Investigating the Monetary Benefits of Crash Reduction on Interstate Highways by Employing Express Intercity Transit Services

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Project Type: Crash analysis and reduction by employing express transit services

Total Funds Requested: $6000

1. Problem Statement

Intercity travel has been on the rise in the last few decades, resulting in severe congestion on intercity highway corridors. According to Fatality Analysis Reporting System (FARS), 12% of all road-related fatalities in the United States occur on interstate highways. On the other hand, while many interstate highways in the U.S. face large capacity challenges, the intercity bus industry has risen over the past decade, and for several years was reported as the fastest growing intercity transit mode (Schwieterman and Fisher, 2010). So, should there be a satisfactory and rapid public transit service between cities, it could entice travelers to switch from driving to public transit. A recent study concerning a new high-speed intercity transit service in Arizona showed that such services can take up a significant part of the market (Ranjbari et. al, 2016). Alleviated congestion and decreased auto traffic on interstate highways could result in fewer crashes, saving lots of lives and money, and would be an important step toward fulfilling the Federal Highway Administration's Vision Zero initiative, with the goal of "working toward no fatalities across all modes of travel" (FHWA, 2017).

The proposed research aims to explore the safety benefits of implementing express bus services on interstate highways, particularly for the State of Washington as a case study, and to quantify the benefits of crash reduction by monetary values. It is an example of life science project as it is directly related to people's mobility needs via different modes of transportation (auto or public transportation), and it analyzes the traffic safety on the interstate highways, trying to improve the losses that happen due to crashes. This research is also a multidisciplinary project as it is a combination of miscellaneous fields of science, such as transportation and highway engineering, econometrics and statistics, and computer programming.

2. Proposed Activity

This research is based on crash databases, and is inherently a data-driven project. Crash databases include information on three levels of crash level, vehicle level and passenger level, and each record in a database includes this information. Since crashes are random events, crash data analysis requires several years of data, and such large amount of information in crash databases necessitates the use of data analysis methods. Therefore, the research team will use R programming software as a data analysis tool along with other programming softwares.

First, the characteristics of intercity crashes will be explored using the 7-year crash database for the State of Washington (Council & Mohamedshah, 2014), and a Safety Performance Function (SPF) will be developed using a Generalized Linear Model (GLM) to predict the total number of crashes on interstate highways. A crash severity model will also be developed to predict the severity of crashes (such as property damage-only, injury, and fatality).

The total number of crashes observed on road segments are considered as count data (non-negative integer). The standard regression models are inappropriate for count data since standard regression models fail to predicted values that are non-integer or negative. Count data is properly modeled by GLM such as Poisson and negative binomial regression models. These models can estimate rare events like crashes pretty well. Lord and Mannering (2010) reviewed different methodological alternatives for modeling a crash frequency model. In addition, feasibility of applying other methodological approaches such as time series analysis (Shumway and Stoffer, 2010) and different statistical machine learning approaches (Hastie et. al, 2001) will be evaluated.

Generally, the total number of crashes on road segments can be modeled by Poisson regression; however, to use this model, the mean of count data needs to be equal to its variance. Negative binomial model, on the other hand, relaxes this assumption. The expected crash frequency for each segment is a function of explanatory variables (Washington et. al , 2010) such that:

$$\lambda = exp(\beta X + \varepsilon)$$

The negative binomial distribution formula is stated below, where $\Gamma(.)$ is the Gamma function and α is overdispersion parameter. λ denotes the expected crash frequency, X is a vector of explanatory variables, β represents the vector of estimable coefficients, and ε is the error term.

$$P(n) = (\Gamma(n + 1/\alpha)/n!)\times((1/\alpha)/\ (1/\alpha + \lambda)^{1/\alpha}\times\ (\lambda/(1/\alpha + \lambda)^{n})$$

In the next stage, the possible demand shift from driving to express transit and the resultant auto traffic volume on the highway will be estimated. To conduct this, team has multiple strategies that can be pursued. One is to employ a developed mode choice model for a high-speed intercity transit service in a similar study (Ranjbari et. al, 2017) to find the market shares for our case study; and the other one is to consider multiple future scenarios, with different percentages of demand shifts from driving to express transit. The estimated new auto volume will then be applied into the developed crash prediction models to determine the number and severity of crashes in the existence of the express intercity transit service.

Finally, using economic models the reductions in the total number of crashes and their severity will be converted to monetary values to study the cost-benefit analysis of implementing express transit services on interstate highways.

3. Goals and Outcomes

Short-term outcomes of this project are an exploratory analysis of crash data in the State of Washington and developing a crash frequency model for Washington interstate highways, in order to quantify the changes in average annual daily traffic on selected interstate highways upon employing high-speed bus transit, and to calculate the monetary benefits of implementing such services from the perspective of crash reduction.

In the long-term, we expect to present our results at one of the well-known transportation related conferences such as Transportation Research Board or Institute of Transportation Engineering annual meetings in 2018 or 2019.

4. Team Members and Contributions

Each team member will have a unique role and contribution to this project as follow:

- **Mohammadreza Hashemi:** Crash data analysis and developing statistical crash models
- **Andisheh Ranjbari:** Developing mode choice model for express bus transit and calculating the monetary benefits of using the proposed system
- **Navid Tafaghodi Khajavi:** Providing statistical methods for necessary data analysis to accomplish the goals of the project

- **Katherine Dolma:** Data preparation and exploratory data analysis

The two students at University of Hawaii will meet in person every month, and the entire team will meet once a month via Skype, sharing the ideas toward the progress of the project.

The team members will meet in person once over the course of project, when a significant progress is made in order to decide on some details and plan the next steps (~4 months after the project approval). The location and time of the meeting will be later determined and announced to the Csol directors.

5. Diversity Statement

The research team follows the diversity goal of NSF:

- Two members of the research team are female.
- The research team is made up of 3 graduate and one undergraduate students.
- Three members are international students and one is a US citizen.
- Two members are majoring in Civil Engineering, and two in Electrical Engineering.

6. Budget and Justification

We plan to present the outcomes of this research project at the Transportation Research Board (TRB) Annual Meeting in January 2019 (or another conference at a similar level). We are requesting funding for the conference registration and travel. Also, as stated earlier, the entire team plans to meet in-person once during the course of project when a significant progress is made, and we are requesting funding for that as well. A rough estimate of expenses associated with the proposed activities is presented as follows:

Category	Item	Estimated Cost
In-person meeting	Travel	$1000
	Lodging	$400
Conference	Travel	$2000
	Registration	$1200
	Lodging	$1400
Total		**$6000**

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