EMPIRICAL ANALYSIS ON INFLUENCE OF TRAFFIC INFORMATION BY DIVERGENCE RATE USING OBSERVED TRAFFIC DATA

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Abstract: It is expected that the development of information technology would contribute to an efficient use of road network. ATIS has been implemented at several developed countries and it is therefore possible empirically to evaluate impacts of ATIS. In this point, this study aims at grasping the change of network traffic flow and the influence of dynamic information provision supported by real-time observation on traffic condition. This study uses divergence rate between two alternative routes to find the influence of provided information on network flow. The divergence rate when incident information is provided is compared with the average divergence rate without congestion. The result suggests the high possibility for drivers to divert his/her route by information.

Key Words: Divergence rate, Average divergence rate, Information provision

1. INTRODUCTION

It is expected that development of information technology would contribute to an efficient use of road network. Among them, Advanced Traveler Information System (ATIS) that provides traffic information such as travel time, delay and accident with various communication media is believed to improve traffic condition by encouraging drivers to divert the alternative routes and preventing from concentration of traffic on the congested section of network. Since 1980's many researches have been carried out to evaluate the effect of information provision. Much of the researches, however, emphasizes on explaining driver behavior since ATIS has not been implemented then.

Generally, researches on evaluation of information provision can categorize into three groups; 1. evaluation by network flow change using simulation model, 2. behavioral analysis under information provision using random utility model and 3. field test. Typical findings from the simulation analysis are; the effect of descriptive information provision would fall down if more than 70% of drivers use information (Mahmassani and Jayakrishnan, 1991), and a good effect of route guidance is expected if network has multiple alternative paths (Moritsu, 1991). On the other hand, Yoshii and Kuwahara (2000) have pointed out that more congestion may happen by providing descriptive information in the case that difference in travel time information is small.

Driver's behavioral analysis considers their preference against traffic information through a questionnaire survey and estimates route choice model. Khattak et al. (1991) investigated temporal detouring behavior through questionnaire survey. Since the effect of information has various influences such as response lag, it is quite difficult to evaluate information only by the survey of one period. One of the popular methods to obtain time series data is carrying out panel surveys. Uchida (1993) conducted 5-wave panel survey to evaluate travel time information provision empirically. He concluded that information provision is mostly welcome to drivers, but quantitative change in path flow cannot be observed on commuting trips. Another effective method of acquiring time series choice data is laboratory experiment. A study conducted by Mahmassani et al. aimed at analyzing driver's travel behavior through laboratory experiment (Chang and Mahmassani 1988; Mahmassani and Herman 1990). This study focuses on the day-to-day dynamics of departure time adjustment and route choice by commuting drivers. Also Iida et al. (1999) analyzed the effect of travel time information by laboratory experiment. They analyzed the relationship between information accuracy and user compliance, and concluded that inaccurate information deteriorates the value of information system.

So far we have summarized former efforts to analyze the effect of information provision and it can be said that much effort has been made for forecasting and estimating the effect of information. ATIS has been implemented at several developed countries and it is therefore possible empirically to evaluate impacts of ATIS. Especially to make sure the propriety of information provision and investigating further improvement of the system, it is strongly required to appraise the effect of information empirically through data obtained at the sites where information has been provided. Recently, Oguchi et al. (2003) analyzed drivers' route choice behavior and traffic congestion together at closed section on Tomei Expressway where there are two routes but no entry/exits on the way. They have pointed out that hunting phenomenon was observed in this particular section, and concluded that 'intelligent' information such as predicted information should be investigated. In this study, a similar approach is made but on the different site where there are entries and exits on two routes.

At the area where information on travel time and congestion is provided, this study attempts to prove propriety of information provision in actual situation by investigating the change in traffic volume. Since information provision has already been implemented, it is impossible to evaluate an impact of introducing the system. Thus the main objective of this study is appraising the relationship between change in traffic flow and provided information.

This paper consists of 5 chapters. Background of this study as an introduction is described here. The methodology of the analysis as well as outline of the study area and the data is summarized in chapter 2. Also, this chapter defined divergence rate as substitute index of path use rate in order to find out a relationship between traffic information and traffic flow. Relationship between divergence rate and traffic information on each route from the macroscopic viewpoint is explored in chapter 3. Divergence rate was then compared with the contents of information in more detail from the microscopic viewpoint in chapter 4. Finally, chapter 5 summarizes the findings and further directions of this study.

2. METHODOLOGY

2.1 Study Area

The influence of information provision is evaluated between Seta-Higashi JCT and Oyamazaki JCT on Meishin Highway, which is a major national trunk highway connecting Nagoya and Kobe. Over hundred thousand vehicles are running on the section per day. Traffic congestion was frequently observed around Kyoto Minami IC. To mitigate this congestion, Japan Highway Public Corporation (JH) decided to connect west end of Keiji-Bypass (which is originally constructed aiming at mitigating congestions on National Route 1) to Meishin Highway. In 2003, Keiji-Bypass was connected with Meishin Highway. The whole distance of two routes are same and about 28km, but travel time in free flow on Keiji Bypass is a bit longer since speed limit is lower (80 km on most sections of Keiji Bypass whereas 100km on Meishin Highway). Drivers originated from further east of Ritto IC and destined to further west of Ibaraki IC(or vise versa) now have a chance to decide which route. Furthermore, the extended Keiji Bypass makes possible that drivers who suppose to go from Nagoya of Kyoto to Osaka use the second Keihan way as a substitute of using Meishin Highway.



