

Center for Teaching Old Models New Tricks (TOMNET)

A USDOT Tier 1 University Transportation Center

PROJECT PROPOSAL

Title: Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modeling

Principal Investigator: Michael Maness, Postdoctoral Research Scholar, Department of Civil and Environmental Engineering, University of South Florida

Co-Principal Investigator: Fred Mannering, Professor, Department of Civil and Environmental Engineering, University of South Florida

1. Introduction/Problem Statement

In recent years, a number of new econometric methods have been introduced that have the potential to introduce attitudinal effects in travel-behavior models in new ways. Many of these methods have, at their core, an approach to address unobserved heterogeneity (factors affecting outcomes but unobserved to the analyst). Many studies in travel behavior and safety analysis have found unobserved heterogeneity to be statistically significant. However, this presents a problem for the interpretation of model results and forecasting because we do not know the source of the unobserved heterogeneity. One could argue, however, that unobserved heterogeneity is really capturing the effects of attitudes and social interaction as well as other potentially measurable factors. But applied work in travel behavior and safety analysis has limited guidance in ways to measure and test for these effects.

The intent of this study is first to review the extant literature of unobserved heterogeneity and the econometric methods used to account for it (Mannering et al., 2016). Then, using contemporary heterogeneity modeling approaches, such as those that capture heterogeneity in the means and variances of parameters, explore the potential influence of attitudinal variables on unobserved heterogeneity. In the extreme case, attitudinal variables could be responsible for much of the unobserved heterogeneity and, if so, the inclusion of attitudinal variables would make spatial and potentially temporal transferability of models possible (both temporal and spatial transferability are highly suspect in traditional heterogeneity models, Mannering 2018). This project will focus primarily on two such variables for inclusion: social capital and opinion change/polarization.

The collection of interpersonal (social) network data and its incorporation into activity and travel behavior models is a growing area of travel behavior research (Maness et al 2015). Prior research has found evidence of a link between strong and weak social connections and variations in activity behavior (Maness 2017). This study will propose to explore the theoretical significance of social capital on leisure activity behavior and residential choice. A social networks perspective provides values in understanding changes in the spatial distribution of social networks and activities. These efforts will lay foundational steps into developing social network-based activity-based modeling frameworks capable of predicting travel patterns under the adoption of disruptive technologies and analyzing socially-focused policy factors such as social isolation.

There is a relatively extensive body of theoretical literature that looks at factors that might make people more or less likely to change their opinions as additional information is gathered. People whose opinions are less likely to change in response to information may have strong commitments to their initial

opinions and others may support their initial opinion by selectively processing information to confirm their initial opinion. The selective processing information can lead to opinion polarization where opinions become more extreme as additional information is provided (Benoit and Dubra, 2017). That is, the process by which people with a diverse initial opinions/attitudes on a subject are provided with the same information only to have their opinions diverge even more (or polarize). In one of the early studies on this polarization tendency, Lord et al. (1979) presented the same mixed evidence on the effectiveness of the death penalty in deterring crime to two types of individuals; those disposed to believe in the deterrence effect and those disposed to doubting it. With the same information both groups of individuals became more confident in their initial death-penalty/deterrence attitudes. Those believing in deterrence cited the general upward trend in crime as the reason that all locations did not go down in absolute terms. Those doubting deterrence cited the mixed results among locations as evidence of inconclusive results thus supporting their doubts. While theoretical literature opinion changing has been relatively abundant, there has been limited empirical evidence relating to transportation-related opinions and how they might change in response to additional information.

2. Project Objectives

Considering the above background, the objectives of this project include:

1. Examining the literature on methods used to model the relationship between attitudes and social factors and behavior (including literature from psychology, sociology, cognitive science, neuroscience, and economics) and reviewing the role that changing attitudes (and other factors) may have on the temporal stability of estimated model parameters
2. Exploring the role that unobserved heterogeneity plays when attitudes are considered in estimated models and developing and applying models that account for unobserved heterogeneity, particularly in relation to attitudinal and social factors
3. Analyzing a social network, leisure activity, and emerging technology attitudinal dataset to explore the effects of social capital on activity behavior and social learning on adoption of emerging technologies.
4. To empirically model attitude/opinion change and polarization behavior in travel contexts

