# 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

| Variables | Latent Class 1 | | | Latent Class 2 | | |
|---|---|---|---|---|---|---|
| | Mean | t-statistic | p-value | Mean | t-statistic | p-value |
| Constant term (random) | -1.720 | -0.961 | 0.337 | 36.153 | 2.573 | 0.010 |
| Acc.type0 (reference cat.) | - | - | - | - | - | - |
| Acc.type1 (fixed) | -2.338 | -1.352 | 0.176 | -2.338 | -1.352 | 0.176 |
| Acc.type2 (fixed) | -26.779 | -2.262 | 0.024 | -26.779 | -2.262 | 0.024 |
| Acc.type3 (fixed) | -7.196 | -2.429 | 0.024 | -7.196 | -2.429 | 0.024 |
| CC (fixed) | -0.002 | -1.755 | 0.079 | -0.002 | -1.755 | 0.079 |
| Tr.Prop_avg_30m_up (fixed) | -1.038 | -2.429 | 0.015 | -1.038 | -2.429 | 0.015 |
| Q_avg_30m_up (random) | 0.027 | 1.362 | 0.173 | -0.236 | -2.354 | 0.019 |
| Occ_stdev_30m_up (random) | 154.060 | 2.597 | 0.009 | -1629 | -2.134 | 0.033 |
| Log-likelihood at zero | | | -134.998 | | | |
| Final Log-likelihood | | | -112.152 | | | |
| Likelihood ratio test | | | 45.692 | | | |
| McFadden $R^2$ | | | 0.169 | | | |

## 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.

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