Evaluation of Road Safety in Portugal: A Case Study Analysis

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OUTLINE

• Objectives
• Methodology
• Results
  – Road environments
  – Expected number of road accidents
• Conclusions
OBJECTIVES

• PhD Research at Technical University of Lisbon

• Definition of different maintenance programmes for skid resistance and texture depth in different road environments

  1. Selection of roads
  2. Definition of road environments
  3. Modelling the expected value of road accidents

    a. Evaluation of the influence of pavement surface characteristics on accident occurrence
    b. Establishing threshold values for the International Friction Index (IFI), skid resistance and texture depth, according to safety criteria
1. SELECTION OF ROADS

Sample Process

Sample Universe
Portuguese Road Network

Sample Subset
Primary and secondary roads, except motorways

Sample Process
Sequential type of non-random sampling

Data acquisition
Pavement condition surveys
(Estradas de Portugal and University of Minho)

Historical data (accidents and precipitation)
(Estradas de Portugal, Directorate-General for Traffic and Hydro Resources Information System)

CHARACTERIZATION OF SELECTED ROADS
2. **DEFINITION OF ROAD ENVIRONMENTS**

- **Cluster Analysis**
  - Elements to cluster: 254 Section with 1 km length
  - Definition of variables: Representative of traffic, road layout and weather conditions

- **Distance Measure**
  - Euclidean Distance

- **Criterion of dis(aggregation)**
  - Hierarchical (Ward Criterion): number of groups
  - Optimization (k-means): composition of final groups

**CHARACTERIZATION OF ROAD ENVIRONMENTS**
METHODOLOGY (III)

3. MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS

Model components
- Probability distribution:
  - Poisson
  - Negative Binomial
- Linear Predictor:
  - Traffic, Road layout, Weather conditions and Pavement
- Link function:
  - Logarithmic

Fitting
- Calculation of model parameters (Maximum-likelihood)
- Coefficient of predictive variables and over-dispersion parameter

Selection of the Model
- Predictive capacity of model
  - Omnibus Test
  - Pseudo-R²
  - Statistical significance Test
  - Wald Test
- Comparison between models
  - Log Maximum-likelihood
  - AIC/AICC/BIC/CAIC

- EVALUATION OF THE INFLUENCE OF PAVEMENT SURFACE CHARACTERISTICS ON ACCIDENT OCCURRENCE
- ESTABLISHING THRESHOLD VALUES FOR THE INTERNATIONAL FRICTION INDEX (IFI), SKID RESISTANCE AND TEXTURE DEPTH, ACCORDING TO SAFETY CRITERIA
RESULTS
SELECTED ROADS

- 8 different roads (A to H) with a total length of 254 km, covering:
  - different road categories,
  - varied geographical distribution,
  - good and bad levels of pavement conditions and accidents.

<table>
<thead>
<tr>
<th>Road</th>
<th>Region</th>
<th>Category</th>
<th>Extension (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Lisboa</td>
<td>Secondary Road</td>
<td>19</td>
</tr>
<tr>
<td>B</td>
<td>Castelo Branco</td>
<td>Secondary Road</td>
<td>21</td>
</tr>
<tr>
<td>C</td>
<td>Beja</td>
<td>Primary road</td>
<td>43</td>
</tr>
<tr>
<td>D</td>
<td>Évora</td>
<td>Secondary Road</td>
<td>15</td>
</tr>
<tr>
<td>E</td>
<td>Faro</td>
<td>Secondary Road</td>
<td>39</td>
</tr>
<tr>
<td>F</td>
<td>Castelo Branco</td>
<td>Primary road</td>
<td>25</td>
</tr>
<tr>
<td>G</td>
<td>Vila Real</td>
<td>Primary road</td>
<td>52</td>
</tr>
<tr>
<td>H</td>
<td>Bragança</td>
<td>Primary road</td>
<td>40</td>
</tr>
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</table>
RESULTS

