

# New England University Transportation Center



NE University Transportation Center  
77 Massachusetts Avenue, E40-279  
Cambridge, MA 02139  
Phone: 617-253-0753  
Fax: 617-258-7570  
web.mit.edu/utc

**Principal Investigator:** Song Gao  
**Title:** Assistant Professor  
**University:** University of Massachusetts Amherst  
**Email:** sgao@engin.umass.edu  
**Phone:** 413-545-2688

**Co-Principal Investigator:** Donald Fisher  
**Title:** Professor  
**University:** University of Massachusetts Amherst  
**Email:** [fisher@ecs.umass.edu](mailto:fisher@ecs.umass.edu)  
**Phone:** 413- 545-1657

## Final Report

*Project Title:*

# Adaptive Route Choice Modeling in Uncertain Traffic Networks with Real- Time Information

**Project Number:**

UMAR21-11

**Project End Date:**

April 30, 2013

**Submission Date:**

March 31, 2013

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or the use thereof.

The New England University Transportation Center is a consortium of 8 universities funded by the U.S. Department of Transportation, University Transportation Centers Program. Members of the consortium are MIT, the University of Connecticut, University of Maine, University of Massachusetts, University of New Hampshire, University of Rhode Island, University of Vermont and Harvard University. MIT is the lead university.

## **Problem Addressed**

The objective of the research is to study travelers' route choice behavior in uncertain traffic networks with real-time information. The research is motivated by two observations of the traffic system: 1) the system is inherently uncertain with random disturbances such as incidents, bad weather, and work zones, and therefore travel times are at most known with uncertainty; 2) traveler information is or will be available so that travelers could make travel decisions adaptive to the random disturbances to reduce negative effects of uncertainty. Two central research questions to be answered are: 1) Can we build and estimate an econometric model for travelers' *en route* updating of route choices? 2) Can such a model provide more realistic prediction of travelers' route choices than existing ones?

## **Approach and Methodology**

### *Stated Preference (SP) Survey*

The survey was designed to measure two aspects of the subjects' route choice behavior: risk attitude and strategic thinking. To this end, the survey was designed using two map types: a "simple risk" map and a "strategy" map, where the former eliciting risk attitude and the other allowing for strategic route choice with a detour to an incident-prone road segment and real-time traffic information. A wide range of travel time scenarios is presented using the same map topology, to collect a large number of data points from a subject. The survey was conducted using interactive graphical maps with a point-and-click interface. The survey was presented to subjects as a graphical map. The survey was taken by 74 individual subjects, with a total of over 3400 observations. Subjects were recruited from the University of Massachusetts student and staff community, as well as the surrounding area.

### *Modeling Strategic Behavior*

The preliminary analysis suggests that a traveler's risk attitude is probability-dependent. A rank-dependent expected utility (RDEU) model is adopted to account for such a phenomenon, where the decision weight of a probabilistic outcome depends on its ranking among all outcomes and a non-linear transformation of the cumulative probability. A latent-class mixed Logit model for panel data is specified with a RDEU component and two latent classes, strategic and non-strategic route choice. The model is compared with other state-of-the-art models for choice under risky, including the mean-variance, mean-standard deviation, and expected utility models.

## **Conclusions and Recommendations**

The preliminary analysis of the SP data showing that a traveler's risk attitude depends on the probability of an outcome in a risky travel time prospect. In the estimated latent-class mixed Logit model for panel data with two latent classes, the strategic class probability is significantly different from both 0 and 1, which suggests that both strategic and non-strategic route choice behavior exist and a proper route choice model under real-time traffic information should consider both. Two RDEU parameters are treated as lognormal random variables distributed over individuals. The exponent of the value function is less than one for almost all travelers, suggesting a diminishing sensitivity to travel time, which is both intuitive and consistent with the economics literature where outcomes are measured by monetary payoffs. The probability weighting function parameter is less than one for almost all travelers, suggesting a pronounced inverted S-shaped curve. Together, the value and weighting functions, with their estimated parameter values, explain the observation of probability-dependent risk attitude.

We compare the RDEU model specifications with the conventional linear-in-parameter specifications. As the purpose of model development is to predict travel choices, the interaction models from the Mean-STD and Mean-VAR groups are not generally applicable due to the lack of predictive capabilities. In this sense, the RDEU models are far superior with a best model fit of 0.327 compared to 0.217 of the Mean-STD model. Even if we ignore the predictive capability, the best Mean-STD model fit (0.324) is still not as good. Furthermore, the RDEU model parameters have clear interpretations, representing sensitivities to outcomes and probabilities. The Mean-STD interaction models, however, seem to simply fit the data without providing much insight into the underlying behavior.

## **Outcomes**

### *Journal Publications*

Razo, M. and Gao, S. (Forthcoming). A Rank-Dependent Expected Utility Model for Strategic Route Choice with Stated Preference Data. *Transportation Research Part C*. doi:10.1016/j.trc.2011.08.009

Razo, M. and Gao, S. (2010). Strategic Thinking and Risk Attitudes in Route Choice: A Stated Preference Approach. *Transportation Research Record* 2156:28-35. doi:10.3141/2156-04

### *Conference Proceedings*

Tian, H., Gao, S., Fisher, D. L. and Post, B.\* A Mixed-Logit Latent-Class Model of Strategic Route Choice Behavior with Real-time Information. *The 91st Annual Meeting of Transportation Research Board Compendium of Papers*. Paper #12-2867. Washington, DC, Jan. 22-26, 2012.

Razo, M. and Gao, S.. Strategic Thinking and Risk Attitudes in Route Choice: A Stated Preference Approach. *The 89th Annual Meeting of Transportation Research Board Compendium of Papers DVD*. Paper #10-3915. Washington, DC, Jan. 10-14, 2010.

### *Conference Presentations*

Tian, H., Gao, S., Fisher, D. L. and Post, B. A Mixed-Logit Latent-Class Model of Strategic Route Choice Behavior with Real-time Information. The 91st Annual Meeting of Transportation Research Board. Washington, DC, Jan. 22-26, 2012.

Razo, M. and Gao, S. A Prospect Theory Model for Strategic Route Choice with Stated Preference Data. The Annual Meeting of the Institute for Operations Research and Management Science, Austin, TX, Nov. 7-10, 2010.

Razo, M. and Gao, S. Modeling Strategic Route Choice Behavior: A Cumulative Prospect Theory Approach. The European Transport Conference (ETC). Glasgow, UK, Oct. 11-13, 2010.

Razo, M. and Gao, S. Risk Taking and Strategic Thinking in Route Choice: A Stated-Preference Experiment. The Seventh Triennial Symposium on Transportation Analysis. Tromsø, Norway, Jun. 20-25, 2010.