Investigation of the impact of weather conditions to young drivers' behaviour and safety in cities

Paper ID 219

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Background

Precipitation (rainfall, rainfall intensity, snowfall)

• Driving in rain is safety critical situation, involving adversities like reduced pavement friction and impaired visibility
• Rainfall increases crash risk and most weather-related accidents occur during rainfall and in wet pavement conditions
• In Mediterranean countries drivers tend to compensate for the increased risk by adjusting their behaviour

Fog

• Fog-related crashes have remarkably higher injury and fatality rates due to low visibility conditions
Objective

• Investigate the **impact of weather conditions** on different driving performance measures of young drivers on urban roads, through a **driving simulator experiment**

  ▪ Specifically, examine the effect of driving in different **weather conditions** in combination with **road type** (urban road), **traffic characteristics** (high/low traffic) and **driver characteristics** (gender, annual mileage, and driving habits)
Driving simulator experiment

Driving simulator
  • Foerst Driving Simulator (1/4 cab)

Road environment
  • Urban: 1.7 km long, dual carriageway

Traffic scenarios
  • QL : Low traffic - 300 vehicles/hour
  • QH : High traffic - 600 vehicles/hour

Unexpected incidents at each trial
  • Child crossing the road
  • Old lady crossing the road
Experiment design

Sample
• 40 young drivers (18-30 years old)
• 24 men and 16 women

Familiarization
• The participant practiced in handling the simulator, keeping the lateral position of the vehicle, keeping stable speed, etc.

Procedure
• 6 trials - rainy, foggy and good weather conditions under (low and high traffic conditions)
Data Collection

- **Driving parameters** extracted from the driving simulator experiment
  - Mean driving speed
  - Average reaction time
  - Average of Revolutions per minute
  - Lateral position of the vehicle
  - Average of headway distance etc.

- **Demographic** and driving behaviour data obtained from the *questionnaire*
  - Age, gender, driving experience, accident history, driving behavior during adverse weather conditions
Methodology

Lognormal linear regression to model mean speed

• The basic equation of the lognormal linear regression model is:

\[ y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_i \]

\[ \log(y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} \]

Binary logistic regression to model accident probability

• If the “utility function” is given by \( U = B_0 + B_i x_i \), then the probability \( P \) is given by \( P = e^{u}/(e^{u}+1) \)
### Analysis results – Mean speed (1/2)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Mean driving speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>βi</td>
</tr>
<tr>
<td>Driving in rain</td>
<td>-0,01</td>
</tr>
<tr>
<td>Gender</td>
<td>-0,02</td>
</tr>
<tr>
<td>Age</td>
<td>0,02</td>
</tr>
<tr>
<td>Average of Revolutions per minute</td>
<td>0,01</td>
</tr>
<tr>
<td>Lateral position of the vehicle</td>
<td>0,01</td>
</tr>
<tr>
<td>Accident with material damages</td>
<td>-0,02</td>
</tr>
<tr>
<td>Enjoy driving</td>
<td>-0,04</td>
</tr>
<tr>
<td>Speed reduction in rain</td>
<td>-0,02</td>
</tr>
<tr>
<td>R²</td>
<td>0,501</td>
</tr>
</tbody>
</table>
The vast majority of male drivers displayed a more unsafe behaviour during their simulated routes, developing higher speed than female drivers.

The higher the lateral position of the vehicle, the higher the driving speed.
## Analysis results – Accident probability (1/2)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Accident probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_i$</td>
</tr>
<tr>
<td>Driving in rain</td>
<td>0.872</td>
</tr>
<tr>
<td>Driving in fog</td>
<td>-1.738</td>
</tr>
<tr>
<td>Traffic conditions</td>
<td>-1.172</td>
</tr>
<tr>
<td>Gender</td>
<td>0.693</td>
</tr>
<tr>
<td>Average of Revolutions per minute</td>
<td>0.002</td>
</tr>
<tr>
<td>Average of headway distance</td>
<td>0.014</td>
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<tr>
<td>Enjoy driving</td>
<td>-1.145</td>
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<tr>
<td>Null log-likelihood</td>
<td>214.316</td>
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<tr>
<td>Final log-likelihood</td>
<td>172.595</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>6</td>
</tr>
</tbody>
</table>
Analysis results – Accident probability (2/2)

- Accident probability increases with the increase of the traffic density

- Two driving behavioral measures that have a negative effect on accident probability seem to be the average of revolutions per minute and the average of headway distance
Conclusions

• Driving in rain leads to a small reduction of the mean speed, which however cannot outweigh the increase of the probability of getting involved in a road accident.

• Driving under foggy conditions leads to a decreased accident probability, indicating drivers’ compensation in adverse weather.

• Regarding traffic conditions, results show that the accident probability increases with the increase of the traffic density, low to high traffic conditions.
Future Challenges

• Larger and more representative sample of drivers with different age groups

• Investigation of the effect of other driving factors (psychological status, fatigue or driving under influence of alcohol)

• Different driving environments and different traffic conditions should be further investigated

• Implementation of other statistical methods for further statistical analysis and export of additional models
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