3. Proposed Methodology and Data

To address some of the analysis objectives, this project will utilize recently collected survey data from two sources. The first source is a questionnaire on consumers' perceptions, intended adoption, and anticipated travel behavior impacts of automated-vehicle technologies. The survey was conducted in 2015 for two different target populations: (1) the students, faculty, and staff of a large university (University of South Florida), and (2) the membership of the AAA foundation for traffic safety in the United States. The research team possesses data of about 3000 individuals from these target populations. This survey was broken up into three parts including: (1) respondent and household characteristics, (2) perceptions of advanced safety features and autonomous vehicles, and (3) anticipated impacts of autonomous vehicles (Menon et al. 2016). This simultaneous collection of perceptions and anticipated impacts allows for the estimation of models that can link demographics and perceptions in models of travel choice. The dataset provides Likert scale measurements of respondents' familiarity and level of comfort with automated-vehicle technology as well as their perceived benefits and expectations for the technology. To explore changing opinions, the survey first asks respondents their likelihood of adopting an autonomous vehicle. Then, respondents are asked about various detailed aspects of autonomous vehicle characteristics and likely performance. After this, we ask the same adoption-likelihood question again to see how their adoption opinions may have changed. We propose to estimate a series of decision-change models that seeks to understand various respondent characteristics that make them more or less likely to change their opinion. Most likely these decision-change models will be discrete response models with random parameters to account for heterogeneity.

The second data source is a web-based survey of US residents currently being conducted that explores leisure activity frequency and use and attitudes towards autonomous vehicles. It is expected that a sample of 1000 respondents nationally will be used. To explore activity variety and frequency, ordered choice or count data models will be used. These will have a similar form to those used in Maness' (2017) prior work but will have a more extensive activity list. Additionally, the incorporation of social capital data from a position generator instrument and other interpersonal network information will be incorporated into these models. Although these indicators can be incorporated directly, they are just indicators of more general constructs (such as social capital and access to social resources). As such hybrid models will be used to form latent variables of the social constructs which will be incorporated into the traditional count and discrete choice models. Particularly, the use of integrated latent variable and choice models in the analysis of social interactions (Karmiganni et al. 2014, Calastri et al. 2018) is a relatively unexplored area of empirical and methodological research. We propose to use such a model (or a similar one) to aid in analyzing causal relationships between activity behavior and social capital.

4. Work Plan (Project Tasks)

The objectives of this study will be accomplished through three tasks including: (1) methodological review and modeling efforts on using attitudes and social factors to account for unobserved heterogeneity, (2) developing a social capital theory of activity behavior, and (3) empirical study of opinion/attitude change and polarization.

Task 1: Methodologies to account for unobserved heterogeneity through attitudes and social factors

An abundance of research in transportation safety and travel behavior has provided empirical evidence that estimated model parameters may vary over time. Attitudes may provide insights as to why this may be the case, and can be potentially used to track temporal shifts. However, from an estimation perspective, unobserved heterogeneity and how it is handled could also influence the apparent effect of attitudes and social interactions and their effect over time. Two sub-task review/position papers will be undertaken to provide a benchmark for future TOMNET work:

- 1.1 Review/position paper on relationship between attitudes and behavior: Undertake a review/position paper that examines the literature on methodologies to account for unobserved heterogeneity using attitudes and behavior (including literature from psychology, cognitive science, neuroscience, and economics), and review the role that changing attitudes (and social effects) may have on the temporal stability of estimated model parameters.
- 1.2 Review/position paper on relationship between social factors and behavior: Undertake a review/position paper that examines the literature on discrete choice modeling methodologies to account for social influence in choice behavior research.
- 1.3 Modelling unobserved heterogeneity and attitudes: Explore ways to incorporate attitudes in heterogeneity models by having attitudes account for heterogeneity in means and variances of model-estimated parameters. Also, assess potential limitations of ordered probability models in their ability to account for unobserved heterogeneity and attitude variations.

Task 2: Developing a social capital theory of activity behavior

Task 2 explores the connections between activity variety and frequency and social capital. Data was collected prior that included activity behavior, weak social tie characteristics, autonomous vehicle perceptions, travel behavior, and respondent characteristics. This task Four sub-task review/position papers will be undertaken to provide a benchmark for future TOMNET work:

- 2.1 Compilation of network, activity, and travel dataset: After screening and cleaning the survey data, the team will compile electronic databases and thoroughly document the data. Data validity will be checked and documented. A detailed data dictionary and description of the data collection methodology will be prepared to support permanent data archival.

