# ANALYSIS OF EXPRESSWAY ROUTE CHOICE BEHAVIOR INCORPORATING THE INTERACTION BETWEEN TRANSPORT COMPANY MANAGERS AND DRIVERS

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Emphasizing on driver's situational avoidance behavior while driving, a specific case study of truck driver's route avoidance behavior have been discussed. Case study is conducted with regarding to two substitutable expressways in Chugoku area of Japan, called Chugoku road and Sanyo road, which are now experiencing a serious issue with unbalanced traffic volume demands. In order to identifying the factors that influencing on situational route driving avoidance behavior, a RP+SP questionnaire survey was conducted in Chugoku Area, Japan (2014~2015). Totally, 525 valid observations obtained from 54 companies with route decision of both manager and driver decision are obtained based on same SP scenario assumption for data analysis.

A Bivariate Probit (BP) model is employed to jointly estimate the potential factors that would significantly influence on people, both company managers and drivers, expressway route avoidance behaviors. Model estimation results imply that for frequent expressway user, here freight forwarders, avoidance behavior are significantly influenced by insurance type insured and experiential factors of frequency of driver's traffic jam and self-traffic accident experiences. Moreover, comparing to drivers, the avoidance behavior of company managers would more likely been influenced by the factors of road congestion information, delivery goods property (fragile goods), and incentives, e.g. more tow truck compensation and even point form refund.

***Key Words :*** *avoidance behavior, expressways, route choice behavior, bivariate probit model*

## 1. INTRODUCTION

In reality, drivers may sometimes avoid driving. Especially, avoid driving on expressway avoidance by some less-confidential drivers. According to the literature review, two types of avoidance behaviors have been introduced, including general punishment driving avoidance (Liourta and Empelen, 2008; Scott-Parker et al., 2014) and situational avoidance behavior.

Punishment driving avoidance driving behavior emphasis on more general driving avoidance awareness enforced by the rule and even punishment by the police management. In this sense, driving safety education program may help driver and encourage drivers to avoid driving in some cases. For example, driving safety education may encourage drivers to avoid driving in some cases. On the other hand, for situational avoidance behavior, drivers tend to perform avoid driving under specific situations, such as heavy snow, unfamiliar driving environment, feeling drowsy/tired, and fear of driving on expressways, in which their impairments identified/obtained from previous crash involvement experience might expose them to an increased risk of accident (Stewart and Peter, 2004; Motak, et al., 2014). Thus, such avoidance behaviors may be influenced by not only drivers' internal factors, but also external environment and/or interventions.

In order to investigate driving route avoidance behavior, a questionnaire survey was conducted in Chugoku Area, Japan, as case study. In the case study area, two expressways, Chugoku Road (blue line) and Sanyo Road (red line), under study is now suffering with unbalanced traffic demand problem, even though two expressways all poses the connecting function of two main areas of Kansai area and Kyushu area (shown in Figure 1). Current situation of traffic volume on two expressway is that due to the larger number of interchanges (IC) exist on the Sanyo road than Chugoku road, traffic volume on Sanyo road is much heavier than Chugoku road. Therefore, larger number of incident and congestions issues have also been identified on the Sanyo

road. Moreover, due to the pressure of heavy traffic volume on the Sanyo road, where average daily traffic volume (ADT) on Sanyo road is 37787.1 vehicles/day, about 2 times of that on Chugoku road of 15431.3 vehicles/day, serious saturated problem have also been encountered in service area (SA) and parking area (PA) along the Sanyo road. In the meanwhile, about 9 parking area have to be closed down or decide to shorten their business hours to face up with the decreasing traffic volume on Chugoku Road.

