Application of Multi-Attribute Tradespace Exploration to the Architecting and Design of a Transportation System

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Domain Context: Transportation Planning

Transportation systems deliver a complex set of benefits and costs to different stakeholder groups over long periods of time and under uncertain conditions. This research addresses the following shortcomings of Cost-Benefit Analysis (CBA):

- Discounting and aggregation of costs and benefits hides information (equity, inequality) in the design process.
- Discounting and aggregation of costs and benefits introduces critical value judgments (value of future lives, future damage; interpersonal value comparisons).
- Decisions are vulnerable to manipulation and error through uncertainty about future costs and benefits.

Expected contributions

- A methodology for incorporating non-monetary costs (e.g. externalities) into tradespace studies during the conceptual design of transportation systems.
- Limiting the amount of critical assumptions that are introduced in the design process at the point of evaluation (e.g. equity, time context).
- Allowing for a time-staged exploration of costs by differentiating them as different cost types.
- Refining sensitivity analysis through explicitly considering changing environments (Epoch-Era Analysis).
- Comparative-research comparative
- Uncoupling of domain biases (space versus transportation).
- Reciprocal findings for application across domains.

Research Questions

How can different types of costs (e.g., externalities) be incorporated in tradespace studies during the conceptual design of transportation systems?

How can changing environments be considered in the sensitivity analysis of cost-benefit analysis?

Improving Classical Cost-Benefit Analysis

Multi-Attribute Tradespace Exploration (MATE) may provide a set of methods for addressing several shortcomings of classical CBA:

Problems with CBA

- Equity, distributional effects (adding up across stakeholders).
- Time-sensitivity of costs and benefits (discounting).
- Focus on a few point designs.
- Vulnerability to manipulation and errors due to uncertainty about future developments.

Benefits of MATE

- Explore tradespaces for different attributes that constitute expenses (negative utility) individually.
- Differential attributes depending on when they occur (e.g. initial and recurring costs).
- Exploration of larger sets of designs.
- Epoch-Era Analysis can be used for broad and time-varying sensitivity analysis.

Case Application: Airport Express for Chicago

Value Propositions for Airport Express revealed at MIT project-specific

<table>
<thead>
<tr>
<th>Rank</th>
<th>Attributes</th>
<th>Measure, Range</th>
<th>CTA</th>
<th>Attributes</th>
<th>Measure, Range</th>
<th>Private Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Estimated tax base change</td>
<td>% increase in equalized assessed property value (median)</td>
<td>$100 (100-300)</td>
<td>Up front investment</td>
<td>$200,000</td>
<td>% of outside project funding paid to consulting firm (15-35)</td>
</tr>
<tr>
<td>2</td>
<td>Generation of employment</td>
<td>% of new jobs created</td>
<td>(20,000-100,000)</td>
<td>Cost of capital needed for airport expansion (25-50)</td>
<td>% of capacity needed for airport expansion (50-75)</td>
<td>% of capacity used by new train (5-10)</td>
</tr>
<tr>
<td>3</td>
<td>Availability of outside project funding</td>
<td>% of state and local share requirement (50-70)</td>
<td>% of capacity used by new train</td>
<td>Probability of recurring delays to existing trains</td>
<td>Automation to meet changes (25-50)</td>
<td>Percent to consult (3-5)</td>
</tr>
</tbody>
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Possible real case application in cooperation with MPP SCUSE project: Exploration of different options for intermediary transit services between automobile and public transportation, such as bus-on-call, car-sharing, etc., to help people transition to more public forms of transportation.

For more information, please visit:
http://seari.mit.edu

For information on the MIT-Portugal Program, please visit:
http://www.mitportugal.org