- 2.2 Perform exploratory study of activity variety and psychological need: The dataset will be used to test the theory that activity frequency and variety are affected by access to social resources from weak/loose social ties. Additionally, the psychological needs of activities vary by activity type and there is limited understanding of how this relates to the frequency and variety of activities pursued as well as to spatiality and travel availability. This task will set out to explore this connection.
- 2.3 Develop and implement models with social network and social capital data: Advanced count data choice models, such as integrated choice and latent variable (ICLV) models, will be developed to examine the impacts of social capital on activity behavior and intended usage of autonomous vehicles. In doing so, modeling methods will be developed to recognize and address the multidimensional nature of social capital indicators (as opposed to the typically used approach of treating indicators as unidimensional variables).
- 2.4 Develop and document estimation software: After the development of choice models that incorporate social capital data, the team will refactor the code used. Documentation on how to use the software and example code paired with the data compiled in Task 2.1 will be provided. The code and documentation will be provided on a publicly accessible website.

Task 3: Empirical Study of Opinion/Attitude Change and Polarization

As discussed earlier, the research team has already collected data on perceptions, intended adoption, and anticipated travel behavior impacts of automated vehicle technologies from the students, faculty, and staff of USF and the members of the AAA foundation for traffic safety. This data will be analyzed to understand how individuals' attitudes toward the potential benefits and concerns of the automated vehicle technology changed after possible benefits and concerns for automated vehicles were raised. This task will involve the development of a model to describe the respondent characteristics that affect susceptibility to opinion/attitude change. A working paper describing this empirical study will be written and submitted to a peer-reviewed journal.

5. Project Schedule

The proposed project schedule is shown in the table below. It is expected that milestones will be accomplished after each subtask (at the end of that subtask’s final month). These are denoted in parentheses below the task labels.

Subtasks	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1.1 Review methodologies to account for unobserved heterogeneity through attitudes (Literature review completed)												
1.2 Review methodologies to account for unobserved heterogeneity through social factors (Literature review completed)												
1.3 Modelling unobserved heterogeneity and attitudes (Discussion paper completed)												
2.1 Compilation of network, activity, and travel dataset (Dataset prepared)												
2.2. Perform exploratory study of activity variety and psychological need (Working paper on activities completed)												
2.3 Develop and implement models with social network and social capital data (Working paper on social capital completed)												
2.4 Develop and document estimation software (R code developed) (Final technical report completed)												
3 Develop and implement models of polarization (Working paper on polarization completed)												

6. Relevance to the Center Theme/Mission

This project’s application area in autonomous vehicles and vehicle safety features directly addresses FAST Act Research Priorities in (1) improving mobility of people and goods, (2) reducing congestions, and (3) promoting safety. This project will contribute to TOMNET’s mission to address barriers related to inclusion of attitudes in travel and safety models. This will be done through data collection and analysis of attitudinal data. Additionally, the project seeks to develop code to estimate models with attitudinal data as well as to produce research addressing whether collecting attitudinal and social data can aid in addressing unobserved heterogeneity. In analyzing new data on social networks for social learning and polarization, this project will attempt to develop data procedures to understand and forecast changes in perceptions and attitudes. Addressing social effects in attitude formation will contribute to TOMNET’s other mission to address barriers related to forecasting attitudes similarly to socioeconomics.

7. Anticipated Outcomes and Deliverables

The project will result in the following deliverables:

1. Three working papers prepared for future submission to peer-reviewed journals
2. A technical report detailing the three phases of the project
3. Publicly available version of the activity behavior and social capital dataset
4. Publicly available software to estimate choice models incorporating social capital data

8. Research Team and Management Plan

Fred Mannering is currently the Associate Dean for Research in the College of Engineering and a Professor of Civil and Environmental Engineering (with a courtesy appointment in Economics) at the University of South Florida. His research interests are in the application of econometric and statistical methods to a variety of engineering problems, highway safety, transportation economics, automobile demand, and travel behavior. He has published extensively in these fields with over 130 journal articles and has coauthored two books: *Principles of Highway Engineering and Traffic Analysis* and *Statistical and Econometric Methods for Transportation Data Analysis*. He is also Editor-in-Chief of the journal *Analytic Methods in Accident Research* and previous Editor-in-Chief (2003-2012) and current Associate Editor for *Transportation Research Part B*.

