Direct Demand models: A relevant alternative In the age Of Big Data?

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Acknowledgements

Jeremy Hackney
Michael Bernard
Ming Lu
Georgios Sarlas
Issue at hand
Activity scheduling dimensions envisaged

Number and type of activities
Sequence of activities

• Start and duration of activity
• Composition of the group undertaking the activity
• Expenditure division
• Location of the activity

• Movement between sequential locations

• Location of access and egress from the mean of transport
  • Parking type
• Vehicle/means of transport
• Route/service
• Group travelling together
• Expenditure division
Land use dimensions envisaged

Parcel use by type
Land value by parcel

- Intensity of use
- Value added by the use
  - Wages paid to the workers
  - Rents paid to the landlords
- Environmental services rendered
- Aesthetic externalities

- Space for movement between locations
- Space for parking at the locations
- Service level of public transport, taxi & sharing fleets

- Home-work linkage
- Home-education linkage
Are we willing?

To agree to the (comprehensive) tracking required of:

- Public transport use (smart cards, face recognition via CCTV)
- Car use (ERP, automatic video analysis, blue tooth)
- Walking (face recognition via CCTV, phone identification)
- Movement (GSM records, GPS traces)

To wait for the models:

- (To be programmed)
- To be estimated
- To be implemented
- To be calibrated
- To be run and the results analysed
- To be run including a full/adequate risk analysis
What do we need?
What does service planning and pricing need?

- Basic:
  - $\Delta \text{volume}_{ijmg}$
  - $\Delta \text{travel time}_{ijmg}$
  - $\Delta \text{price}_{ijmg}$

- Group g by
  - Income
  - (Distance)
  - Purpose
  - Age
  - Gender
  - Ethnicity
What does CBA need?

- Basic:
  - $\Delta \text{volume}_{im}$
  - $\Delta \text{speed}_{im}$

- Advanced:
  - $\Delta \text{volume}_{ijm}$
  - $\Delta \text{travel time}_{ijm}$
Minimum requirements
\( q, v \) sensitive to density

- Intensity of land use by
  - Car-owning population (by type)
  - Employment (by type)

- Network densities by
  - Node
  - Link capacity
  - Parking spaces
  - Seat capacity

- Prices (densities) of
  - Parking
  - Link
Some initial examples
Hackney and Bernard on speeds in Kt. Zürich
Average weekday peak hour speeds (Kanton Zürich)
Alternative approach and its model formulation

\[ \rho W_a Y \quad \lambda W_e \varepsilon \quad u \sim N(0, \sigma) \]

- OLS
- Spatial error model (SEM)
- Spatial autoregressive model (SAR)
- General spatial model (SAC)
Spatial weighting matrix (2) – Spatial/network neighbour

Spatial neighbour:
• n closest links from centre of link

5 spatial neighbours
(Euclidian distance)

Network neighbour:
• reachable links passing n (max.) intersections

2 intersections → ~5 neighbours
(network distance)
### Best spatial weighting

<table>
<thead>
<tr>
<th>Model</th>
<th>Best W-matrix</th>
<th>$\bar{R}^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighted least squares (WLS)</td>
<td>not needed</td>
<td>0.5347</td>
</tr>
<tr>
<td>Spatial error model (SEM)</td>
<td>$W_a: not needed$</td>
<td>0.5749</td>
</tr>
<tr>
<td></td>
<td>$W_e: 3$ network neighbours</td>
<td></td>
</tr>
<tr>
<td>Spatial autoregressive model (SAR)</td>
<td>$W_a: 4$ network neighbours</td>
<td>0.5518</td>
</tr>
<tr>
<td></td>
<td>$W_e: not needed$</td>
<td></td>
</tr>
<tr>
<td>General spatial model (SAC)</td>
<td>$W_a: 4$ network neighbours</td>
<td>0.5827</td>
</tr>
<tr>
<td></td>
<td>$W_e: 3$ network neighbours</td>
<td></td>
</tr>
</tbody>
</table>
Sarlas on Swiss speeds
Case study
### Estimation and comparison of models of average v

