Minnesota Highway Cost Allocation Study

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Outline

Highway Cost Allocation (HCA) Study

- Minnesota Highway Cost Allocation Tool (MHCAT)
- HCA results

Fuel versus Mileage-Based Taxes

- Is it possible to adjust fuel taxes to achieve equity and efficiency?
Tax Structure 101

Efficiency
Recoup expenditures.

Equity
“Fair” allocation.

Vertical Equity
Tax paid by each road user is proportional to ability to pay

Horizontal Equity
Tax paid by each road user is proportional to usage

Efficiency

Equity

Conflict
Highway Taxes Evaluation

• **Key Concepts**
  – Tax Revenue-to-Expenditure Responsibility Ratio (RC ratio)
  – Adjusted Revenue-to-Expenditure Ratios

• **Goal:** Calculate R-C & Adjusted R-C ratios
Part I
Highway Cost Allocation Study
Using MHCAT
Why Develop MHCAT

• FHWA tool
  – VMT cannot be zero (the user must enter a number, which may affect calculations)
  – Revenues do not add up correctly
  – Traffic management cost is not allocated
• Vehicle classification issues
  – FHWA tool uses HCA 20-vehicle classification.
  – Minnesota data are based on FHWA 12-vehicle classification
• FHWA tool does not allow new vehicle classes to be created
• User Friendliness Issues
Cost Responsibility Calculation

Expenditure Data
- Construction costs
- Maintenance costs
- Operational costs

Federal-Aid

State Level

HCA Spreadsheet
- Annual miles per vehicle per class
- Weight distributions
- Pavement parameters
- Bridge parameters

Other Data
- VMT
- Pavement thickness
- Highway miles

Cost Responsibility for each Vehicle class
Revenue Attribution

Federal Revenue
- Fuel taxes
- Heavy vehicle use tax
- Vehicle sales tax
- Tire tax

State Revenue
- Fuel taxes
- Weight fees
- Ad valorem tax
- Vehicle sales tax
- Special permits’ fees

HCA Spreadsheet
- MPG, annual miles per vehicle per class
- Type of fuel & weight distributions

Other Data
- Tax rates
- VMT

Revenue Attributed to Each Vehicle Class
Summary of Data Sources
7/1/2003-6/30/2007

Federal-Aid and State level Expenditures

• Lynn Poirier, MnDOT Finance

Federal/State Revenue

• Highway Statistics (FE-9) (Federal Revenue)
• Highway Users Tax Distribution Fund (State Revenue)
  http://www.dot.state.mn.us/safianace/commorder/
  mn_hwy_users_tax_dist_fund.html

Tax Information

• Highway Statistics (MF-121T)
• Minnesota Statutes 168.10 and 168.013

Other Data

• VMT – Thomas Nelson, Office of Transportation Data & Analysis
• Pavement Parameters – Curtis Turgeon, Pavement Engineer, Mn/DOT
• Highway Miles – from Highway Statistics
• MPG, Annual Distance, and RGW distribution – vehicle inventory and use survey 2002 (VIUS 2002)
• OGW distribution – from WIM data
# Vehicle Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Avg. VMT (10^6) / yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO</td>
<td>Automobiles and motorcycles</td>
<td>35620</td>
</tr>
<tr>
<td>LT4</td>
<td>Light trucks</td>
<td>17277</td>
</tr>
<tr>
<td>SU2</td>
<td>Single unit, 2-axle, 6 tire trucks</td>
<td>1278</td>
</tr>
<tr>
<td>SU3</td>
<td>Single unit, 3-axle trucks</td>
<td>397</td>
</tr>
<tr>
<td>SU4+</td>
<td>Single unit trucks with 4- or more axles</td>
<td>120</td>
</tr>
<tr>
<td>CB3&amp;4</td>
<td>Truck Trailer or tractor-semitrailer combinations with 3 or 4-axles</td>
<td>215</td>
</tr>
<tr>
<td>CB5</td>
<td>Truck Trailer or tractor-semitrailer combinations with 5-axles</td>
<td>1888</td>
</tr>
<tr>
<td>CB6+</td>
<td>Truck Trailer or tractor-semitrailer combinations with 6- or more axles</td>
<td>382</td>
</tr>
<tr>
<td>DS5</td>
<td>Tractor-double semitrailer combinations with 5-axles</td>
<td>33</td>
</tr>
<tr>
<td>DS6</td>
<td>Tractor-double semitrailer combinations with 6-axles</td>
<td>7</td>
</tr>
<tr>
<td>DS7+</td>
<td>Tractor-double semitrailer combinations with 7-axles</td>
<td>10</td>
</tr>
<tr>
<td>BUS</td>
<td>Buses all types</td>
<td>155</td>
</tr>
</tbody>
</table>
Revenue Attritions and Expenditure Allocations