Figure 1. Study area

In order for encouraging their decision-making on route used more rational, JH provides the drivers with the dynamic traffic information via several variable message sign boards. The VMS shown in Figure 2 displays the travel time information together with jam length on the simplified network. This area has not been heavily congested since Keiji-Bypass has extended. There is no delay at further east of Seta-Higashi JCT. On further west of Oyamazaki JCT, congestion is most likely to occur. Within study area, congestion caused by outflows at Kyoto Minami IC is often observed on weekends, but the congestion on the highway may not occur without any incidents.



(from : Japan Highway Public Corporation)



Observed traffic data	• $1^{st} \sim 31^{st}$ October 2003
Observed traffic data	• 5 minutes traffic volume after divergence to 2
	routes
Ticket data	• 23 rd October 2003
	• time entering/exiting at interchanges for each
	vehicle
Traffic information data	 1st ~ 31st October 2003 Message on VMS (saved whenever its content changes)

Table 1. Data Used in This Study

2.2 Data

The influence of traffic information was analyzed by traffic volume observed before and after the divergence. Traffic volume after Seta-Higashi JCT is used for analyzing traffic bound for Osaka and Kobe, and that after Oyamazaki JCT is used for analyzing traffic bound for Nagoya. At this section, several variable message sign boards are equipped and jam length information and travel time information has been provided. Table 1 sumarizes the data used in this study. Link traffic volumes after divergence between Keiji-Bypass route and Meishin Highway route during October 2003 and corresponding data on traffic information provided via VMS are used. Traffic volumes are recorded every 5 minutes whereas traffic information data contains the contents of information together with the time when the contents were changed. OD data obtained from tickets are also used to grasp how much percentage of vehicles exits from the interchanges of both routes within the study area.

Contents of traffic information data are expressed on VMS board as Figure 2. Travel time information and jam length information is provided on each black rectangular in VMS board.

Because of the limitation of spaces either travel time information or jam length information is provided. Travel time information is usually provided but it is replaced to jam length information when congestion occurs.

2.3 Divergence rate

The objective of this study is to find out a relation between information and rate of path use. In our study section, it is possible to grasp entry/exit ICs together with time of entry/exit from ticket data. However, the ticket data can not specify the path the ticket holders take, and thereby, it is impossible to estimate the path flow. Therefore in this study, divergence rate between Keiji-Bypass route and Meishin Highway route is defined as a substitute index against the rate of path use. Divergence rate is calculated by Eq 1.

$$DR_{M} = \frac{V_{M}}{V_{M} + V_{K}} \tag{1}$$

where,

DR_M	:	divergence rate to Meishin Highway
V_M	:	link traffic volume on Meishin Highway after divergence,
V_K	:	link traffic volume on Keiji Bypass after divergence.

2.4 Average divergence rate

Since traffic volumes exiting from ICs within the study area are included in DR_M , the rate of traffic affected by the information may change according to the traffic exiting from ICs within the study area. Since a major aim of this study is to evaluate the changes in path use caused by information, it is important to get rid of this effect. For this purpose, we compare the DR_M between recurrent and non-recurrent condition. When no specific incident happens, VMS provides drivers with fixed travel time information. Therefore 'normal' condition is defined as the time periods when travel time information of both Meishin Highway and Keiji Bypass is 40 minutes for outbound route (for Osaka and Kobe), and travel time information for Meishin Highway is 35 minutes whereas that of Keiji-Bypass is 40 minutes for inbound route (for Nagoya). Average divergence rate in normal condition is then calculated by hour to understand the daily fluctuation. Figure 3a and 3b show the hourly average divergence rate on normal condition for outbound and inbound direction, respectively. 90% confidence interval together with the standard deviations is also shown in the figures. These values will be compared with the divergence rate when the information on occurrence of non-recurrent condition is provided to the drivers.



Fig. 3a. Average Divergence Rate Bound for Osaka



Fig. 3b. Average Divergence Rate Bound for Nagoya

2.5 Matching information and traffic data

Information data is recorded whenever the content of information changes, whereas the time interval to record the traffic data is five minutes. For the analysis the traffic volume should be matched with the contents of information. For this purpose, traffic volume is divided proportionally when information is changed within the time interval to record the traffic data, and matched with it. The procedure is summarized in Figure 4. Traffic volume for Pattern B in Figure 4 is calculated as 120 (=100/5 + 250*2/5). As it is preferable to have similar length

of time intervals, the maximum length of time period is set to be five minutes. Therefore Pattern D in Figure 4 is regarded as two different information data with different traffic volumes.



