Reliability in Swedish CBA – current practice and what needs to be done

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Topics of the talk

• Present current Swedish state-of-practice:
  − CBA recommendations (valuations of reliability)
  − Present modeling approaches

• Point out a few good ideas, findings and approaches

• Point out where practice should be improved
Introduction

• Uncertain journey times creates an additional travel cost, both through experienced delays and the need for ”margins” when choosing departure time
• Hence, should be included in cost-benefit analyses
• … even more so when regulations (pricing etc.) and information infrastructure become more important tools than physical investments
• Several studies have studied valuations of journey time variability
• Can be shown that disutility is proportional to standard deviation of the travel time
  – Assumes free choice of departure time, not-too-long headways and given a certain travel time distribution
• For evaluation, we need ways to forecast journey time variability
What’s needed to include reliability in CBA

<table>
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**Digression:**

Effects of the Stockholm congestion charges: 30-50% less time in queues & less variability
Congestion charges:
More days became "good days" in terms of travel time

- Black: April 2005, no charges
- Red: April 2006, congestion charges
- Both mean and standard deviation of travel times decreased
- The distributions got more skewed in 2006
  - High congestion => less skewed distributions
Road: valuation

- Valuation based on the *standard deviation* of travel time
  - *After* controlling for "anticipated" travel time variation due to time-of-day, season etc.
  - Std.dev. increases in congested conditions

\[ u = \alpha \times \text{average}_\text{time} + \beta \times \text{cost} + \gamma \times \text{stddev} \]
  - interpreting the interval as a 95% confidence interval

- \( \frac{\gamma}{\alpha} \) = relative value of variability – “reliability ratio”
  - typically 0.7 – 1.3

- \( \gamma \) should depend on the shape of the travel time distribution (the “H factor”) (Bates, Fosgerau later)

<table>
<thead>
<tr>
<th>Time</th>
<th>VoT (€/h)</th>
<th>VoStdDev (€/h)</th>
<th>Rel. ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>7.6</td>
<td>3.7</td>
<td>0.95</td>
</tr>
<tr>
<td>Business</td>
<td>13.3</td>
<td>2.2</td>
<td>0.32</td>
</tr>
<tr>
<td>Afternoon</td>
<td>6.4</td>
<td>1.6</td>
<td>0.59</td>
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- (Eliasson, 2003)
Road: Valuation (in practice)

- Recommendation: VoR = 0.9*std.dev.*VoT
  - Based on Eliasson (2003); similar to several other studies
  - Similar to e.g. UK, Netherlands…

- No adjustment for the distribution of the travel time (the ”H factor”/”mean lateness factor”)
  - The ”0.9” part should really depend on the shape of the travel time distribution

- This is applied not only for private trips, but also for freight transport and business trips
  - No justification for this, really

- Occasionally, replaced by ”queue driving 1.5 as onerous as free-flow driving”
  - But this is actually something else and additional to travel time variability
Road: Modeling the congestion/std.dev. relationship
Road: Modeling

• Estimated relationship between congestion and std.dev. of travel time:

\[
\sigma = c_{ToD} t^{\alpha} L^\beta \left( \frac{t}{t_0} - 1 \right)^\gamma
\]

\[\alpha = 1.1, \beta = -0.3, \gamma = 0.5\]

• \(c_{ToD}\) is a time-of-day constant, different for the period before peaks (queue build-up phase) and after peak (queue dissipation phase)

• Estimated in Eliasson (2006), using automatic travel time measurements for 41 urban links

• No modeling of the distribution (the "H factor") yet (see Joel Franklin tomorrow)
Road: Modeling (in practice)

• The formula is implemented in Emme/2
• Emme/2 travel times underestimated in high congestion, though… so std.dev. is underestimated

• Not used during assignment, only as an evaluation measure in the CBA once the traffic forecast is made
• Link travel times assumed to be uncorrelated (necessary for skimming)
Can we assume that link travel times are uncorrelated?

- Uncorrelated travel times on links along a route necessary for "skimming" the stddev for an entire O-D route
- Not really true, though… but the error seems not too large

Total std.dev. assuming uncorrelated travel times on pair of adjacent links

Correct total std.dev. for pair of adjacent links
Road reliability in CBA: towards fairly OK

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Long-distance trains: Valuation

• "Delays" are defined as the positive difference between actual and scheduled arrival time
• Practice: Average delay (risk*length) valued as 2*(travel time)
• … unfortunately
• We know that delay valuation is not proportional to delay risk
  – increases slower than linearly in the risk
  – See Maria Börjesson tomorrow
• … but this is not yet reflected in official recommendations
• The factor 2 should be much higher – 5-10 (depending on risk level)
  – Practice: 2 is changed into 3 or 4

• Theory for reliability valuation with long headways not as well developed
• Freight treated as person travel (delays = 2*VoT) – no good base for this
Long-distance trains: Modeling

- No "official" modeling method for forecasting impacts of investments/measures/timetables on delays
- Practice: use statistics and subjective judgments
- Ongoing work: simulating how primary delays "propagates" into secondary delays
  - Averaging over possible "classes" of timetables, given infrastructure and primary delays
- No good estimates of how infrastructure/maintenance affects primary delays
Evaluating how infrastructure improvements affect secondary delays

- The infrastructure determines which timetables are possible
  - Where trains can meet etc.

- Idea: specify a class of possible future timetables
  - …that are possible given the infrastructure

- Given distribution of primary delays, simulate distribution of secondary delays (for all trains) – averaged over the class of timetables
  - The distribution of primary delays is assumed to be unaffected – given by historical statistics
Rail reliability in CBA: Much to do, and recommendations not up-to-date

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Urban transit: Valuation

• No official recommendation yet
• Tentative result: VoR = 1.1*stddev*VoT
• Should depend on distribution ("H factor") and headway – but currently doesn’t

• Ongoing valuation study
Urban transit: Modeling

• Essentially nothing: statistics and subjective judgment – in the best case

• Additional complication: Importance of interconnections?
Transit reliability in CBA: Most things remain to be done

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A complement: The vulnerability approach

"Vulnerability" approach:

- Identify critical links (through e.g. vulnerability maps)

- Analyse how the consequences of a breakdown of given critical links are affected by e.g. an added link
Results from the ongoing National Transport Investment Plan

- National Transport Investment Plan 2010-2021
- Reliability included in CBA for the first time

- Road: Travel time reliability benefits around 10% of time benefits
- Rail: 20% of time benefits
Conclusions

• Travel time reliability important factor in CBA
  – 10-20% extra benefits on average; higher for some projects
• … even more so when regulations (pricing etc.) and information infrastructure become more important tools than physical investments
• Road traffic: beginning to look OK, more work under way
• Rail traffic: valuations soon OK, modeling efforts under way
  – Main deficit: sources of primary delays
• Urban transit: valuations soon OK, almost no modeling

• To a certain extent, other approaches such as ”vulnerability studies” can help out