<table>
<thead>
<tr>
<th>Class</th>
<th>State Only</th>
<th>Federal and State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Revenues</td>
<td>Expenditures</td>
</tr>
<tr>
<td>AUTO</td>
<td>690,773 (52.65%)</td>
<td>483,514 (46.96%)</td>
</tr>
<tr>
<td>LT4</td>
<td>358,814 (27.35%)</td>
<td>272,875 (26.50%)</td>
</tr>
<tr>
<td>SU2</td>
<td>53,535 (4.08%)</td>
<td>35,390 (3.44%)</td>
</tr>
<tr>
<td>SU3</td>
<td>29,817 (2.27%)</td>
<td>19123 (1.86%)</td>
</tr>
<tr>
<td>SU4+</td>
<td>7,783 (0.59%)</td>
<td>9,489 (0.92%)</td>
</tr>
<tr>
<td>CB34</td>
<td>18,144 (1.38%)</td>
<td>13,117 (1.27%)</td>
</tr>
<tr>
<td>CB5</td>
<td>114,467 (8.72%)</td>
<td>132,661 (12.88%)</td>
</tr>
<tr>
<td>CB6</td>
<td>28,227 (2.15%)</td>
<td>52,550 (5.10%)</td>
</tr>
<tr>
<td>DS5</td>
<td>1,770 (0.13%)</td>
<td>2,048 (0.20%)</td>
</tr>
<tr>
<td>DS6</td>
<td>439 (0.03%)</td>
<td>763 (0.07%)</td>
</tr>
<tr>
<td>DS7+</td>
<td>643 (0.05%)</td>
<td>1,668 (0.16%)</td>
</tr>
<tr>
<td>BUS</td>
<td>7,573 (0.58%)</td>
<td>6,515 (0.63%)</td>
</tr>
<tr>
<td>Total</td>
<td>1,311,986 (100.00%)</td>
<td>1,029,713 (100.00%)</td>
</tr>
</tbody>
</table>
State Adjusted Ratios
Federal+State Adjusted Ratios
Weight Fees vs Mileage Based Fee

• Weight Fees (Current System)
  – Each vehicle pays based on its registered gross weight

• Weight-Mileage Fees
  – Each vehicle pays based on its registered gross weight, axle configuration and distance traveled

• Assumptions
  – The travel habit (VMT) does not change
  – Fuel tax remains in the system
## Weight Fees vs Mileage Based Fee – State Adjusted Ratios

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Weight Fees (current)</th>
<th>W-M Fees Scenario 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO</td>
<td>1.12</td>
<td>1.08</td>
</tr>
<tr>
<td>LT4</td>
<td>1.03</td>
<td>1.00</td>
</tr>
<tr>
<td>SU2</td>
<td>1.19</td>
<td>0.86</td>
</tr>
<tr>
<td>SU3</td>
<td>1.22</td>
<td>1.00</td>
</tr>
<tr>
<td>SU4+</td>
<td>0.64</td>
<td>0.80</td>
</tr>
<tr>
<td>CB34</td>
<td>1.09</td>
<td>1.07</td>
</tr>
<tr>
<td>CB5</td>
<td>0.68</td>
<td>0.88</td>
</tr>
<tr>
<td>CB6+</td>
<td>0.42</td>
<td>0.71</td>
</tr>
<tr>
<td>DS5</td>
<td>0.68</td>
<td>0.93</td>
</tr>
<tr>
<td>DS6</td>
<td>0.45</td>
<td>0.77</td>
</tr>
<tr>
<td>DS7</td>
<td>0.30</td>
<td>0.67</td>
</tr>
<tr>
<td>BUS</td>
<td>0.91</td>
<td>0.88</td>
</tr>
</tbody>
</table>
Weight Fees vs Mileage Based Fee – Average Fee per Mile ($0.01/mile)

