Center for Teaching Old Models New Tricks (TOMNET)

A USDOT Tier 1 University Transportation Center

PROJECT PROPOSAL 2021-2022

Title: Addressing potentially missing relevant information on attitudes and other behavioral elements as unobserved heterogeneity in highway safety studies

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

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1. Introduction

Understanding highway safety requires an assessment of physical and behavioral factors that influence the occurrence and resulting injury severity of crashes. This assessment is exceedingly difficult because it involves an understanding of wide variety of factors including human responses to external stimuli and complex interactions between the vehicle, roadway features, roadway conditions, traffic-related factors, and environmental conditions. In addition, attitudes and other factors that potentially affect drivers' safety-risk profiles could play a key role in the occurrence and resulting injury severity of crashes (Abay and Mannering, 2016). Recognizing that it would be virtually impossible to collect all of the data that could potentially influence the occurrence and severity of crashes, the safety field has moved forward by addressing omitted data as unobserved heterogeneity – using mixing distributions to arrive at appropriate statistical estimations (Mannering et al., 2016). The intent of the current study is to explore mixing distribution approaches to gain insight on the potential role that attitudes and other behavioral elements may play. This will be accomplished by considering data on pedestrian injuries in motor-vehicle crashes and crash frequencies and severities on roadway segments where part-time shoulder use is permitted.

Regarding pedestrian injuries, the injury and fatality rates of pedestrians involved in collision with motorized vehicles has risen considerably in recent years, and there is a national emphasis on improving pedestrian safety. We plan to use multi-year data from the state of Kansas to analyze pedestrian injuries and understand both the observed and unobserved factors that determine injury severity. Of particular interest will be difference in day vs. night injuries (where limited visibility is expected to play a key role) and how the factors affecting injury severity have changed over time. A range of probabilistic models with mixing distributions to account for unobserved heterogeneity will be estimated (considering heterogeneity in the means and variances of parameters and potential correlation among random parameters), and the unobserved heterogeneity will be evaluated with consideration to the possible influence of attitudes, behavioral differences and other unobserved factors.

The second portion of the proposes study will consider roadway segments from multiple states where part-time shoulder use is allowed in an effort to relieve congestion or to improve safety. Part-time shoulder use presents an interesting exploration of unobserved heterogeneity because it is speculated that driving patterns, motorist attitudes and other factors that affect safety will vary significantly across states, and that the effect on safety will be particularly pronounced with an unusual traffic pattern such as part-

time shoulder use. To understand this unobserved heterogeneity, attention will be focused on both the frequency and resulting injury severities of observed crashes on identified roadway segments. To be consistent with current highway safety practice, consideration will be given only to variables typically available to state highway agencies during model estimation. Using a series of mixing distributions to account for unobserved heterogeneity, and considering heterogeneity in the means and variances of parameters and potential correlation among random parameters, focus will be directed toward how the possible differences between states and other factors that may suggest the influence of attitudes and other unobserved factors.

2. Project Objectives

Considering the above, the objectives of this project include:

1. Assemble multi-year pedestrian injury severity data (injuries resulting from motor-vehicle crashes) from the State of Kansas.
2. Gather highway geometric and traffic data on over 700 highway segments, from 5 states where part-time shoulder use has been implemented. Combine these data with the 3 to 5 year crash histories on these highway segments.
3. Develop a series of advanced heterogeneity models using a variety of mixing distributions to account for potential unobserved heterogeneity. Statistically assess and compare all models and gain an understanding of their differences.
4. Evaluate the estimated statistical models (with and without unobserved heterogeneity) in light of TOMNET work on attitudinal data.
5. Develop a comprehensive assessment of the findings.

