"Technical Research and Development for Road Policy Quality Improvement" Study Summary

No.	Title	Principal Researcher
No.24-3	Research & Development for the Evaluation and Management of Travel Time Reliability	Tokyo Institute of Technology Assoc. Prof. Daisuke Fukuda

This study developed economic evaluation method of travel time reliability improvement due to road projects and also developed dynamic route guidance system considering travel time uncertainty. More specifically, we conducted the following subthemes: (1) Establishment and verification of valuation method of travel time reliability, (2)-1 Development of hyperpath-based risk averse route recommendation algorithms and vehicle navigation systems, (2)-2 Examination of market-diffusion effects of risk-averse route guidance through agent-based traffic simulation.

1. Background and Objective

Since road investment would contribute not only to (mean) travel time savings but also to the improvement of travel time reliability, it is highly expected to examine the economic benefit of reliability improvement and to explore the possibility that it would be incorporated into the guideline/practice of cost-benefit analysis for road projects. On the other hand, each driver would have higher expectation for utilizing vehicle navigation systems that would recommend "Reliable Routes" by which the punctuality of journey travel time is significantly assured. This study developed economic evaluation method of travel time reliability improvement due to road projects and also developed dynamic route guidance system considering travel time uncertainty. More specifically, we conducted the following subthemes: (1) Establishment and verification of valuation method of travel time reliability, (2)-1 Development of hyperpath-based risk averse route recommendation algorithms and vehicle navigation systems, (2)-2 Examination of market-diffusion effects of risk-averse route guidance through agent-based traffic simulation.

2. Activity during Research Period

[2013]   ("a" denotes valuation studies and "b" denotes management ones)

a-1. Comprehensive review of theory and practice of valuing travel time variability

a-2. Development of an integrated approach for appropriately valuing travel time variability

a-3. Development of prototype models for forecasting travel time variability with projects

b-1. Comprehensive review of study and practice on reliable routing under travel time uncertainties

b-2. Development of hyperpath-based risk averse route recommendation algorithms and its verification

[2014]

a-4. Preliminary investigation and estimation of reliability benefit for an actual urban expressway project

a-5. Development of a prototype method for evaluating network-wide reliability with mathematical statistics approach

b-3. Implementation of reliable routing for a cloud-based web system

b-4. Development of a prototype of an agent-based traffic simulation for evaluating market-diffusion effects

[2015]

a-6. Further investigation of a case study of reliability benefit evaluation and exploring the simplification of the method

a-7. Theoretical analysis of social marginal cost of travel time variability

b-5. Development "HyperNav" (Android Apps) for vehicle navigation and its verification through field experiments

b-6. Enhancement of an agent-based traffic simulation and evaluation of market-diffusion effects on an actual network

3. Main Results

(1) We developed an integrated approach for valuing travel time variability. The method is consistent with microeconomic theory and the economic benefit is simply measured as the reduction of the standard deviation of travel times multiplied by value of reliability. Hence the method has a large potential of being applied in practice. Case studies indicated that the share of reliability improvement benefit accounts for about 20% of the total user benefits. Hence, we found reliability improvement benefit not to be negligible.

(2) We developed a risk-averse route guidance criterion and its accelerated algorithms for navigation, based on the optimal strategy with the concept of hyperpath. Further we developed a server-client system for actual applications of the proposed route guidance algorithms. The field experiment revealed that the proposed route guidance indeed significantly would improve the reliability of travel times along the recommended routes in an actual traffic network.

(3) We developed an agent-based microscopic traffic simulation that enables to evaluate the market-diffusion effects of the proposed hyperpath-based route recommendation and its impacts on network traffic. Through day-to-day simulation runs, we revealed that the market penetration of such intelligent route guidance indeed would reduce average journey travel time as well as network-level travel time reliability, particularly at higher penetration rates. The similar pattern was also observed in an application to actual large-scale traffic network with arterial roads in Tokyo.

4. Representative Research Papers

[1] **Fukuda, D.**, Ma, J., Yamada, K. and Shinkai, N. (forthcoming) Tokyo: Simulating hyperpath-based vehicle navigations and its impact on travel time reliability. In: Horni, A., Nagel, K. and Axhausen, K. (Eds.) *The Multi-Agent Transport Simulation MATSim*, Chapter 78.

[2] Ma, J. and **Fukuda, D.** (forthcoming) A hyperpath-based network generalized extreme-value model for route choice under uncertainties. *Transportation Research Part C: Emerging Technologies.*

[3] Xiao, Y. and **Fukuda, D.** (2015) On the cost of misperceived travel time variability. *Transportation Research Part A: Policy and Practice*. Vol.75, pp.96-112.

[4] Ma, J., Schmöcker, J.-D. and **Fukuda, D.** (2013) Faster hyperpath generating algorithm for vehicle navigation. *Transportmetrica*. Vol.9, pp.925–948.

[5] Fosgerau, M. and **Fukuda, D.** (2012) Valuing travel time variability: Characteristics of the travel time distribution on an urban road. *Transportation Research Part C: Emerging Technologies*, Vol.24, pp.83–101.

5. Future Issues

Regarding economic valuation, the following issues still remain to be further studied: (1) Development of survey method for estimating value of reliability, (2) Development of practical guideline for the utilization of the integrated approach, (3) Improvement of the predictive accuracy of forecasting models of travel time variability, and (4) Consistent integration with traffic assignment models.

Also, regarding route guidance, the following issues still remain to be further studied: (1) Further speed up of hyperpath search algorithms, (2) Improvement of user interfaces of Apps, (3) Accumulation of field experiments data for credibility of the results, and (4) Evaluations of various transport policies for reducing network-level travel time reliability with the developed agent-based simulation.

6. Contribution to the Quality Improvement of Road-related Policies

We advocate that the results of the subtheme (1) would directly contribute to methodological advancement of economic evaluation of road project by further incorporating travel time reliability benefit. By considering the general tendency of Japanese people emphasizing on time punctuality, the share of reliability benefit would be expected to be further larger. It would become further distinct in the case of freight vehicle traffic. The developed approach could serve as one of the new insights for considering the guideline of cost-benefit analysis for road projects.

The results of the subtheme (2)-1 would imply that it is possible to new technology leading to the optimal route guidance under travel time uncertainties. One of the major concerns by drivers would be unreliability in travel times and hence the development of reliable routing system with easy handing would directly enhance the utility for driving. Particularly, the developed system might be commercialized in the future if the Apps and its interfaces are further improved. Also the subtheme (2)-2, in relation to (2)-1, confirms the potential benefit of the market diffusion of reliable routing into the society. With further advancement of the proposed traffic simulator, the developed tool would be utilized for evaluating some transport policies for improving network-wide travel time reliability.

7. Reference Website

http://fukudalab.hypernav.mobi/