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Weight Fees</th>
<th>W-M Fees Scenario 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>SU2</td>
<td>1.17</td>
<td>0.08</td>
</tr>
<tr>
<td>SU3</td>
<td>4.02</td>
<td>4.34</td>
</tr>
<tr>
<td>SU4+</td>
<td>3.08</td>
<td>7.41</td>
</tr>
<tr>
<td>CB34</td>
<td>3.20</td>
<td>5.06</td>
</tr>
<tr>
<td>CB5</td>
<td>2.27</td>
<td>6.55</td>
</tr>
<tr>
<td>CB6+</td>
<td>3.37</td>
<td>13.24</td>
</tr>
<tr>
<td>DS5</td>
<td>1.52</td>
<td>5.61</td>
</tr>
<tr>
<td>DS6</td>
<td>1.94</td>
<td>9.48</td>
</tr>
<tr>
<td>DS7</td>
<td>2.70</td>
<td>16.99</td>
</tr>
</tbody>
</table>

- Some vehicle classes pay less when charging W-M fees.
Part 2
Fuel Tax vs Weight-Mileage Fee

From a Modeling Perspective
A Stylized Model

- $X_j = \text{type-}j \text{ demand in pound miles}$
- $y_{ij} = \text{portion of demand } X_j \text{ served by type-}i \text{ vehicles}$
- $r_j = \text{revenue per pound-mile for demand } X_j$
- $c_i = \text{capital cost per type-}i \text{ vehicle}$
- $t_i = \text{registration fee per type-}i \text{ vehicle}$
- $\theta_i = \text{operating cost per pound-mile for type-}i \text{ vehicles}$
- $\delta_i = \text{diesel tax per pound-mile for type-}i \text{ vehicles}$
- $g_i(y) = \text{number of vehicle required if } y \text{ is the total pound-miles carried by type-}i \text{ vehicles}$
Truck Industry’s Equilibrium Solution

\[
\max_{y_{ij}} \sum_{i=1}^{n} \left[ r_i X_i - \sum_{j=1}^{i} y_{ij} [\theta_i + \delta_i] - g_i \left( \sum_{j=1}^{i} y_{ij} \right) [c_i + t_i] \right]
\]

Subject to

\[
\sum_{i=j}^{n} y_{ij} \leq X_j \text{ for each } j = 1, 2, \ldots, N.
\]

\[y_{ij} \geq 0 \text{ for all } (i, j).\]

This formulation is called a \textit{linear program} => it can be solved efficiently using MATLAB or Excel solver.

The optimal solution is denoted by \(y_{ij}^*\) and \(y_i^* = \sum_{j=1}^{i} y_{ij}^*\).
State’s Perspective

- $RC : \text{Overall revenue-expenditure ratio}$

$$RC = \frac{\sum_{i=1}^{n} [y_i^* \cdot \delta_i + g_i(y_i^*) \cdot t_i]}{\sum_{i=1}^{n} y_i^* \cdot \kappa_i}.$$ 

- $RC_i : \text{Adjusted revenue-expenditure ratio for vehicle type } i$

$$RC_i = \frac{y_i^* \cdot \delta_i + g_i(y_i^*) \cdot t_i}{RC} \cdot \frac{1}{y_i^* \cdot \kappa_i}.$$
Effect of Fuel Taxes

• Setting
  - Two vehicle classes (light, heavy)
  - Demand
    • Light-load demand: 20,000; Heavy-load demand: 40,000

Adjustments in fuel tax rates do not lead to high levels of equity and efficiency simultaneously.
Effect of W-M Fees

• Setting
  – Two vehicle classes (light, heavy)
  – Demand
    • Light-load demand: 20,000 ; Heavy-load demand: 40,000

<table>
<thead>
<tr>
<th>(δ₁, δ₂)</th>
<th>(y₁, y₂₁, y₂₂)</th>
<th>RC</th>
<th>RC₁</th>
<th>RC₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1, 0.8)</td>
<td>(20000, 0, 40000)</td>
<td>0.36</td>
<td>2.75</td>
<td>0.71</td>
</tr>
<tr>
<td>(1, 2)</td>
<td>(20000, 0, 40000)</td>
<td>0.53</td>
<td>1.87</td>
<td>0.86</td>
</tr>
<tr>
<td>(1, 4)</td>
<td>(20000, 0, 40000)</td>
<td>0.82</td>
<td>1.22</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Increase tax

Mileage-based taxes can improve both efficiency and equity
Take Away

• To achieve tax equity,
  – Tax structure needs to be adjusted based on *vehicle characteristics* that are directly related to highway cost such as *weight*, *axle configuration*, and *distance travelled*. 
Questions and Comments

Details are available in three task reports that can be requested from Mn/DOT