3. Proposed Methodology and Data

To explore how unobserved heterogeneity influences pedestrian injury severities resulting from collisions with motor vehicles, multiyear data of pedestrian-involved collisions will be gathered from the State of Kansas. With these data, random parameters logit models that consider unobserved heterogeneity in both the means and variances of the random parameters will be estimated. These estimations will be undertaken by year (to make certain temporal instability is not an issue) and by day and night collisions to account for the effects that reduced visibility at night may have on resulting injury severities. The resulting estimation results and specifically the unobserved heterogeneity findings as reflected by the likely statistical significance of numerous random parameters will then be carefully evaluated.

To explore how unobserved heterogeneity might influence model estimation relating to crash occurrences, traditional crash frequency data will be gathered from five states (Georgia, Hawaii, Minnesota, Ohio and Virginia) where part-time shoulder use is allowed in an effort to relieve congestion or improve safety. We will consider the frequency and resulting injury severity of crashes on the segment and determine the effect of unobserved heterogeneity in the statistical model estimations using the following modeling alternatives:

1. Three simple fixed parameters negative binomial models which are the current the mainstay of transportation practice (see the Highway Safety Manual), will be estimated for the total number of crashes, non-injury crashes only, and injury crashes only.
2. A bivariate fixed parameters model (of non-injury and injury counts) will be estimated to account for the correlation of non-injury and injury crashes. Forecasts will be made to show the error

introduced by ignoring model correlations and discussion of the sources of these errors will be provided.

3. A random parameters negative binomial model will be used to estimate the total number of crashes, and this will be combined with a mixed logit model that will assign the crashes to injury-severity outcomes following the method described in Milton et al. (2008).
4. The simple random parameters models in alternative 3 will be extended to allow for the possibility of heterogeneity in the means and variances of random parameters. This will give great flexibility in accounting for unobserved heterogeneity.
5. For alternatives 3 and 4, model extensions will be estimated to allow for correlation among random parameters.

A thorough statistical and theoretical assessment of the modeling alternatives presented above will then be undertaken. This assessment will focus on predictive accuracy and concerns, causal effects and, most importantly, an analysis will be undertaken regarding the likely sources of unobserved heterogeneity. This analysis will be undertaken with particular attention being given to the possible effects of attitudes toward safety as well as other risk-related factors found to be significant in other studies (see Abay and Mannering, 2016). It is expected that the findings will provide important new insights that will help guide existing safety practice as well as future safety research.

4. Work Plan

Task 1: Assemble data

To prepare the data for model estimation the following subtasks will be undertaken:

1.1 Gather and code data Kansas pedestrian-injury data: Process data from pedestrian crashes in the state of Kansas, using data from 2013-17 (5 years of data).\

1.2 Gather and code roadway segment data: Assemble the crash histories on roadway segment from five states (Georgia, Hawaii, Minnesota, Ohio and Virginia) where part-time shoulder use is allowed in an effort to relieve congestion or improve safety.

Task 2: Estimate pedestrian-injury models

In estimating pedestrian-injury models with Kansas data, the following sub-tasks will be undertaken:2.1 Estimate initial models and test for temporal instability: Because the data cover a 5-year period, the possibility of temporal instability must be considered. A series of likelihood ratio tests will be conducted to determine if individual models by year need to be estimated.

2.2 Estimation of injury-severity models with random parameters: Full model estimation with random parameters including heterogeneity in the means and variances of the random parameters will be estimated. Tests for the possibility of correlated random parameters will also be considered.

2.3 Assessment of unobserved heterogeneity findings: A thorough assessment of the statistical findings will be made by scanning the relevant literature to determine the source of the likely statistically significant unobserved heterogeneity.

Task 3: Highway segment model estimations

Crash models that are used across the US typically consider the number of crashes occurring on a specific highway segment over some specified time period. Crash models used in practice do not consider

unobserved heterogeneity and thus ignore the many factors that affect the frequency of crashes but are not typically in crash databases. The implications of this will be studied by performing the following tasks:

3.1 Estimation of statistical models of crash frequencies: Using data from subtask 1.2, for the sample of highway segments, estimate three alternative models: the simple fixed parameters negative binomial which is current the mainstay of transportation practice (see the Highway Safety Manual); the traditional random parameters negative binomial model; a random parameters negative binomial with heterogeneity in the means and variances.