Michael Maness is a Postdoctoral Research Fellow in the Department of Civil and Environmental Engineering at the University of South Florida. His research interests are in the methodology and application of behavioral modeling in urban and regional systems. His dissertation, which was awarded the 2015 Eric Pas Dissertation Prize, involved incorporating social interactions into activity and travel behavior models. Maness is experienced in advanced choice models with applications to activity behavior, car ownership, autonomous vehicles, electric vehicles, managed lanes, cycling, and communication behavior. His professional experience includes a postdoc at Oak Ridge National Laboratory and a graduate research fellowship at Turner-Fairbank Highway Research Center. He has published articles in top transportation journals including *Transportation Research Part B*, *Transportation Research Part A*, and *Journal of Transport Geography*.

The team will be led by Michael Maness. Primary research responsibilities for (1) analyzing activity behavior and social capital will fall on Michael Maness and (2) understanding the role of unobserved heterogeneity and polarization will fall on Fred Mannering. The team is expected to have internal communications biweekly and communication with the greater TOMNET team monthly. The PI and Co-PIs will supervise the student researchers with direct weekly reporting.

9. Technology Transfer Plan

The technology transfer component of the project involves: (1) dissemination of project findings and outcomes in the form of conference presentations (such as the Transportation Research Board Annual Meeting) and peer-reviewed journal publications and (2) making the model estimation software codes available for public use through TOMNET website. The project will also include a webinar component on the topics of unobserved heterogeneity and/or social interactions in transportation modeling. The webinar will be used to disseminate knowledge about the results of the project's work and to educate researchers and practitioners on emerging modeling and data collection methods. Additionally, project funds will be used to support the activities of the *Journal of Public Transportation* to promote public dissemination of research.

10. Workforce Development and Outreach Plan

The project will directly provide career development opportunities for a postdoctoral research fellow. The research effort will allow the postdoc to expand his technical skills into new areas of discrete choice modeling and transferability analysis. The project will also provide opportunities for the postdoctoral research associate to gain teaching experience as an instructor of record for an undergraduate and graduate course. The postdoctoral scholar is expected to gain experience in managing a research project and supervising and mentoring of student researchers.

The project will include an educational component where data and information from the project will be provided to students to aid in their development. The PI and Co-PI both will teach graduate-level courses on econometric methods and travel demand modeling. These courses will likely include homework assignments and a project component involving the analysis of transportation data. The past data collection effort on automated vehicles and/or activity behavior and social capital will be used in these efforts to expose students to real-world travel and activity data. Additionally, the classes will have

components on data collection including questionnaire/survey design. Students will be exposed to the process that respondents partake of in providing travel data.

11. References

- Benoit, J.-P., & Dubra, J. (2017). When do populations polarize? An explanation. Working Paper. London Business School, London, UK.
- Calastri, C., Hess, S., Daly, A., Carrasco, J.A. & Choudhury, C. (2018). Modelling the loss and retention of contacts in social networks: The role of dyad-level heterogeneity and tie strength. *Journal of Choice Modelling*.
- Kamargianni, M., Ben-Akiva, M. & Polydoropoulou, A. (2014). Incorporating social interaction into hybrid choice models. *Transportation*, 41(6), 1263-1285.
- Lord, C., Ross, L., & Lepper, M. (1979). Biased assimilation and attitude polarization: the effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology*, 37(11), 2098-2109.
- Maness, M. (2017). A theory of strong ties, weak ties, and activity behavior: Leisure activity variety and frequency. *Transportation Research Record: Journal of the Transportation Research Board*, 2665, 30-39.
- Maness, M., Cirillo, C. & Dugundji, E.R. (2015). Generalized behavioral framework for choice models of social influence: Behavioral and data concerns in travel behavior. *Journal of Transport Geography*, 46, pp.137-150.
- Mannering, F. (2018). Temporal instability and the analysis of highway accident data. *Analytic Methods in Accident Research* 17, 1-13.
- Mannering, F., Shankar, V., & Bhat, C. (2016). Unobserved heterogeneity and the statistical analysis of highway accident data. *Analytic Methods in Accident Research* 11, 1-16.
- Menon, N, Pinjari, A., Zhang, Y., & Zhou, L. (2016). Consumer perception and intended adoption of autonomous-vehicle technology: Findings from a university population survey. Presented at the Transportation Research Board's 95th Annual Meeting, Washington D.C.

