Outline

- Roles for Cost Models
- Conventional Model Types
  - Fully Allocated Causal Factor Models
  - Temporal Variation Models
  - Incremental Fixed Variable Cost Models

Cost Estimation

Roles for Cost Models

- Predict cost change associated with a service change
  - concerned with marginal (incremental) costs
  - different results over different time periods
  - routine performance monitoring/service policy triggers
- Predict cost change associated with change in production process
  - introduce part-time operators
  - contract out maintenance work
  - contract out suburban routes
  - new fare technology
- Subsidy allocation among jurisdictions
  - fairly allocate joint or overhead costs
  - often critical to participation decision in regional transit authority and even route level of service

Classification of Transit System Expenses

Capital Costs
- Vehicles
- Fixed facility construction -- track, garages, stations
- Other long term physical assets

Operating Costs
- Labor wages and benefits
- Materials and supplies
- Agency administration
- Other expenses incurred in operations

Types of Cost Models

1. Fully allocated causal factor models
2. Temporal variation models
3. Incremental fixed/variable cost models
Fully Allocated Causal Factor Models

1. Select causal factors: e.g. vehicle hours, vehicle miles, and peak vehicles.
2. Assign each expense type to appropriate factor. e.g. operator wages and benefits assigned to vehicle hours, fuel assigned to vehicle miles, administration assigned to peak vehicles.
3. Calculate average costs per unit of Factor A, B, and C: e.g. A = costs assigned to vehicle hours / total vehicle hours.
4. Define cost model as:
   \[
   \text{cost} = (A \cdot \text{vehicle hours}) + B \cdot \text{vehicle miles} + (C \cdot \text{peak vehicles})
   \]

Temporal Variation Models

1. Follow fully allocated causal factor model procedure for all except operator (crew) costs.
2. To estimate operator costs, for each 30-min time period \( t \):
   a. Identify all runs, \( i \), with at least 15 minutes of vehicle time in period \( t \).
   b. For each run \( i \) compute the average pay per vehicle hour by dividing daily pay \( W_i \) by vehicle hours \( H_i \).
   c. Find the minimum, average and maximum pay per vehicle hour in period \( t \). Average given by:
   \[
   W_t = \frac{\sum_{i=1}^{n} \left( \frac{W_i}{H_i} \right)}{n}
   \]


<table>
<thead>
<tr>
<th>Basis of Assignment</th>
<th>F/V</th>
<th>Cost Assigned ($ M)</th>
<th>% of Total</th>
<th>Operating Stat. (Annual)</th>
<th>Unit Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rev. Veh Hours V</td>
<td>79.0</td>
<td>45.5</td>
<td>2.13 million</td>
<td>37.13</td>
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<td>F</td>
<td>5.7</td>
<td>3.3</td>
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<td>Rev. Veh Miles V</td>
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<td>28.8</td>
<td>22.0 million</td>
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<td>F</td>
<td>3.0</td>
<td>1.7</td>
<td>0.14</td>
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<tr>
<td>Peak Vehicles F</td>
<td>35.9</td>
<td>20.7</td>
<td>775</td>
<td>$46,323</td>
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<tr>
<td>Total</td>
<td>173.6</td>
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</tr>
</tbody>
</table>

Possible Cost Models:
- Full Annual Cost = (39.82 * Rev Veh Hrs + 2.41 * Rev Veh Miles) x 1.261
- Full Annual Cost = (39.82 * Rev Veh Hrs + 2.41 * Rev Veh Miles) + (46,323 * Peak Veh)
- Variable Annual Cost = (37.13 * Rev Veh Hrs + 2.27 * Rev Veh Miles)

The Driver Requirement for One MBTA Garage


From Herzenberg, A. Method for Estimating the Costs of Drivers’ Wages for Bus Services. In Transportation Research Record 947, Figure 1, p. 9 and Figure 2, p. 11. Copyright, National of Sciences, Washington, D.C., 1983. Reproduced with permission of the Transportation Research Board.
Cost Estimation Exercise

