

学位論文の要旨 (論文の内容の要旨)
Summary of the Dissertation (Summary of Dissertation Contents)

論 文 題 目
Dissertation title

Analysis of Multi-faceted Driving Risks on Expressways and Drivers' Responses to Information Provision

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The research emphasizes the roles of information provision in helping drivers to develop a better understanding of their daily driving risks and to voluntarily modify their driving behaviors for reducing driving risks and adapting to the occurrence of traffic accidents. Research purpose are twofold. The first purpose is to mitigate driving risks by focusing on the role of contradictory use of smartphones, and the second is to mitigate the impacts of traffic accidents on drivers' travel choices. Both purposes further focus on dynamic traffic information provision on expressways in Japan. Concretely speaking, this study examines whether smartphone apps with diagnosis functions of driving risks and dynamic information provision should be promoted or not by targeting drivers' internal driving risks. On the other hand, this study clarifies drivers' adaptation and avoidance behaviors under the influence of dynamic information provision by targeting drivers' external driving risks.

In summary, this research is consists of 8 Chapters. Chapter 1 provides introductory information related, including research background and motivations, objectives and contributions. Literature review is given in Chapter 2, and data are explained in Chapter 3, where the smartphone app Safety Supporter is also described. Here, other chapters are briefly illustrated. Chapters 4 – 6 are prepared for the first research purpose, and Chapters 6 – 7 for the second research purpose, where Chapter 6 connects the two research purposes via avoidance behavior analysis.

Chapter 4 focuses on short-term effects of the smartphone app on second-by-second driving risks, where various functions of the app are emphasized. First, effects of the app Safety Supporter on driver's over-speeding behavior are evaluated based on the ZINBR model, where heterogeneity across drivers is reflected in terms of behavioral change stages related to driving safety. Second, drivers' compliance of speed limit and control behavior of acceleration and deceleration are jointly estimated by employing the BOP model to explicitly accommodate the influence of correlations between the two driving behaviors. Totally, 187,549 epochs (calculated every two seconds) were extracted from 201 trips made by 15 drivers. Model estimation results show that more evidence supporting the use of smartphone apps is found with respect to improving drivers' safety instantly. Effects of some additional functions of the app on improvement in driving risks are mixed. It is further revealed that drivers' heterogeneous driving propensity should be properly considered when deploying individualized traffic safety measures in practice.

Chapter 5 deals with drivers' safe driving performance at the trip level. Here, an extensive set of behaviors related to driving safety are targeted, including driving risks measured by violation rates of speed limit compliance, acceleration/deceleration, and driving stability, multitasking behaviors and affective experiences (measured in terms of different moods) during driving. To reflect potential correlations and behavioral dependencies existing in the above behaviors, the SURE model is adopted. As a result of data matching and cleaning, 353 trips made by 13 drivers were extracted for analysis. Analysis results confirm the significant long-term influencing impact of the Safety Supporter. The importance of driving safety self-recognition is confirmed. It is necessary to incorporate subjective well-being factors and multitasking behavior during driving in driving risk studies. With the results from Chapters 4 and 5, it is further revealed that some of the effects on driving performance are not consistent with the two measurement scales: i.e., second-by-second and trip levels. This

suggests the necessity of paying sufficient attention to the measurement scale in evaluating traffic safety measures for avoiding any misleading policies. Nevertheless, it is found that the developed app is surely effective to improve driving safety, especially in terms of speed limit compliance, and a relatively high level of acceptance of using such apps in future is also confirmed.