12. Budget Including Non-Federal Matching Funds

Institution: University of South Florida

Project Title: Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modelling

Principal Investigator: Michael Maness

Budget Period: 8/1/2018 - 07/31/2019

CATEGORY	Budgeted Amount from Federal Share	Budgeted Amount from Matching Funds	Explanatory Notes; Identify Source of Matching Funds
Faculty Salaries	\$23,461	\$22,671	Fred Mannering's Salary
Other Staff Salaries	\$0	\$0	
Student Salaries	\$26,000	\$0	
Fringe Benefits	\$6,656	\$5,723	Fred Mannering's and Michael Maness' Benefits
Total Salaries & Benefits	\$56,116	\$28,394	
Student Tuition Remission	\$0	\$9,051	Tuition Remission for One Graduate Research Assistant
Operating Services and Supplies	\$1,548	\$0	
Domestic Travel	\$6,000	\$0	
Journal of Urban Transportation Support	\$5,000	\$0	
Total Direct Costs	\$68,664	\$37,445	
F&A (Indirect) Costs	\$33,989	\$14,055	
TOTAL COSTS	\$102,653	\$51,500	

MICHAEL MANESS

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Education

Ph.D., Civil Engineering, University of Maryland, May 2015.

M.S., Civil Engineering, University of Maryland, December 2010.

B.S., Civil Engineering, University of Maryland, May 2009

B.S., Computer Science, University of Maryland, May 2009

Selected Employment and Professional Experience

Postdoctoral Scholar, Department of Civil and Environmental Engineering, USF, 2017-present.

Postdoctoral Research Associate, Center for Transportation Analysis, Oak Ridge National Laboratory, 2015-2016.

Graduate Research Fellow, Office of Operations Research and Development, Federal Highway Administration, 2013-2014.

Fields of Interest and Expertise

(1) Advanced discrete choice modeling; (2) agent-based modeling of people and freight; (3) The role of social networks and social interactions in decision making; (4) Forecasting emerging technologies in transportation; (5) Data collection and experimentation in transportation

Recent Relevant Publications

1. M. Maness (2017). Comparison of Position Generators and Name Generators as Social Capital Indicators in Predicting Activity Selection. *Transportation Research Part A: Policy and Practice*, 106, 374-395.
2. M. Maness (2017). A Theory of Strong Ties, Weak Ties, and Activity Behavior: Leisure Activity Variety and Frequency. *Transportation Research Record: Journal of the Transportation Research Board*, 2665, 30-39.
3. C. Calastri, S. Hess, A. Daly, M. Maness, M. Kowald, and K. Axhausen (2017). Modelling Contact Mode and Frequency of Interactions with Social Network Members Using the Multiple Discrete-continuous Extreme Value Model. *Transportation Research Part C: Emerging Technologies*, 76, 16-34.
4. M. Maness and C. Cirillo (2016). An Indirect Informational Conformity Social Influence Choice Model: Formulation and Case Study. *Transportation Research Part B: Methodological*, 93, 75-101.
5. M. Maness, C. Cirillo, and E. Dugundji (2015). Generalized Behavioral Framework for Choice Models of Social Influence: Behavioral and Data Concerns in Travel Behavior. *Journal of Transport Geography*, 46, 137-150.
6. M. Maness and C. Cirillo (2012). Measuring Future Vehicle Preferences: Stated Preference Survey Approach with Dynamic Attributes and Multiyear Time Frame. *Transportation Research Record: Journal of the Transportation Research Board*, 2285, 100-109.

Recent Honors and Awards

Appointed as a Member of the Traveler Behavior and Values Committee (ADB10),
Transportation Research Board, 2017-Present

2015 Eric Pas Dissertation Prize, International Association for Travel Behaviour Research, 2017

Outstanding Student of the Year, University Transportation Centers Program, 2015

Eisenhower Transportation Fellowship, Federal Highway Administration, 2010-2012, 2013-2014

FRED L. MANNERING

Professor of Civil and Environmental Engineering
University of South Florida, 4202 E Fowler Avenue, ENC 3506, Tampa, FL 33620

Education

Ph.D.	Massachusetts Institute of Technology	1983
M.S.C.E.	Purdue University	1979
B.S.C.E.(with Distinction)	University of Saskatchewan	1976

Research expertise

Application of advanced statistical and econometric methods to engineering problems, transportation safety analysis, transportation economics, automobile demand, and travel behavior.