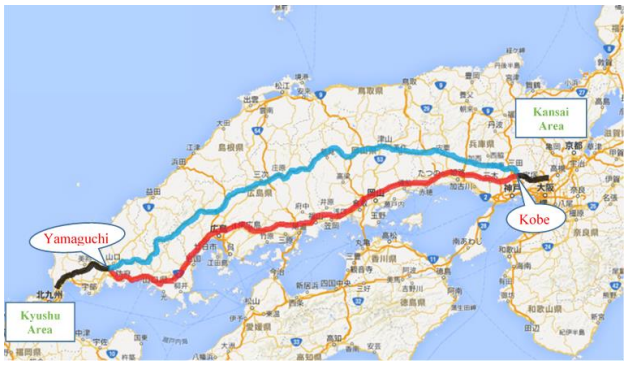


**FIGURE 1. Map of Chugoku Road (blue line) and Sanyo Road (red line)**

Focusing on the expressway route choice behavior, situational driving avoidance behavior is expected to be one of the main factors that influences on driver's expressway route choice behavior. As a typical situational driving avoidance behavior, influential factors and potential reasons why most drivers, especially truck drivers, choose to use Sanyo road but not Chugoku road is the main purpose of this survey conduction.

In the remaining part of this paper, Section 2 introduces questionnaire survey design and complementation. Section 3 provides a description aggregation analysis of the data obtained. Section 4 briefly introduced the model introduced for data analysis, and followed by model estimation result discussion and conclusion in Section 5 and Section 6.

## 2. QUESTIONNAIRE SURVEY

Prior to the implementation of questionnaire survey, an interview survey was conducted with two freight forwarder companies in Kansai area on November 12~13, 2014. Main topic of the hearing survey is focusing on company route decision making mechanism and route decision rules under unexpected emergency, current transporting status, and preferred incentives to alter to Chugoku road usage.

Based on the hearing survey, A RP+SP questionnaire survey was conducted in 2014~2015. In terms of the respondents for this survey, freight forwarder companies, located in Kansai, Kyushu, Sanin, and Sanyo of Chugoku area have been selected, by considering the potential target expressway usage.

In case of route decision making of truck freight, two main decision making mechanism are exists: company manger decide before hand, and driver decide according to driving situation. However, in practice, there is no research has been conducted to investigate the decision making of freight forwarder company decision making mechanisms with empirical data. Therefore, in this survey, the complex decision making mechanism have also been considered to reflect the avoidance route selection behavior in practice.

Focusing on the survey content, RP survey part for company manager and driver was designed separately, while during the SP survey part, the same questionnaire contents have been provided to all the respondents belong to the same company. A brief summary of the survey contents is shown in Table 1.

**TABLE 1. Summary of RP Survey Contents**

| | |
|---|---|
| Respondents | Company manager and drivers of freight forwarders in Kansai, Kyushu, Sanin, and Sanyo area. |
| Survey Contents | Company scale (e.g. vehicle ownership, employee number, freight delivery cost), Chugoku road usage inducing incentives, personal attributes of manager and drivers (e.g. age, gender, professional driving age), RP survey of previous driving experience evaluation of driving route and SA/PA services, image of Chugoku road, and SP survey |

**TABLE 2. Levels of SP Factors**

| | |
|---|---|
| Goods type | 1.fragile goods |
| | 2.general goods |
| Travel time on Sanyo Road | 1. same as normal travel time |
| | 2. once in 10 times, 1.5 times of normal travel time |
| | 3. once in 5 times, 1.5 times of normal travel time |
| Tow truck subsidy for incident/ malfunction | 1.No subsidy for both Sanyo and Chugoku Road |
| | 2.subsidy is provided for the part that is not covered by insurance, only for Chugoku Road (must be insured) |
| | 3.full subsidy is provided without any requiremnt of insurance insured on Chugoku Road |
| Reduction | 1. no reduction |
| | 2. 2000 JPY point reduction for oneway Chugoku road use |
| | 3. 3000 JPY point reduction for oneway Chugoku road use |

As for SP survey, factors identified from the previous hearing survey are utilized. Detail information of each SP factor levels are shown in Table 2. Totally, four importance factor have been employed in the SP pattern generation with each have two or three different levels. By employing an orthogonal

design method (realized in SPSS16.0 software), 9 SP patterns with different level combination, have been obtained.

Seven selected OD pairs are provided in the SP scene assumption, total number of SP profiles is 63 obtained from 7 OD route multiple with 9 SP patterns. Figure 3 shows an example of the SP card provided to respondent. In this survey design, each respondent is expected to deal with three SP cards, with only one OD route but three different SP patterns.

