An In-Vehicle Data Recorder for Evaluation of Driving Behavior and Safety

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In-Vehicle Data Recorders

- Monitor vehicle movement and control
  - Most applications center on crash event
  - Recently, also continuous monitoring as a form of non-police enforcement

- Limited empirical evidence
  - Installation positively affect driving behavior
  - Correlation with drivers crash history
  - Correlation with car maintenance and expenses
Continuous monitoring of all trips

Braking, Accelerating, Break into turn, Accelerate into turn
Turn while accelerating, Turn while braking, Turning, Accelerate while in turn, Break while in turn.....

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Maneuver</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/01/2004 7:30:21</td>
<td>Session Start</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 7:30:40</td>
<td>Turn and Xel</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 7:34:46</td>
<td>Xel out of Trn</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 7:55:19</td>
<td>Accelerating</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 8:07:50</td>
<td>Brk in Turn</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 8:50:08</td>
<td>Turn and Xel</td>
<td></td>
</tr>
<tr>
<td>29/01/2004 9:09:29</td>
<td>Session End</td>
<td></td>
</tr>
</tbody>
</table>
Feedback to Drivers

Drivers receive feedback through personal web-pages

Drivers’ classification based on rates of events and their severity

**Profile: cautious**
Average of 0-20 maneuvers in 10 driving hours

**Profile: moderate**
Average 20-50 maneuvers in 10 driving hours

**Profile: aggressive**
Average 50+ maneuvers in 10 driving hours
Validation Experiment

Objective

- Evaluate connection between IVDR data and risk of accident involvement
- Impact of IVDR installation and feedback on driving behavior

Experiment

- 33 drivers, 6486 driving hours
- Two phase experiment structure:
  - **1st phase**: Blind profiling for approximately 1 month. Drivers are not aware of IVDR and receive no feedback
  - **2nd phase**: drivers are exposed to the system and receive access to web based feedback

Data

- IVDR data
- Historic crash involvement records
- Login entries to the personal feedback web pages
Experimental Design

Blind profiling

Installation
Exposure announcement
Initial exposure
Feedback phase
Connection between IVDR data and risk of accident involvement

Risk index and number of crashes

\[ y = \beta_0 + \beta_1 e^x + \varepsilon \]

<table>
<thead>
<tr>
<th>$y$</th>
<th>$R^2$</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of crashes per year</td>
<td>0.460</td>
<td>0.424 (4.7)</td>
<td>1.55E-4 (4.9)</td>
</tr>
<tr>
<td>Number of fault crashes per year</td>
<td>0.763</td>
<td>0.131 (3.1)</td>
<td>1.40E-4 (9.5)</td>
</tr>
</tbody>
</table>

Risk index and crash costs

\[ y = \beta_0 + \beta_1 e^x + \varepsilon \]

<table>
<thead>
<tr>
<th>$y$</th>
<th>$R^2$</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of crashes per year (NIS)</td>
<td>0.524</td>
<td>531.0 (2.8)</td>
<td>0.368 (5.6)</td>
</tr>
<tr>
<td>Cost of fault crashes per year (NIS)</td>
<td>0.400</td>
<td>297.0 (1.7)</td>
<td>0.268 (4.3)</td>
</tr>
</tbody>
</table>

NIS 4.5 ≈$1
Feedback Usage and Impact

Impact of IVDR
• Drivers know that they are monitored
• Drivers receive feedback through personal real-time web access

Feedback Usage
• Measure: number of login entries to the personal web pages
• Initially interest is high, but decays in time without follow-up activities

Impact on risk index
• Initial exposure to feedback significantly affects driving behavior
• But, without follow-up activities impact diminished in time
Impact of Feedback over Time

Data

- Observations of monthly risk indices and login entries to the personal web-pages
- 27 drivers, 123 observations

Treatment of Panel Data

- Correlations among observations of same driver over time
- Use fixed-effects specification with driver-specific constants

Feedback Usage

Risk indices depend on:

- Time since initial exposure to feedback
- Level of access to feedback

\[ y_{it} = \beta X_{it} + \gamma_i W_{it} + \varepsilon_{it} \]

\[ W_{it} = \begin{cases} 
1 & \text{for individual } i \\
0 & \text{otherwise} 
\end{cases} \]

<table>
<thead>
<tr>
<th>( x )</th>
<th>( \beta ) (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>score(0)</td>
<td>1.156 (2.8)</td>
</tr>
<tr>
<td>( \Delta score(0,t-1) )</td>
<td>-0.317 (-3.2)</td>
</tr>
<tr>
<td>logins</td>
<td>-0.069 (-4.1)</td>
</tr>
<tr>
<td>( (logins)^2 )</td>
<td>6.2E-4 (2.6)</td>
</tr>
</tbody>
</table>
Conclusion

Summary of Results

- Connection between IVDR data and safety exists
- Installation and feedback affect driving behavior
  - Impact decreases with time
  - Requires follow-up efforts

Future Research Directions

- IVDR as a tool to study driving behavior
  - Novice young drivers & their parents
  - Professional and non-professional drivers
  - Impact of fleet safety policies on employees
  - Impact of trip circumstances and vehicle types on driving behavior.
Young Driver’s Experiment – An Example

Safety profile for the last four months

Changes in safety level during the last four months.
The vertical axis displays the date.
The horizontal axis displays the number of aggressive trips for 10 hours

Manoeuvres/10-Hours

Accompanied driving

Blind profiling

Independent driving, no feedback

Initial exposure

Additional feedback to parents