Professional History

Professor, Department of Civil Engineering (courtesy appointment, Department of Economics) at the University of South Florida (2015-present). Charles Pankow Professor of Civil Engineering (2009-2015), Professor of Civil Engineering (2001-2009), Head of the School of Civil Engineering (2001-2005) at Purdue University. Assistant, associate, and full professor during 14-year tenure at the University of Washington (1987-2001), Chair of the Department of Civil and Environmental Engineering at Washington (1997-2001). Assistant Professor, Department of Civil Engineering at the Pennsylvania State University (1983-1986).

Publications/Presentations

Published 138 refereed journal articles, 2 text books (8 editions), 73 other publications (conference proceedings, project reports, book reviews and commentaries), and 103 presentations at professional conferences, 9 keynote speeches and distinguished lectures; and 37 invited talks.

Citations

Published work has been cited over 6,000 times in the *Institute for Scientific Information* databases, over 7,500 times in Scopus, and over 17,000 times in Google Scholar.

Funded Research

Principal investigator on 44 research projects with total funding of over 4 million dollars.

Graduate Student Supervision

Supervised 25 PhD students (3 in progress, 14 currently in academic positions) and 45 MS students.

Professional Activities and Awards

Founding Editor and Editor-in-Chief of Elsevier Science's Analytic Methods in Accident Research (2012-present), previously Editor-in-Chief of Elsevier Science's Transportation Research Part B: Methodological (2003-2012). Awards include: inclusion in the Eno Foundation's Top 10 Transportation Thought Leaders in Academia (2016); inducted into Purdue University's "Book of Great Teachers" (2013); Fellow, Purdue University Teaching Academy (2013-2015); Charles B. Murphy Outstanding Undergraduate Teaching Award, Purdue University's highest undergraduate teaching honor (2013); Arthur M. Wellington Prize; American Society of Civil Engineers, for the best paper in the Journal of Transportation Engineering (2010); James Laurie Prize, American Society of Civil Engineers (2009) "For his outstanding contribution to the advancement of transportation engineering through his influential research and publication in the area of highway safety"; Wilbur S. Smith Award, American Society of Civil Engineers (2005) "For outstanding contributions to the enhancement of the role of the civil engineer in highway engineering through excellence in teaching and research"; and the National Highway Safety Award (2001) for "A new method for prioritizing intersection improvements"

Grant Deliverables and Reporting Requirements for UTC Grants (November 2016)
Exhibit F

UTC Project Information	
Project Title	Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modelling
University	University of South Florida
Principal Investigator	Michael Maness
PI Contact Information	Address: 4202 E. Fowler Ave, ENB 118 Tampa, FL 33620 Email: manessm@usf.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	US Department of Transportation (Federal UTC): \$102,653 University of South Florida (Cost Share): \$51,500
Total Project Cost	\$154,152
Agency ID or Contract Number	
Start and End Dates	09/01/2018 – 08/31/2019
Brief Description of Research Project	In recent years, a number of new econometric and data collection methods have been introduced that incorporate attitudinal and social effects in travel behavior models. The core of many of these methods address unobserved heterogeneity (factors affecting outcomes but unobserved by analysts). Many travel behavior and safety analysis studies have found unobserved heterogeneity to be statistically significant. However, interpretation of model results and forecasting are difficult because the source of the unobserved heterogeneity is unknown. For example, some argue, that unobserved heterogeneity is really capturing the effects of attitudes and other potentially measurable factors. The intent of this study is first to review the extant literature of unobserved heterogeneity and the econometric methods used to account for it. Then, explore the potential influence of attitudinal variables on unobserved heterogeneity with contemporary heterogeneity modeling approaches (e.g. heterogeneity in the means and variances of parameters). If attitudinal and social variables are responsible for much of the unobserved heterogeneity, then their inclusion could improve spatial and temporal transferability of models. This project will focus primarily on two such variables: social capital and polarization.

<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	<p>The project will provide review documents and empirical estimations that will form the basis for subsequent TOMNET work on the incorporation of attitudes and social interactions in travel and transportation safety models.</p>
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>The eventual impact of this research will be to improve the accuracy of travel and highway safety forecasting models.</p>
<p>Web Links</p> <ul style="list-style-type: none"> • Reports • Project Website 	<p>Reports will be made available on the TOMNET website.</p>