Assume there is one trip to deliver fragile goods according to the OD below:
Origin Destination
Chugoku Suita IC (Osaka) → Mojiko IC (Fukuoka Prefecture)
ETC night price 12600Yen (normal price 18700Yen)

| | Chugoku Road | Sanyo Road |
|---|---|---|
| Travel Distance | 544.2 km | 520.4 km |
| Toll fee | ETC night price 12600 JPY (normal price 18700 JPY) | |
| Travel Time | About 7 hours (normal time) | About 6 hours (normally), but once in 10 times about 9 hours (1.5 times) due to accident caused congestion |
| Tow truck subsidy for incident/ malfunction | Full subsidy is provided without any requirement of insurance insured on Chugoku Road | No subsidy |
| Reduction | No reduction | No reduction |

Based on those information, please circle out the route you want to choose.

Chugoku Road · Sanyo Road

**FIGURE 3. Example of Expressway Route Avoidance SP Profile**

## 3. DATA

Survey was conducted during 2014 ~2015. Totally, the questionnaire are allocated to 173 target companies through mails, and until now, questionnaire filled up by 58 companies have been received. Totally, 232 valid questionnaire from 54 company managers and 178 drivers have been obtained for data analysis.

As for route selection behaviours of freight forwarder, decision makers for specific route selection might be different across different company. Decision makers might include company manager, truck driver, as well as driver act according to circumstance. In terms of the 54 companies participated in our questionnaire survey, it is reported that about 53% of the companies' route decision is made by manager, 16% by driver, 20% of the route decision is made according to circumstance, while others takes 12%. In this part of analysis, separated expressway route selection behavior under same condition conducted by manager and truck driver from same company have been investigated.

In order to identifying the different route selection and avoidance properties of company managers and drivers, data with at least one pair of manager and driver fully answer the questionnaires are keep in data processing. As a result, totally 525 observations with route decision of both manager and driver decision are obtained based on same SP scenario assumption.

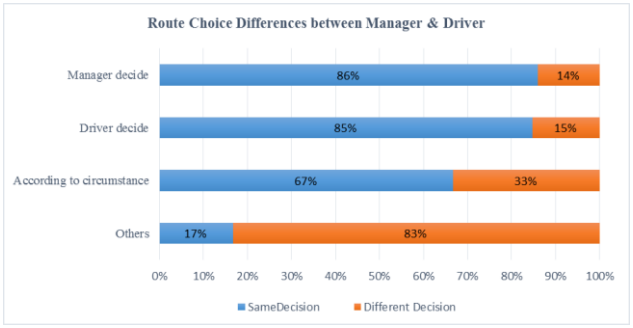


**FIGURE 4. Route Choice Differences between Manager and Driver**

Figure 4 shows the cross-aggregation between the manager reported route choice decision maker and the real route selection results generated by company manager and truck drivers, separately. The figure shown that for those companies who make the route decision either by manager or driver, about 85% agreement rate can be obtained, while the rest 15% of case opposite decision have been selected by managers and drivers. Meanwhile, for companies with decision making according to circumstance, there are 67% of the cases consensus decision making have been achieved by company manager and driver under same described scenarios.

## 4. METHODOLOGY

Considering that the final route decision making, whether made by company manager, driver, or according to specific circumstance, is not only decision of one person, but also co-consideration of various prospects, especially idea of their colleagues, whether drivers or managers. Therefore, in this part of study, the potential correlation of avoidance route selection behaviors between managers and drivers have been analyzed. It is assumed that under the

same situation, driver or manager will make their own route selection behaviors with consideration of potential decisions of the other, such as "which road would the driver prefer to drive?", and "Do the manager also want to avoid driving on Chugoku road?" Hence, in the following model analysis of data, the bivariate probit (BP) model is employed to jointly estimate selections of both manager and driver from two substitute expressways.

