Developing a Toll Demand Model for DelDOT’s Statewide Travel Demand Model

TRB 87th Annual Meeting
Washington, D.C.

Introduction

DelDOT is facing the same deteriorating infrastructure, increasing congestion and funding shortfalls as state agencies throughout the country. They are more frequently considering tolling as an option for funding major transportation investments and increasing transportation revenue.
Introduction

DelDOT set out to develop an improved toll demand model that would be sensitive to a variety of tolling policies.

Background – Existing Tolling

- DelDOT has two limited access toll roadways:
  - I-95
  - SR 1
- Additional Toll Bridges:
  - Chesapeake Bay Bridge (US 50)
  - Delaware Memorial Bridge (I-295)
Background – Existing Tolling

Toll Collection Methods:

- Cash
- E-ZPass
  - Standard
  - Highway-Speed
  - Frequency of Use
  - HOV

Background – Existing Model

DelDOT’s Statewide Travel Demand Model (Peninsula Model)

- Four-step model with Feedback
- Mode Choice model
- Assignment with Tranplan Logit Toll Diversion Model
- Peak Season Model
Model Selection

- Current State-of-the-Practice Toll Models
  - Part of Activity Based Model
  - Post Processor
  - Sketch-Planning
  - Model in Traffic Assignment
  - Model in Mode Choice

Model Selection

Model in Traffic Assignment

- Benefits
  - Easy to implement
  - No re-calibration of Mode Choice
  - Explicitly account for peak congestion
Model Selection

Model in Traffic Assignment

- **Drawbacks**
  - Not typically fed-back through trip distribution and mode choice
  - Difficult to account for differences in toll use by trip type
  - Doesn’t account for TAZ demographics or travel characteristics

Model Selection

Model in Mode Choice

- **Benefits**
  - Use existing mode choice utility function
  - Improve estimation of highway utility
  - Accounts for TAZ demographics and travel characteristics
  - Accounts for value of time and operating cost by trip type
  - Included in feedback
Model Selection

Model in Mode Choice

- Drawbacks
  - Potential for large mode specific constant
  - Current model only implicitly accounts for peak periods in mode choice

DelDOT chose to develop an enhanced mode choice model.
Model Development

DelDOT’s existing mode choice model

- Choice
  - Highway
    - SOV
    - HOV
  - Transit
    - Walk
      - Bus
      - Rail
    - Drive
      - Bus
      - Rail

Model Development

DelDOT’s revised mode choice model

- Choice
  - Highway
    - SOV
      - No Toll
      - Cash/E-ZPass
    - HOV
      - No Toll
      - Cash/E-ZPass
  - Transit
    - Walk
      - Bus
      - Rail
    - Drive
      - Bus
      - Rail
Model Development

Revised Mode Choice Model

- Maintained variables and coefficients from existing model
- Determined nesting coefficients based on institutional knowledge
- Developed new E-ZPass ownership model

Model Development – E-ZPass Model

E-ZPass ownership model

- Based on toll utilization and E-ZPass ownership data provided by DelDOT
  - Utilization Data provided for each toll collection point:
    - Cash, E-ZPass, HOV
    - Vehicle Classification
    - Frequency of Use
Model Development – E-ZPass Model

- E-ZPass ownership data
  - 109,735 accounts registered a payment
  - 79% registered in Delaware’s 65 zip codes

Model Development – E-ZPass Model

Variable Correlation

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles/Household</td>
<td>-0.11</td>
</tr>
<tr>
<td>Persons/Household</td>
<td>0.37</td>
</tr>
<tr>
<td>Workers/Household</td>
<td>0.40</td>
</tr>
<tr>
<td>Household Income ($)</td>
<td>0.45</td>
</tr>
<tr>
<td>HBW Trips per Household</td>
<td>0.38</td>
</tr>
<tr>
<td>HBW Trip Length (miles)</td>
<td>0.14</td>
</tr>
<tr>
<td>Distance to Nearest Toll(miles)</td>
<td>-0.38</td>
</tr>
<tr>
<td>Impedance to Nearest Toll</td>
<td>-0.41</td>
</tr>
<tr>
<td>Proportion of Toll Trips</td>
<td>0.59</td>
</tr>
</tbody>
</table>
Model Development – E-ZPass Model

