A latent class modeling approach for identifying vehicle driver injury severity factors at highway-railway crossings

Naveen Eluru\textsuperscript{a,}\textsuperscript{*}, Morteza Bagheri\textsuperscript{b,}\textsuperscript{1}, Luis F. Miranda-Moreno\textsuperscript{a,}\textsuperscript{2}, Liping Fu\textsuperscript{c,}\textsuperscript{3}

\textsuperscript{a} Department of Civil Engineering and Applied Mechanics, McGill University, Canada
\textsuperscript{b} School of Railway Engineering, Iran University of Science and Technology, Iran
\textsuperscript{c} Department of Civil & Environmental Engineering, University of Waterloo, Canada

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\textbf{A B S T R A C T}

In this paper, we aim to identify the different factors that influence injury severity of highway vehicle occupants, in particular drivers, involved in a vehicle-train collision at highway-railway grade crossings. The commonly used approach to modeling vehicle occupant injury severity is the traditional ordered response model that assumes the effect of various exogenous factors on injury severity to be constant across all accidents. The current research effort attempts to address this issue by applying an innovative latent segmentation based ordered logit model to evaluate the effects of various factors on the injury severity of vehicle drivers. In this model, the highway-railway crossings are assigned probabilistically to different segments based on their attributes with a separate injury severity component for each segment. The validity and strength of the formulated collision consequence model is tested using the US Federal Railroad Administration database which includes inventory data of all the railroad crossings in the US and collision data at these highway railway crossings from 1997 to 2006. The model estimation results clearly highlight the existence of risk segmentation within the affected grade crossing population by the presence of active warning devices, presence of permanent structure near the crossing and roadway type. The key factors influencing injury severity include driver age, time of the accident, presence of snow and/or rain, vehicle role in the crash and motorist action prior to the crash.

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1. Introduction

There are more than 250,000 highway-railway crossings in the US catering to a broad spectrum of road and train traffic. In spite of the success of the recent safety initiatives that have substantially reduced the number of highway-railway crossing collisions, the US Federal Railroad Association (FRA) still recorded more than 30,000 collisions during the ten year period from 1997 to 2006. Traffic crashes at highway-railway crossings are often catastrophic and it is of utmost importance for transportation agencies and other stakeholders to identify collision contributing factors and counter measures to reduce traffic collisions and the resulting consequences.

Collisions occurring at these facilities could result in serious consequences including severe injuries to roadway vehicle occupants and train passengers, and substantial property damage to vehicles and trains (e.g. derailment), and delay in railway and highway traffic (Raub, 2009). In collisions involving freight trains carrying hazardous materials the consequences can be further exacerbated due to release of hazardous materials into the environment. A number of earlier research studies have focused on identifying the contributing factors that affect the occurrence of collisions at highway-railway crossings (see studies such as Saccomanno et al., 2007; Washington and Oh, 2006; Saccomanno and Lai, 2005). These studies employ different techniques such as factor/cluster analysis, negative binomial regression models, and Bayesian methods. For a literature review, the reader is referred to Lord and Mannering (2010). However, collision frequency is only one element of collision risk at highway-railway crossings. The risk associated with a crossing is typically defined as a function of collision frequency and collision consequence – total risk (Miranda-Moreno et al., 2009). To consider just frequency as a measure of risk would ignore crossings with a low expected collision frequency, but high potential for severe consequences. Therefore, it is essential that research efforts in safety literature examine the factors associated with the injury severity (consequence)