Set up of the BP model is shown as follows:

$$y_{i,1}^{*}=\beta_1' x_{i,1}+\varepsilon_{i,1},\quad y_{i,1}=1 \text{ if } y_{i,1}^{*}>0;\quad y_{i,1}=0, \text{otherwise} \tag{1}$$

$$y_{i,2}^{*}=\beta_2' x_{i,2}+\varepsilon_{i,2},\quad y_{i,2}=1 \text{ if } y_{i,2}^{*}>0;\quad y_{i,2}=0, \text{otherwise} \tag{2}$$

where, $y_{i,1}$ and $y_{i,2}$ are dependent variables of road selection for individual $i$. $\beta_1$ and $\beta_2$ are vectors of unknown parameters, $\varepsilon_{i,1}$ and $\varepsilon_{i,2}$ are error terms, which follows bivariate normal distribution with correlation of $\rho$.

$$E(\varepsilon_{i1}) = E(\varepsilon_{i2}) = 0 \tag{3}$$

$$Var(\varepsilon_{i1}) = Var(\varepsilon_{i2}) = 1 \tag{4}$$

$$\mathrm{Cov}(\varepsilon_{i1},\varepsilon_{i2})=\rho;\ i=1,2,3,\ldots,n \tag{5}$$

Then, the log-likelihood function for the BP model can be calculated as follows:

$$\begin{aligned} logL &= \sum_{i=1}^{n} \log \Phi_2\left[(2y_{i1}-1)\beta_1' x_{i,1}, (2y_{i2}-1)\beta_2' x_{i,2}, (2y_{i1}-1)(2y_{i2}-1)\rho,\right] \\ &= \sum_{i=1}^{n} \log \Phi_2\left[q_{i1}\beta_1' x_{i,1}, q_{i2}\beta_2' x_{i2}, q_{i1}q_{i2}\rho\right] \end{aligned} \tag{6}$$

where, $\Phi(\cdot)$ is the cumulative distribution function for the standard Norma, and $q_{i,1}$ and $q_{i,2}$ are defined below.

$$q_{i1}=(2y_{i1}-1)=-1 \quad if\ y_{i1}=0,\quad =+1,\quad if\ y_{i1}=1 \tag{7}$$

$$q_{i2}=(2y_{i2}-1)=-1 \quad if\ y_{i1}=0,\quad =+1,\quad if\ y_{i1}=1 \tag{8}$$

## 5. MODEL ESTIMATION RESULTS

Model estimation result is shown in Table 3. The likelihood ratio test against the independence between the route choice of manager and driver suggests that the independence is rejected. The correlation (the "rho" value) between two models is statistically significant, which also supports the rejection of the independence. Joint estimation of two model performs better than estimate two models separately.

Focusing on the impact of SP factors, it is observed that there is no significant influencing impact could be identified on route choice model of driver, even though the significant influences could be identified from the route choice model of manager. Potential explanation of this result might be that factors extracted from the hearing survey are mostly reflected from the company managers, and therefore, those factors proposed are mostly related to manager's interests. On the other hand, in the manager choice model, the significant positive influencing impact of "*Compensation provide to company with insurance*", "*Traffic jam on Sanyo road every per 5 times drive*", "*3000 yen refund on Chugoku road*", and "*Damageable goods*" imply that the managers are more likely to choose the Chugoku road as delivery route when compensation are provided for presumptions of the tow truck usage, which is not fully covered by insurance, high frequency of traffic jam experience (once/10 times usage) on Sanyo road, higher refund incentives (3000 yen) provision, and Fragile good transport condition. The big difference between influencing impact of SP factors on two decision model indicate that factors selected in this SP survey are more effective to influencing on manager's route selection behavior, however, factors that work on driver's decision making should be further investigated.

Comparison of imagination between two substitute expressway (Sanyo and Chugoku) shown that firstly one's impression of "be relieved" significantly influence on route choice behavior of both manager and driver. Negative sign of "be relieved" make sense since the more unsatisfied with the Chugoku road, people are more likely to choose the Sanyo road instead. One more factor that significantly influence on driver's choice is "non-irritable", however, the positive estimated parameter indicate that driver's irritable impression of the Chugoku road will still lead to driver's Chugoku road usage decision. Same unhelpful imagination have also been identified from factors of "safety", "brightness", and "non-monotonous" on manager's Chugoku road selection behavior.