Chapter 6 focuses on drivers' avoidance behaviors from two perspectives by responding to their internal and external risks. Firstly, for drivers' internal risks, four types of driving avoidance behaviors, including punishment avoidance, weather-related avoidance, traffic-related avoidance, and riding avoidance, are targeted with their associations of affective experiences and multitasking behavior during driving and three driving risk indicators are jointly estimated by using the SURE model. Results show that driving avoidance behaviors are statistically affected by speed limit compliance, driving stability, bad moods during driving, and multitasking behaviors in terms of mental distraction and radio operation. It is further revealed that the four types of driving avoidance behaviors also significantly influence driving risks, especially speed limit compliance level. Secondly, concerning drivers' external risks, a case study is conducted regarding choices of truck driving routes in the Chugoku Region of Japan, called Chugoku Expressway and Sanyo Expressway, which have different levels of traffic accidents and the resulting congestion. Based on a combined revealed preference (RP) and SP questionnaire survey conducted in 2014 and 2015, totally, 525 valid observations on choices of truck driving routes obtained from 54 companies (a manager of truck operation and several truck drivers from each company) with respect to different SP scenarios. The BP model is employed to jointly estimate the potential factors that would significantly influence both company managers' and drivers' decisions on choosing expressway routes for avoiding risks caused by uncertain travel time. Model estimation results indicate that for truck drivers who frequently use expressways, avoidance behavior are significantly influenced by types of insurances purchased by their companies, and their experiences of encountering serious traffic congestion and traffic accidents. In contrast, the avoidance behavior of company managers is more likely to be influenced by the factors of road congestion information, characteristics of delivery goods (especially, fragile goods), and incentives of avoiding use of congested routes.

Chapter 7 provides evidence on drivers' travel choice behaviors by adapting to the occurrence of traffic accidents for mitigating the resulting impacts. Here, the adaptation behavior is classified into no change in behavior; changes with respect to departure time, driving route, travel mode, and/or wait and see behavior on expressway; and trip cancelation, depending on three major decision contexts: before departure, on the way to expressway, and on expressway. The following dynamic traffic-related information attributes are defined by reflecting each driver's personal tastes: accident condition factors (relative location and severity of traffic accidents), accident impact factors (queue length and changes due to accident-induced congestion), alternative routes or travel modes, and traffic management factors (traffic regulation, estimated clearance time of congestion, estimation accuracy of clearance time, probability of clearing away the congestion at a certain length of clearance time, and clearance time provision method). For this part of this thesis study, an SP survey was implemented by collecting 30,000 SP responses from 2,500 expressway drivers. Analyses based on the NL model first found that interval values (rather than point-based values) of clearance time of traffic congestion play a considerably larger role in influencing drivers' adaptation behavior than other information contents and especially, the influences become larger and larger moving from "before departure" to "on the way to expressway" and to "on expressway". To further confirm the effectiveness of provided information by reflecting drivers' heterogeneous responses, a new concept of travel information style was proposed. As a result of the K-means cluster analysis, three types of travel information styles are derived: high dependence on information for relatively inflexible trip-making, high dependence on experience for risky trips, and least information users by investigating an extensive set of travel information search and usage items collected from the RP survey. Analysis results show that driver's behavioral responses among three information styles are considerably different under different decision contexts. Context-sensitive travel information targeting drivers with different travel information styles should be provided in the traffic management practice.

Chapter 8 summarizes the findings, implications, limitations of this thesis, and directions for future research.

Major findings of this study can be summarized from two folds. Firstly, findings related to the first research purpose, data and modeling analysis results have revealed both positive and negative evidence on promoting use of smartphone apps in traffic safety practices, where positive evidence is more prevalent. Furthermore, it is revealed that there are complicated associations between driving risks, affective experience and multitasking during driving as well as driving avoidance behaviors. However, evidence is mixed depending on different types of driving propensities and measurement scales of driving risks. All the above results re-confirm the importance and necessity of as well as difficulties in reflecting drivers' various heterogeneities (measured in terms of both objective attributes and subjective attributes) in traffic safety measures. Such findings implies that policy makers may need to encourage more risky drivers in traffic safety practices. On the

other hand, in terms of findings related to the second research purpose, drivers' adaptation behaviors to the occurrence of traffic accidents on expressways are context-sensitive in terms of drivers' decision timings. The adaptations further vary with drivers' travel information styles measured by the dependence level on information and types of trips. It is revealed that interval values (rather than point-based values) of clearance time of traffic congestion play a much larger role in influencing drivers' adaptation behavior to abnormal driving situations caused by traffic accidents than other information contents. Especially, the role grows before departure to on expressway.

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