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>SAR error coeff.</th>
<th>SAR lag coeff.</th>
<th>SAC coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed-limit</td>
<td>0.254</td>
<td>0.272</td>
<td>0.26</td>
</tr>
<tr>
<td>Highways: Constant</td>
<td>96.456</td>
<td>38.421</td>
<td>83.897</td>
</tr>
<tr>
<td>Trunk roads: Constant</td>
<td>56.704</td>
<td>26.84</td>
<td>51.514</td>
</tr>
<tr>
<td>Collector roads: Constant</td>
<td>54.042</td>
<td>30.047</td>
<td>51.287</td>
</tr>
<tr>
<td>Distributor roads: Constant</td>
<td>38.941</td>
<td>24.363</td>
<td>38.95</td>
</tr>
<tr>
<td>Urban roads: Constant</td>
<td>30.332</td>
<td>20.189</td>
<td>30.428</td>
</tr>
<tr>
<td>Curveness</td>
<td>-3.592</td>
<td>-4.248</td>
<td>-3.597</td>
</tr>
<tr>
<td>Distributor: PuT stops density, r=0.5km</td>
<td>-0.083</td>
<td>-0.186</td>
<td>-0.143</td>
</tr>
<tr>
<td>Urban: PuT stops density, r=0.2km</td>
<td>-0.095</td>
<td>-0.073</td>
<td>-0.094</td>
</tr>
<tr>
<td>Highways: ln(popul, r=5km)</td>
<td>-7.978</td>
<td>-2.073</td>
<td>-5.962</td>
</tr>
<tr>
<td>Trunk roads: ln(popul, r=2km)</td>
<td>-3.602</td>
<td>-1.497</td>
<td>-3.15</td>
</tr>
<tr>
<td>Collector roads: ln(employm,r=2km,kernel)</td>
<td>-3.429</td>
<td>-2.04</td>
<td>-3.452</td>
</tr>
<tr>
<td>Distributor roads: ln(employm,r=1km,kernel)</td>
<td>-1.081</td>
<td>-0.881</td>
<td>-1.244</td>
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<tr>
<td>Urban roads: ln(employm,r=0.5km,kernel)</td>
<td>-0.501</td>
<td>-0.404</td>
<td>-0.554</td>
</tr>
<tr>
<td>Urban roads: Ramps' dens, r=1km</td>
<td>0.346*</td>
<td>-0.054</td>
<td>-0.049</td>
</tr>
<tr>
<td>Distributor roads: Road density, r=500 m</td>
<td>-0.271</td>
<td>-0.133</td>
<td>-0.256</td>
</tr>
<tr>
<td>Urban roads: Road density, r=100 m</td>
<td>-0.112</td>
<td>-0.093</td>
<td>-0.115</td>
</tr>
</tbody>
</table>

(length dummies)
Lu on travel time reliability in Germany
Map of some of the 635 elected routes (635)
Path analysis of the 3 parameter GE

Road density
Emp density
Pop density
VKTdensity
Intersections

Distribution Parameters

Skewness
mean
median

Observed
Unobserved

...
Path analysis – path chart

Intermediate variables:
- PearsonSkewness
- MedianTravelTime
- MeanTravelTime
- Std.TravelTime
- Percentile Skewness

Dependent variables:
- GEV_ξ
- GEV_μ
- GEV_σ

Observed variables:
- OriginVKTdensity
- ContourDiff
- RoadDensity1km
- Intersections
- IntersectionDen
- RoadDensity50m
- Den_p_ba07
- RoadLength
- PopulationDen
- ContourDiffDen
- Intersections
- OriginVKTdensity
- RoadLength
- RoadDensity50m
What is next?
What is next?

- Compare
  - Differences by model against counts, measurements
  - Differences between models
- Which (policy) changes can be captured
  - Fully
  - Partially
  - How to translate change into model variable change
- How often is the CBA recommendation different?
Questions?

www.ivt.ethz.ch
Literature and references