Focus on driver specific factors, two parts of factors are selected for data analysis. First, driver's previous target expressway usage, the significant positive sign of Sanyo road usage and negative sign of Chugoku road usage imply that drivers are more likely to select the Chugoku road usage influenced by each road usage experiences. However, the decision maker of driver's previous target road usage shows no significant influencing impact. The second part is mainly driver attributes and their driving related factors, different from our expectation, influences of those factors are quite limited on driver's decision making. Only one exception come from driver's working time period from 2 am to 9 am, significant positive sign means that driver's works on the early morning are more prefer to select the Chugoku.

As for manager specified factors, significant negative sign of "share of target expressway usage" indicate that for companies with larger share of Chugoku and Sanyo road usage, the manager are more likely to choose Sanyo road for goods delivery.

Moreover, it is observed that Sanyo road are more preferred by managers with the consideration of travel time and travel safety issues.

Since in this analysis, the route choice decision making behaviors of one staff, either manager or driver, are assumed to be correlated with the other colleges. Driver's experiential factor have been employed in both model to capture the potential influences between two decision maker groups. Model estimation result shown that driver's higher frequency of traffic jam and self-accident experience would significantly contribute to Chugoku road selection of both managers and drivers. On the other hand, type of insurance insured also impose significant influencing impact, more Chugoku road usage have been identified from company with human/objective insurance and tow truck fee insurance. Whereas, company's ownership of self-vehicle insurance significantly contribute to driver's Sanyo road selection.

Moreover, more Chugoku road selections could be made by both manager and driver from company with the contract assignment of high frequency expressway usage and larger total vehicle ownership. Trade volume factor only significantly influence on manager's route choice selection, positive sign indicates that managers are more likely to choose the Chugoku road while more trade volumes have been obtained by company.

## 6. CONCLUSION

Emphasizing on driver's situational avoidance behavior while driving, a specific case study of truck driver's route avoidance behavior have been discussed. Case study is conducted with regarding to two substitutable expressways in Chugoku area of Japan, called Chugoku road and Sanyo road. Even though two expressway are substitutable to each other at certain degree, Sanyo road is now facing up with a serious high traffic demand problem and approaching its saturation point of service level. However, on the contrary situation, the Chugoku road is now experiencing a decreasing traffic volume demand problem, and negative result of that is the closing down of nine SA/PA districts in selected road section.

A RP+SP questionnaire survey have been conducted towards freight forwarder companies in this case study areas to investigate the factors that caused the occurrence of route avoidance behavior.

Data analysis of this avoidance route selection behavior shows that, firstly, route choice decision making of freight forwarders diverse across company manager, truck driver, as well as situational specific. Moreover, decision making by either manager or drivers are correlated with the other. Then，SP factors generated from a hearing meeting with the company stuffs only impose significant influence on manager's route choice behavior. Whereas, no significant influencing impact could be observed on truck driver's decision making behaver.

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**Table 3. Model Estimation Results of Bivariate Probit model**

