The Trade-Offs between Delays and Capacity Utilisation: Observations from the UK

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Outline

• Context
• Methods
• Data
• Results
• Implications
Public Performance Measure (PPM)

South West Trains – Main Line Services
Method

Over 20 years, passenger traffic has broadly doubled.

Rail Technical Strategy: 4Cs

Carbon, Cost, Customer Experience and Capacity.

5th C: Congestion.

Four approaches to capacity:

1. Analytical methods
2. Parametric methods
3. Simulation
4. Optimisation
Capacity Utilisation Calculations

Large variation in results from Analytical Methods:

- UIC 406: 72%
- DB: 27% (Platform), 43% (Track)
- SZDC: 47%
- CUI: 51% (Node), 64% (Link)
- Haith et al. (2014) champion sum of the shortest headway reciprocals (after Vromans).
Parametric Methods

Alternative functional forms: linear, quadratic, power, second order approximation.
Alternative distributions: normal, Weibull, gamma, lognormal.
Data (I)

Congestion Related Reactionary Delay (CRRD) data for 2012 from Arup for Congestion Charge Recalibration exercise.

Data from Network Rail’s TRUST data system.

59,655 data points summed into 76 Common Track Sections and 8 time bands.

With missing values, 563 annual records for each direction.
Data (II)

Data on total delays for period 4, 2013/14 skimmed from
www.realtimetrains.co.uk

608 observations for each direction.
Analysis and Issues

\[ \ln (\text{Delay}) = \alpha + \beta \text{CUI} + \sum_{i=2}^{8} \beta_i \text{Time}_i + \sum_{j=2}^{76} \beta_j \text{CTS}_j + \beta_k \text{Direction} \]

- Treatment of train miles
- Network effects (time and space spillovers)
- Treatment of termini
- Simultaneity
General Results

<table>
<thead>
<tr>
<th></th>
<th>R²</th>
<th>Adjusted R²</th>
<th>β</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRRD – two-way</td>
<td>0.880</td>
<td>0.860</td>
<td>0.043</td>
<td>10.901</td>
</tr>
<tr>
<td>Realtime – two-way</td>
<td>0.779</td>
<td>0.744</td>
<td>0.010</td>
<td>2.609</td>
</tr>
</tbody>
</table>

Fixed effects models found to be superior to random effects models.
Two-way model: Geography and Time effects.
## Specific Results

<table>
<thead>
<tr>
<th>Model Type</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>$\beta$</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRRD – two-way model</td>
<td>0.871</td>
<td>0.857</td>
<td>0.039</td>
<td>11.885</td>
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<tr>
<td>Realtime – one-way model</td>
<td>0.414</td>
<td>0.398</td>
<td>0.034</td>
<td>17.390</td>
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</tbody>
</table>

One-way model: Geography effects only.
An Illustrative Calculation

• Increase Southampton Central to London Waterloo fast trains from two to three per hour.

• Benefits to passengers of reduced Service Interval Penalty equivalent to 5,670 passenger minutes per hour.

• Disbenefits to passenger of increased Delays equivalent to 2,930 passenger minutes per hour.

• But Delay time valued more highly than Journey Time by a weight (λ).

• If λ > 1.94, Delay disbenefits outweigh Service Interval benefits.

• Expect λ to be around 3.
Conclusions

- CUI has a significant effect on delays, especially CRRD.
- SWML has some problems with performance.
- In this particular case, service expansion may be problematic even when CUI for much of the route is substantially below the UIC406 threshold for mixed traffic of 60%.
- Likely that service expansion would require signalling (ERTMS Level 3) or infrastructure upgrades.
- Focus of future work, including the DITTO project.