Final E-ZPass Ownership Models

Initial Feedback Loop:
Prob. = 0.00967 x HBW trip length + 0.00000389 x household income - 0.00248 x distance to nearest toll plaza

Subsequent Loops:
Prob. = 0.00427 x HBW trip length + 0.0000036 x household income - 0.7397 x proportion of toll trips

Model Development – Final Model

Final Mode Choice Model

<table>
<thead>
<tr>
<th>Constant</th>
<th>Multinomial Coefficient</th>
<th>Nested Logit Coefficient</th>
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</thead>
<tbody>
<tr>
<td>Shared Ride Constant</td>
<td>-1.41</td>
<td>-2.17</td>
</tr>
<tr>
<td>Toll Constant</td>
<td>0.774</td>
<td>3.4</td>
</tr>
<tr>
<td>Transit Constant</td>
<td>-0.27</td>
<td>-0.27</td>
</tr>
<tr>
<td>Drive to Transit Constant</td>
<td>-3.79</td>
<td>-12.6</td>
</tr>
<tr>
<td>Premium Constant</td>
<td>0.2</td>
<td>1.16</td>
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</table>
## Model Development – Calibration

### Calibration Results

<table>
<thead>
<tr>
<th>Toll Location</th>
<th>Payment Method</th>
<th>Count</th>
<th>Model</th>
<th>% Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-95</td>
<td>Cash</td>
<td>40188</td>
<td>34985</td>
<td>-13%</td>
</tr>
<tr>
<td></td>
<td>E-ZPass</td>
<td>26106</td>
<td>24245</td>
<td>-7%</td>
</tr>
<tr>
<td>SR 1-Biddles Corner</td>
<td>Cash</td>
<td>19615</td>
<td>20886</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>E-ZPass</td>
<td>21981</td>
<td>17935</td>
<td>-18%</td>
</tr>
<tr>
<td>SR 1-Dover</td>
<td>Cash</td>
<td>16191</td>
<td>15908</td>
<td>-2%</td>
</tr>
<tr>
<td></td>
<td>E-ZPass</td>
<td>14793</td>
<td>13395</td>
<td>-9%</td>
</tr>
</tbody>
</table>

### Case Studies

- **Case Study: Old versus New toll results – Biddles Corner**
Case Studies – Biddles Corner

Toll Plaza
Immediately South of C&D Canal with easy diversion

- Easy Diversion after canal crossing
  - Use the new bridge
  - Don’t pay toll
- What happens if DelDOT raises the toll?
Case Studies – Biddles Corner

Travel Demand and Revenue Results

Case Study – Toll Sensitivity Test
(2006 AADT, at Biddles Corner)

Case Study – Toll Sensitivity Test
(2005 AADT, at Biddles Corner)
Conclusions and Future Direction

- Tolling is being considered as a potential funding source on all major new projects.
- DelDOT developed a toll model that is sensitive to a variety of different policies such as toll rates, electronic toll collection, and policy decisions.
- It is closely tied to TAZ-level demographics and travel characteristics.
Conclusions and Future Direction

- It will be easy to enhance and update in the future.
- DelDOT is adding toll-related questions to their monthly surveys.
  - Allow us to derive trip-type specific toll data
  - Allow us to estimate E-ZPass ownership at household level
  - Allow us to derive temporal toll use

Conclusions and Future Direction

- DelDOT recently changed their toll policies.
  - Tolls doubled on weekends
  - Eliminated nighttime trucker discount
  - HOV and E-ZPass discounts eliminated on SR1
  - Frequency of use discount remained the same
Conclusions and Future Direction

Questions?

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