For an agency which cannot employ part-time operators, the following operator costs have been determined based on an analysis of existing operator runs:

<table>
<thead>
<tr>
<th></th>
<th>Peak</th>
<th>Off-peak</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum cost/operator hour</td>
<td>$30</td>
<td>$30</td>
<td>$30</td>
</tr>
<tr>
<td>Average cost/operator hour</td>
<td>$38</td>
<td>$31</td>
<td>$35</td>
</tr>
<tr>
<td>Maximum cost/operator hour</td>
<td>$45</td>
<td>$33</td>
<td>$45</td>
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</table>

What would you estimate the incremental cost impact per operator hour to be for the following possible service changes:
1. Proportional increases in both peak and off peak services.
2. Proportional decreases in both peak and off peak services.
3. Increases in peak period services only.
4. Decreases in peak period services only.
5. Increases in off peak period services only.
6. Decreases in off peak period services only.


Total fixed costs to be allocated (see p. 8) = $44.6 mill

<table>
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<tr>
<th># Buses operating</th>
<th>Weekday</th>
<th>Sat</th>
<th>Sun</th>
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<tbody>
<tr>
<td></td>
<td>Peak</td>
<td>Base</td>
<td>Evening</td>
</tr>
<tr>
<td>Hours/day</td>
<td>4.5</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Allocate share of fixed costs for 250 buses across all time periods:
   - Share of fixed costs to be allocated 250/775 = 32%
   - Fixed costs to be allocated = $44.6 * 0.32 = $14.4 mill
   - Annual bus hours operated by 250 buses
     = 250(wkday hrs + Sat hrs + Sun hrs)
     = 250(4.5*250 + 12*58 + 12*57)
     = 1.25 mill
   - Average Cost/bus hour = $11.52

2. Allocate share of fixed costs for next 125 buses across all time periods except Sundays and weekday evenings
   - Fixed costs to be allocated = 44.6(125/775) = $7.2 mill
   - Annual bus hours operated by 125 buses = 125(10.5*250 + 12*58) = 0.42 mill
   - Average Cost/bus hour = $17.14
3. Allocate remaining fixed costs to weekday peak service:
   - Fixed costs to be allocated = $23 mill
   - Annual bus hours operated by peak buses only = 400*4.5*250 = 0.45 mill
   - Average Cost/bus hour = $51.11
4. Fixed costs will increase the variable vehicle hourly cost ($37.13) by:
   - $11.52 for Sunday/evening service
   - $13.97 for Saturday and weekday base service
     (11.52*250/375 + 17.14*125/375)
   - $32.86 for weekday peak service
     (11.52*250/775 + 17.14*125/775 + 51.11*400/775)

Comparison of Traditional and Peak/Base Models: MBTA 1996 Cost Model: Motor Bus

- Traditional Model
  - Full Annual Cost = ((39.82*Rev Veh Hrs)+(2.41*Rev Veh Miles)) * 1.261
- Variable Cost Model:
  - Variable Cost = (37.13*Rev Veh Hrs)+(2.27*Rev Veh Miles)
- Peak Period Model:
  - Full Annual Peak Cost = (69.99*Peak Rev Veh Hrs) + (2.41*Peak Rev Veh Miles)
- Off-Peak Period Model:
  - Full Annual Base Cost = (50.04*Off-Peak Rev Veh Hrs) + (2.41*Off-Peak Rev Veh Miles)

Incremental Fixed/Variable Models

1. Classify costs on the basis of variable, semi-variable, and fixed as well as the causal factors.
2. Determine unit costs for each cell of the matrix.

<table>
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<tr>
<th>Resource</th>
<th>Expense</th>
<th>Bus Hours</th>
<th>Bus Miles</th>
<th>Peak Buses</th>
<th>Variable</th>
<th>Semi-Variable</th>
<th>Fixed</th>
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<tr>
<td>Crew Wages</td>
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<tr>
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3. Apply the 9 variable cost model.