3.2 Model comparison and assessment of unobserved heterogeneity: Based on the model estimation results in sub-task 3.1 a critical assessment and comparison of the alternative models will be undertaken. In addition, as in sub-task 2.3, the possible sources of unobserved heterogeneity will be explored and the implications for highway safety practice will be assessed.

3.3 Assessment of unobserved heterogeneity findings: A thorough assessment of the statistical findings will be made by scanning the relevant literature to determine the source of the likely statistically significant unobserved heterogeneity.

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
Task 1: Assemble data												
1.1 Gather and code data Kansas pedestrian-injury data (Data gathered from various sources)												
1.2 Gather and code roadway segment data (Data gathered from various sources)												
Task 2: Estimate pedestrian-injury models												
2.1 Estimate initial models and test for temporal instability												
2.2. Estimation of injury-severity models with random parameters												
2.3 Assessment of unobserved heterogeneity findings (Paper completed)												
Task 3: Highway segment model estimations												
3.1 Estimation of statistical models of crash frequencies												
3.2 Model comparison and assessment of unobserved heterogeneity												
3.3 Assessment of unobserved heterogeneity findings (Paper 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 congestion, and (3) promoting safety. This project will contribute to TOMNET's mission to address barriers related to inclusion of attitudes in travel 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 temporal instability, 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 data collected.
4. A modeling vignette brief on incorporating unobserved heterogeneity in highway safety modeling

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 150 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.

Fred Mannering will be involved in statistical model development and interpretation of findings. The team will also consist of student researchers with the student directly reporting to Dr. Mannering weekly.

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 datasets available for public use through TOMNET's website.

10.Workforce Development and Outreach Plan

The project will directly provide career development opportunities for 1 doctoral student. The research effort will allow the doctoral student to expand his/her technical skills into new areas of econometric modeling and temporal transferability analysis. The supported doctoral student is expected to gain experience in managing research projects and mentoring undergraduate 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 will teach graduate-level courses on econometric methods. These courses will likely include homework assignments and a project component involving the analysis of transportation data. Additionally, the classes will have components on data collection including questionnaire/survey design. Students will be exposed to the process of gathering highway safety data.

11.References

Abay, K., Mannering, F., 2016. An empirical analysis of risk-taking in car driving and other aspects of life. Accident Analysis and Prevention 97, 57-68.

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.

Milton, J., Shankar, V., Mannering, F., 2008. Highway accident severities and the mixed logit model: An exploratory empirical analysis. Accident Analysis and Prevention 40(1), 260-266.

Washington, S., Karlaftis, M., Mannering, F., Anastasopoulos, P., 2020. Statistical and econometric methods for transportation data analysis. Third Edition, CRC Press, Taylor and Francis Group, New York, NY. 478 pages.

12.Qualifications of Investigators

FRED L. MANNERING, Ph.D.
Professor, School of Civil and Environmental Engineering,
University of South Florida, Tampa, FL Ph: (813) 974-5817; Email: flm@usf.edu

EDUCATION

- Massachusetts Institute of Technology, Cambridge, MA, USA
  - Ph.D., Civil Engineering (Transportation Systems), May 1983
- Purdue University, West Lafayette, IN, USA
  - M.S., Civil Engineering, May 1979
- University of Saskatchewan, Saskatoon, SK, Canada
  - B.S., Civil Engineering (with Distinction), May 1976

PROFESSIONAL EXPERIENCE

- Interim Executive Director, Center for Urban Transportation Planning, University of South Florida, 2020-
- College of Engineering, University of South Florida, Tampa, FL
  - Professor, 2015-
  - Associate Dean for Research, 2016-
- School of Civil Engineering, Purdue University, West Lafayette, IN
  - Charles Pankow Professor of Civil Engineering, 2009-2015
  - Professor, 2005-2009
  - Professor and Head of Civil Engineering, 2001-2004
- Department of Civil and Environmental Engineering, University of Washington, Seattle, WA
  - Professor and Chair, 1997-2001
  - Professor, 1992-1997; Associate Professor 1989-1993; Assistant Professor, 1987-1989
- Department of Civil Engineering, The Pennsylvania State University, State College, PA
  - Assistant Professor, 1983 – 1986

