Exploring Crash Injury Severity on Urban Motorways by Applying Finite Mixture Models

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Introduction
• The effective treatment of crashes and the proactive transportation safety is a major concern to societies.
• Much research that utilized real-time collected traffic and weather data in freeways has been carried out recently.
• Crash injury severity is underrepresented.
• Alternative modeling techniques should also be considered.
• Relevant studies from Europe are rare.

Objectives
• The main objective is to propose finite mixture models for modeling crash injury severity.
• Injury severity of occupants involved in crash is examined.
• Address unobserved heterogeneity.
• Real-time traffic and weather data from an urban motorway in Athens, Greece are considered.

Data preparation
• The available dataset refers to the period 2006-2011 and come from a high demand urban motorway of Athens, Greece (Attica Tollway).
• Crash data were collected from the Greek accident database, SANTRA, which is provided by NTUA.
• Traffic data were extracted from the Traffic Management Centre (TMC) of Attica Tollway.
• Traditional crash characteristics were also considered.
• The TMC data included traffic flow, traffic occupancy, truck proportion and mean time speed every 5 minutes.
• Traffic data from the adjacent upstream loop detector were considered. Data were further aggregated to 15-min and 30-min traffic information to obtain averages, standard deviations and so on, prior to a crash occurrence.
• Weather data were collected from the Hydrological Observatory of Athens, which is an online open-access database, covering more than 10 meteorological stations located in the greater Athens area.
• Weather data include rainfall, temperature, relative humidity, solar radiation, wind direction and wind speed.
• The 10-min raw weather data were aggregated over hour in order to obtain maxima, averages and standard deviations, in the time-slice of 1-hour, 2-hours, 6-hours and 12-hours prior to the time of the crash occurrence.

Method of Analysis
• The core analysis of this study is the finite mixture binary logistic model (Latent Class).
• The Finite Mixture modelling approach can be considered as an extension of the standard binary logit model.
• It includes a latent class model that captures the effect of unobserved variables on the binary outcome variable.
• It is based on a finite mixture approach in which the unobserved heterogeneity is accounted for via latent classes.
• Finite mixture analysis divides the sample into distinct classes with homogenous attributes, an important issue is the determination of the number of classes.
• To overcome this issue Bayesian information criterion (BIC) is applied.

Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Latent Class 1</th>
<th>Latent Class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant term (random)</td>
<td>-1.720</td>
<td>-3.615</td>
</tr>
<tr>
<td>Acc.type0 (reference cat.)</td>
<td>-1.704</td>
<td>-3.615</td>
</tr>
<tr>
<td>Acc.type1 (fixed)</td>
<td>-2.338</td>
<td>-1.352</td>
</tr>
<tr>
<td>Acc.type2 (fixed)</td>
<td>-2.769</td>
<td>-2.262</td>
</tr>
<tr>
<td>Acc.type3 (fixed)</td>
<td>-7.196</td>
<td>-2.429</td>
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<tr>
<td>CC (fixed)</td>
<td>-0.002</td>
<td>-1.755</td>
</tr>
<tr>
<td>Tr.Prop_avg_30m_up (fixed)</td>
<td>-1.038</td>
<td>-2.429</td>
</tr>
<tr>
<td>Q_avg_30m_up (random)</td>
<td>0.027</td>
<td>1.362</td>
</tr>
<tr>
<td>Occ_stdev_30m_up (random)</td>
<td>0.027</td>
<td>1.362</td>
</tr>
<tr>
<td>Log-likelihood at zero</td>
<td>154.060</td>
<td>2.597</td>
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<tr>
<td>Final Log-likelihood</td>
<td>-134.998</td>
<td>-1629</td>
</tr>
<tr>
<td>Likelihood ratio test</td>
<td>-112.152</td>
<td>45.692</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>0.009</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Conclusions
• Promising fit of the finite mixture models.
• A number of traffic parameters such as truck proportion, average flow and standard deviation of occupancy, and other risk factors, such as accident type and engine size have a significant effect on the injury severity outcome of vehicle occupants.
• The model accounted for the heterogeneity among two distinct groups of observations.
• The impact of average flow and standard deviation of occupancy was not fixed across the two produced latent classes and diverse results were produced.
• Collisions with fixed objects or run-off road collisions as well low engine size vehicles are associated with higher severity levels.
• This paper contributes to current knowledge, by having a specific consideration of real-time traffic and weather data and also by applying finite mixture models.