ROAD ENVIRONMENTS

- 7 different road environments

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>%H_TRAF</td>
<td>26%</td>
<td>4%</td>
<td>8%</td>
<td>7%</td>
<td>10%</td>
<td>9%</td>
<td>9%</td>
<td>10%</td>
<td>6%</td>
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<tr>
<td>AV_SP (km/h)</td>
<td>81</td>
<td>81</td>
<td>84</td>
<td>83</td>
<td>89</td>
<td>94</td>
<td>85</td>
<td>86</td>
<td>5</td>
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<tr>
<td>SP_85 (km/h)</td>
<td>90</td>
<td>90</td>
<td>94</td>
<td>92</td>
<td>91</td>
<td>101</td>
<td>93</td>
<td>94</td>
<td>4</td>
</tr>
<tr>
<td>%EXT_I</td>
<td>7.9%</td>
<td>29.2%</td>
<td>2.1%</td>
<td>3.8%</td>
<td>10.4%</td>
<td>7.3%</td>
<td>50.3%</td>
<td>11.7%</td>
<td>19.4%</td>
</tr>
<tr>
<td>%EXT_UZ</td>
<td>23%</td>
<td>87%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>24%</td>
</tr>
<tr>
<td>EXT_C (m)</td>
<td>320</td>
<td>220</td>
<td>41</td>
<td>465</td>
<td>486</td>
<td>471</td>
<td>270</td>
<td>321</td>
<td>264</td>
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<tr>
<td>CL_C</td>
<td>2.3</td>
<td>1.8</td>
<td>0.1</td>
<td>2.2</td>
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<td>2.3</td>
<td>1.7</td>
<td>1.8</td>
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<td>CL_G</td>
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<td>0.0</td>
<td>0.1</td>
<td>0.3</td>
<td>0.8</td>
<td>0.6</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>A_PREC (mm)</td>
<td>1058</td>
<td>735</td>
<td>591</td>
<td>693</td>
<td>1669</td>
<td>490</td>
<td>722</td>
<td>881</td>
<td>461</td>
</tr>
<tr>
<td>N° of segments</td>
<td>19</td>
<td>15</td>
<td>63</td>
<td>38</td>
<td>55</td>
<td>39</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RESULTS

MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS (I)

• Two different assumptions:
  – In each road environment, segments present homogeneous traffic conditions, road layout and precipitation, and regression was done with only one explanatory variable, the IFI: RE_IFI

  – In defining road environments, some characteristics were dominant, leading to some heterogeneity among the other variables. For this reason, the regression was made by introducing other explanatory variables into the model (i.e., the same variables used in the cluster analysis) – RE_MULT

\[
N_{\text{accid/km}} = TRAF_{\text{ACUM}_i} \times \exp (\beta_0 + \beta_1 \times \text{IFI}_i + \beta_2 \times \%H_{\text{TRAF}_i} + \beta_3 \times AV_{\text{SP}_i} + \beta_4 \times SP_{\text{D5}_i} + \beta_5 \times \%\text{EXT}_{\text{UZ}_i} + \beta_6 \times \%\text{EXT}_{\text{L3}_i} + \beta_7 \times \text{EXT}_{\text{C4}_i} + \beta_8 \times CL_{\text{C4}_i} + \beta_9 \times CL_{\text{L3}_i} + \beta_{10} \times A_{\text{PREC}_i})
\]
RESULTS

MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS (II)
The influence of surface characteristics on accident occurrence was evaluated by analysing the coefficients associated with the explanatory variable IFI and measuring the impact that a change in IFI produces in the expected number of accidents.

From this analysis, it was possible to conclude that there are, basically, three environments (E_i) where the pavement properties significantly, yet distinctly, influence the occurrence of accidents:

- E_1: Rural environment with a heavy presence of urban characteristics – RE1 and RE2;
- E_2: Environment characterised by a considerable predominance of intersections in a rural environment – RE7;
- E_3: Environment with curved segments, high longitudinal gradients and average speed higher than the tolerable speed – RE6.
RESULTS

ESTABLISHING THRESHOLD VALUES FOR THE INTERNATIONAL FRICTION INDEX, SKID RESISTANCE AND TEXTURE DEPTH

<table>
<thead>
<tr>
<th></th>
<th>Minimum Values / Safety Values</th>
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<tbody>
<tr>
<td>IFI</td>
<td>Skid Resistance</td>
</tr>
<tr>
<td>E₁</td>
<td>20 / 25</td>
</tr>
<tr>
<td>E₂</td>
<td>25 / 28</td>
</tr>
<tr>
<td>E₃</td>
<td>30 / 33</td>
</tr>
</tbody>
</table>

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CONCLUSIONS (I)

• A further scientific attempt to establish relationships between functional characteristics of pavement and road accidents by using a set of roads selected from the Portuguese road network.

• The cluster analysis used to identify different road environments is presented as innovative and a valid alternative for choosing the segments to be used in road accident prediction models.

• Weaknesses of cluster analysis: the groups formed are not, in most cases, completely homogeneous and there is some variation of characteristics within the same group, even if the variation within the group is less than between groups.
CONCLUSIONS (II)

- Problems with statistical significance, over-dispersion and reliability of accident data took place during the calibration process.

- Results show that road environments where braking manoeuvres are more common (E₁ and E₂) or those with small radii of curvature and high speeds (E₃) require higher skid resistance and texture depth levels.

- The Portuguese Highways Agency recently recognised the importance of research studies to support the development of maintenance programmes for surface characteristics to be incorporated into pavement management systems. This work seeks to contribute a set of values established according to safety criteria for skid resistance and texture depth maintenance.
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THANK YOU

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