REFEREED PUBLICATIONS (Total: 158 Refereed Publications)

- Published work has been cited more than 10,500 times in Clarivate Analytics Web of Science Core Collection, with h-index = 52. (https://publons.com/researcher/2601045/fred-l-mannering/)
- Published work has been cited more than 13,500 times in Scopus (Elsevier), with h-index = 56. (https://www.scopus.com/authid/detail.uri?authorId=7005423388)
- Published work has been cited more than 25,500 times in Google Scholar with h-index = 73. (https://scholar.google.com/citations?user=HJc-5WMAAAAJ&hl=en)

RESEARCH PROJECTS (Total Sponsored Research: exceeding $5 million)

JOURNAL EDITORIAL ACTIVITIES

- Editor-in-Chief, *Analytic Methods in Accident Research*, Founding Editor, 2013-present
- Editor-in-Chief, *Transportation Research Part B* (*Methodological*), 2004-2012
- Associate Editor, *Transportation Research Part B* (*Methodological*), 2003, 2013-present
- Associate Editor, *Transportation Research Part A* (*Policy and Practice*), 2001-2002

EDUCATION AND STUDENT ADVISING

- Thesis/Dissertation Major Advisor/Chair
  - 24 PhD students completed; 43 MS (Thesis) students completed
- Thesis/Dissertation Committee Member

- 92 PhD students completed; 125 MS (Thesis) students completed

- Course Instructor
  - Graduate: *Statistical and Econometric Methods I, Statistical and Econometric Methods II*

13.Budget Including Non-Federal Matching Funds

Institution: University of South Florida
Project Title: Addressing potentially missing relevant information on attitudes and other behavioral elements as unobserved heterogeneity in highway safety studies
Principal Investigator: Fred Mannering
Budget Period: 8/1/2020 - 07/31/2021

CATEGORY	Budgeted Amount from Federal Share	Budgeted Amount from Matching Funds	Explanatory Notes; Identify Source of Matching Funds
Faculty Salaries	$15,833	$9,572	Salary for Fred Mannering
Other Staff Salaries	$0	$0	
Student Salaries	$13,000	$0	One half-time GA
Fringe Benefits	$5,390	$2,194	Faculty and Student Benefits
Total Salaries & Benefits	$34,323	$11,766	
Student Tuition Remission	$0	$7,993	Tuition waivers for GA (24/24/15 credits)
Operating Services and Supplies	$0	$0	
Domestic Travel	$0	$0	
Other Direct Costs	$0	$0	
Total Direct Costs	$34,323	$19,758	
F&A (Indirect) Costs	$16,940	$5,824	
TOTAL COSTS	$51,163	$25,582	

Grant Deliverables and Reporting Requirements for UTC Grants (November 2022)
Exhibit F

UTC Project Information	
Project Title	Addressing potentially missing relevant information on attitudes and other behavioral elements as unobserved heterogeneity in highway safety studies
University	University of South Florida
Principal Investigator	Fred Mannering
PI Contact Information	Address: 4202 E. Fowler Ave, ENB 118 Tampa, FL 33620 Email: flm@usf.edu
Funding Source(s) and Amounts Provided (by each agency or organization)	US Department of Transportation (Federal UTC): $51,163 University of South Florida (Cost Share): $25,582
Total Project Cost	$76,745
Agency ID or Contract Number	
Start and End Dates	09/01/2021 – 08/31/2022
Brief Description of Research Project	
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	The eventual impact of this research will be to improve the accuracy of highway safety forecasting models.
Web Links • Reports • Project Website	Reports will be made available on the TOMNET website.