Figure 4. Matching Traffic Volume Data and Information Data

2.6 Rate of Traffic Exiting from Interchanges within the Study Area

For drivers exiting and entering to/from interchanges within the study area, it is impossible to choose routes. Therefore, the effect of information might be unclear when the rate of these traffics to the total traffic volumes is large. Figure 5 illustrates the rate of traffic exiting from interchanges within study area obtained from ticket data. Comparing the traffic bound for Osaka with that for Nagoya, the latter includes the larger percentage of traffic exiting from interchanges within the study area. This is because many traffic from Osaka exit from either Kyoto Minami or Kyoto Higashi ICs. This tendency changes in the morning peak hour when many traffic flows out to Kyoto from Shiga Prefecture (far east of the study area). It is also worth mentioning that rate of through traffic (traffic going through the study area) is large during midnight. It can be said from the figure that at least 40% of traffic volume will flow out within the study area during daytime.



Figure 5. Rate of Traffic Exiting from Interchanges within the Study Area

3. MACROSCOPIC ANALYSIS ON INFLUENCE OF INFORMATION

In this chapter, relationship between DR_M and travel time information on each route is explored. Using observed traffic volumes, average divergence rate is calculated for travel time and jam length provided by the information system. Results are shown in Figure 6. We call this analysis as macroscopic because the effect of information on traffic flow is evaluated only from the average divergence rate.

From Figure 6a, the divergence rate bound for Osaka showed a little change when travel time information up to 55 minutes are provided on Meishin Highway. However, the divergence rate changes drastically when travel time on Meishin Highway is larger than 60 minutes. Especially when travel time information on Meishin Highway is longer, the average divergence rate falls down to 50%. The relation is not so clear in Figure 6a when jam length information is provided, but the average divergence rate decreases when length of congestion on Meishin Highway is large.



(b) Bound for Nagoya Figure 6. Average Divergence Rate by the content of information.

Looking at Figure 6b heading to Nagoya, the change in average divergence rate is not so drastic than that in Figure 6a. It means that traffic bound for Nagoya is less sensitive to information. It might be because of the structural constraints for this direction (Figure 1).

Meishin Highway has two parallel routes with two lanes each between Ibaraki IC and Kyoto Minami IC and drivers can only use Keiji-Bypass if they are driving on the left-side route. Furthermore, there is a huge ramp to flow into Keiji-Bypass which might be a mental barrier for drivers. Even considering these effects, it can be said that information has a potential to guide drivers to less congested route.

4. MICROSCOPIC ANALYSIS ON INFLUENCE OF INFORMATION

In chapter 3, the average divergence rate is analyzed together with contents of information. It is concluded that information might give a certain effect to drivers' route choice behavior. However, as discussed in chapter 2, traffic volumes exiting from the interchanges within the study area are included to calculate the average divergence rates. To get rid of this problem, the temporal changes in divergence rate are compared with the contents of information together with hourly average divergence rate. To emphasize how the divergence rate is apart from hourly average divergence rate, 90% confidence interval shown in Figure 3 is also included. Figure 7 is a typical result when an incident happened and the corresponding information was provided to drivers. Upper graph in Figure 7 expresses the divergence rate and the existence of incident information. We can see how different the divergence rate is when incident information is provided. Lower graph illustrates the information provided during the same time period. From Figure 7a, from 13 to 21 o'clock when the jam length according to the information for Meishin Highway is longer, the divergence rate fell down below the lower boundary of 90% confidence interval. Especially when jam length information on Meishin Highway is at least 5 km longer, the divergence rate fell down to 50%.

Looking at the other direction (Figure 7b), the similar tendency can be found. During 11:30 to 14:00 when incident information is provided and travel time information for Meishin Highway is far longer than Keiji-Bypass, the divergence rate fell down to 60%. It is worth noting that even the differences in travel time information reaches almost 1 hour, whereas decrease in the divergence rate from its average is only 20%. Again the reason might be the structural shape.

There were 811 time periods when incident happened in case bound for Osaka and among them, 273 time periods (about 34% of all incidents) fell down below 90% confidence interval of the average divergence rate. Incident situation found out 1201 time periods in case bound for Nagoya and among them, 345 (about 29% of all incidents) time periods fell down below 90% confidence interval of usual divergence rate distribute. It is proved by this analysis that drivers tend to change their route according to information.

5. CONCLUSION

This study evaluates how information provision influences onto the traffic flow empirically considering the destinations. The method adopted here has an advantage of grasping the influence of provided information with only traffic volume data. This study used divergence rate in order to find out the influence of provided information and used 90% confidence interval in order to compare normal condition with non-recurrent condition. It is found that divergence rate changed drastically compared with average divergence rate especially when incident information is provided on Meishin Highway. From the analysis, it can be concluded

that effect of information is not small by both macroscopic and microscopic point of view.

AKNOWLEDGEMENT

We are indebted to Kansai Branch of Japan Highway Public Corporation and Institute of Systems Science Research for providing data.

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Figure 7a. Divergence Rate of Meishin Highway with Information Bound For Osaka





Figure 7b. Divergence Rate of Meishin Highway with Information Bound For Nagoya