| | Driver choice model | | | Manager choice model | | |
|---|---|---|---|---|---|---|
| | Coef. | z-value | sig | Coef. | z-value | sig |
| *Stated Preference factors* | | | | | | |
| Compensation provide to company with insurance | -0.20 | -0.27 | | 3.10 | 3.52 | *** |
| Compensation provide without any constrain | 0.004 | 0.02 | | 0.06 | 0.26 | |
| Traffic jam on Sanyo road every per 10 times drive | -0.20 | 1.26 | | -0.29 | 1.54 | |
| Traffic jam on Sanyo road every per 5 times drive | -0.20 | 0.51 | | 1.33 | -2.8 | *** |
| 3000 yen refund on Chugoku road | -0.04 | -0.12 | | 1.70 | 4.4 | *** |
| 2000 yen refund on Chugoku road | 0.36 | 0.53 | | -2.86 | -3.49 | *** |
| Fragile goods | -0.39 | -1.23 | | 1.02 | 2.57 | ** |
| *Image on Chugoku road compare with Sanyo road (1~5, satisfied to unsatisfied)* | | | | | | |
| Safety | 0.04 | 0.36 | | 0.41 | 2.19 | ** |
| Be relieved | -0.24 | -1.78 | * | -1.00 | -4.35 | *** |
| Brightness | -0.08 | -1.42 | | 0.33 | 1.95 | * |
| Non-irritable | 0.15 | 1.99 | ** | -0.06 | -0.39 | |
| Calm | -0.13 | -1.24 | | 0.11 | 0.53 | |
| Non-monotonous | -0.06 | -0.83 | | 0.23 | 1.67 | * |
| *Driver specified factors* | | | | | | |
| Experience of Sanyo road usage | -0.95 | -3.63 | *** | | | |
| Deicision maker of sanyo road usage: driver | 0.02 | 0.13 | | | | |
| Experience of Chugoku road usage | 0.47 | 2.72 | *** | | | |
| Decision maker of Chugoku road usage: driver | 0.08 | 0.44 | | | | |
| Age | -0.10 | -1.29 | | | | |
| Professional driving age | 0.01 | 0.7 | | | | |
| Flexible workday | -0.21 | -1.63 | | | | |
| Working period: 9am~12am | -0.04 | -0.26 | | | | |
| Working period: 12am~6pm | 0.20 | 1.21 | | | | |
| Working period: 6pm~10pm | 0.06 | 0.43 | | | | |
| Working period: 10pm~2am | -0.06 | -0.37 | | | | |
| Working period: 2am~9am | 0.31 | 1.68 | * | | | |
| Vehicle type_1:wing | -0.22 | -1.46 | | | | |
| Vehicle type_2: dry van | -0.11 | -0.62 | | | | |
| Vehicle type_3: flat body | 0.06 | 0.27 | | | | |
| *Manager specified factors* | | | | | | |
| Share of target expressway usage | | | | -0.02 | -5.98 | *** |
| Road decision maker: manager | | | | 0.20 | 0.81 | |
| Road decision maker: situational | | | | 0.07 | 0.29 | |
| M_route selection reason: travel time | | | | -0.62 | -2.99 | *** |
| M_route selection reason: travel cost | | | | -0.24 | -1.18 | |
| M_route selection reason: travel safety | | | | -1.23 | -6.17 | *** |
| *Experiential factors from drivers* | | | | | | |
| Frequency of traffic jam experience | 0.17 | 4.46 | *** | 0.1523 | 3.65 | *** |
| Frequency of self-traffic accident experience | 0.21 | 4.04 | *** | 0.19821 | 3.41 | *** |
| Frequency of vehicle malfunction experience | 0.005 | 0.08 | | -0.0081 | -0.13 | |
| *Insurance factors* | | | | | | |
| Human/object insurance | 0.77 | 3.72 | *** | 0.85 | 3.03 | *** |
| Self-vehicle insurance | -0.57 | -2.91 | *** | -0.54 | -2.62 | *** |
| Tow truck fee insurance | 0.78 | 3.84 | *** | 0.62 | 2.67 | *** |
| Other type of insurance | -0.13 | -0.58 | | 0.06 | 0.23 | |
| *General factors from Manager* | | | | | | |
| Satisfaction with road information | 0.15 | 1.33 | | 0.16 | 1.05 | |
| High frequency expressway usage contract | 0.54 | 2.85 | *** | 0.54 | 1.9 | * |
| Total vehicle ownership | 0.009 | 3.7 | *** | 0.008 | 3.22 | *** |
| Number of employees | -0.06 | -0.45 | | 0.12 | 0.81 | |
| Business volume | -0.07 | -1.31 | | 0.14 | 1.97 | ** |
| Constant terms | -1.21 | -1.26 | | -4.10 | -3.11 | *** |
| athrho | 1.60 | 5.58 | *** | | | |
| Rho | 0.92 | 21.48 | *** | Significant level: “***”99%, “**”95%, and “*” 90%. | | |