 9, where 1 indicates "strongly disagree" and 9 indicates "strongly agree," please indicate your level of agreement with the following statements.

strongly disagree (1) — strongly agree (9)

	1	2	3	4	5	6	7	8	9	NA
a) I often take an entrance or exit interchange that is different from the one I had planned to take at the start of the trip.	209	92	96	27	93	38	67	28	45	32
b) I like discovering new routes.	96	38	63	30	115	48	88	69	151	29
c) I am willing to try new routes to avoid traffic delays.	47	21	39	22	118	43	116	101	189	31
d) I am always trying to acquire traffic information.	24	10	36	33	102	48	104	101	241	28
e) Traffic information on expressways is not sufficient.	67	46	60	38	140	59	94	75	111	37
f) I trust my own judgment more than traffic information on expressways.	175	78	137	54	153	23	34	22	19	32
g) I feel frustrated being stuck in traffic.	22	27	32	28	102	37	91	85	268	35
h) I like driving.	125	7	17	13	111	58	102	100	263	31

2. On a scale of 1 to 9, where 1 indicates "not important at all" and 9 indicates "very important," please indicate the importance of the following factors in choosing your route on the trip you made using the Tomei Expressway on which we distributed this questionnaire to you.

not important at all (1) — very important (9)

	1	2	3	4	5	6	7	8	9	NA
a) Travel time	23	9	25	12	82	31	98	95	327	25
b) Travel cost	84	40	53	46	170	54	84	50	116	30
c) Route length	71	34	57	40	184	58	74	56	114	39
d) Traffic safety	33	15	32	27	124	48	102	91	219	36
e) Habit	41	21	33	20	189	77	99	91	119	37
f) Traffic volume	17	9	14	19	100	45	127	142	223	31
g) Risk of being stuck in traffic	13	4	15	14	88	44	99	148	268	34
h) Existence of traffic lights and intersections	63	28	53	24	147	56	103	75	134	44
i) Service level of traffic information	34	25	44	28	184	74	99	64	139	36
j) Level of difficulty in following the route	24	9	25	17	92	47	125	123	229	36
k) Departure time of day	36	23	21	18	127	35	98	109	227	33
l) Weather	63	31	36	23	149	41	95	79	180	30

E. About yourself

The information requested in this section concerns your personal and household data, and will help us to better understand how personal and family characteristics affect drivers' behavior. All information collected will remain strictly confidential.

1. What is your gender? (653) ❑ male (55) ❑ female (19) N.A.

2. What is your marital status? (156) ❑ single (529) ❑ married (42) N.A.

3. What is your age? __ years old
n=706 μ=42.57 σ=12.51

4. What is your current occupation? (18) N.A.

(70) ❑ self-employed
(73) ❑ professional driver
(106) ❑ administrative employee
(124) ❑ managerial, executive
(17) ❑ student
(58) ❑ other *(please specify)*___________
(12) ❑ retail sales
(136) ❑ technical employee
(33) ❑ professional specialty
(55) ❑ public employee
(25) ❑ housewife

5. How many years of driving experience do you have? ___ years
n=698 μ=19.71 σ=10.41

6. How often do you drive? (19) N.A.

(426) ❑ approximately every day
(85) ❑ approximately once a week
(2) ❑ approximately once a month
(2) ❑ a few times in the past
(166) ❑ 2-6 times a week
(24) ❑ 2-3 times a month
(3) ❑ 1-11 times a year
(0) ❑ this is the first time

7. What is your annual household income before taxes? (29) N.A.

(20) ❑ less than 2,000,000 yen
(190) ❑ 4,000,0000-5,999,999 yen
(110) ❑ 8,000,0000-9,999,999 yen
(37) ❑ 12,000,0000-14,999,999 yen
(14) ❑ 20,000,000 yen or more
(103) ❑ 2,000,0000-3,999,999 yen
(140) ❑ 6,000,0000-7,999,999 yen
(54) ❑ 10,000,0000-11,999,999 yen
(30) ❑ 15,000,0000-19,999,999 yen

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