Preferred citation style


Direct Demand models: A new lease of life ?

KW Axhausen
IVT
ETH
Zürich
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Acknowledgements

Michael Bernard
Raphael Fuhrer
Jeremy Hackney
Ming Lu
Georgios Sarlas

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Issue at hand

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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
Demographic dimensions envisaged

Balance of population by type

- Fertility by age and type of female
- Morbidity by age and type of person

- Out-migration by type of person
  - Education level
  - Age
  - Sex
  - Marital status

- In-migration by type of person
  - Education level
  - Age
  - Sex
  - Marital status

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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)

- Wages by residential and employment locations
- Land prices by location

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Are we willing?

To accept the myopic models of:

- Activity scheduling and participation
- Residential choice
- Work place & employer choice

as a guide to long-term decision making?

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Are we willing?

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

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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:
  - $\Delta \text{volume}_{m}$
  - $\Delta \text{speed}_{m}$

- Advanced:
  - $\Delta \text{volume}_{ijm}$
  - $\Delta \text{travel time}_{ijm}$

Minimum requirements

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Full requirements to explain observed travel time

- Demand on parallel and/or connecting infrastructure, splitback effects
- Population characteristics, traffic mix, cultural factors
- Traffic information and user response

Reduced form: \( q, v \) 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
Plus/Minus of regression approaches

Benefits:

• Usage of existing anonymous data
• Separating the effects of network improvements from employment and population effects (Monitoring)
• Quicker turn around then network modelling

Distadvantages:

• Parametric assumptions
• Averaging over locations
• Uniformity of weighting (but there is GWR)

• Long-distance travel is implicitly omitted
• Effects of spatially uniform impacts have to be added
Some initial examples

Hackney and Bernard on speeds in Kt. Zürich
Average weekday peak hour speeds (Kanton Zürich)

Alternative approach and its model formulation

\[ \rho W \gamma \lambda W_\varepsilon \varepsilon \sim N(0, \sigma) \]

- OLS
- Spatial error model (SEM)
- Spatial autoregressive model (SAR)
- General spatial model (SAC)
Spatial weighting matrix \( W \) (1) – Example of assembly

Contiguity: directed, 1 node distance

Contiguity matrix:

\[
\begin{array}{c|cccc}
\text{sum(rows)=1} & \text{W} & \text{A} & \text{B} & \text{C} & \text{D} \\
\hline
\text{A} & 0 & 0.5 & 0.5 & 0 \\
\text{B} & 0.5 & 0 & 0.5 & 0 \\
\text{C} & 0.33 & 0.33 & 0 & 0.33 \\
\text{D} & 0 & 0 & 1 & 0 \\
\end{array}
\]

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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 \( \rightarrow \) \( \sim 5 \) neighbours (network distance)

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## 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</td>
<td></td>
</tr>
<tr>
<td></td>
<td>neighbours</td>
<td></td>
</tr>
<tr>
<td>Spatial autoregressive model (SAR)</td>
<td>$W_a$: 4 network</td>
<td>0.5518</td>
</tr>
<tr>
<td></td>
<td>neighbours</td>
<td></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</td>
<td>0.5827</td>
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<tr>
<td></td>
<td>neighbours</td>
<td></td>
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<tr>
<td></td>
<td>$W_e$: 3 network</td>
<td></td>
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<tr>
<td></td>
<td>neighbours</td>
<td></td>
</tr>
</tbody>
</table>

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## Sarlas on Swiss speeds

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### Case study

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### Estimation and comparison of models of average v

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>SAR error</th>
<th>SAR lag</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coeff.</td>
<td>coeff.</td>
<td>coeff.</td>
</tr>
<tr>
<td>Speed-limit</td>
<td>0.254</td>
<td>0.272</td>
<td>0.26</td>
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<tr>
<td>Highways: Constant</td>
<td>96.456</td>
<td>38.421</td>
<td>81.897</td>
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<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>
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<tr>
<td>Curveness</td>
<td>-3.592</td>
<td>-4.248</td>
<td>-3.597</td>
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<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>
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<tr>
<td>Trunk roads: ln(popul, r=2km)</td>
<td>-3.602</td>
<td>-1.497</td>
<td>-3.15</td>
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<td>Collector roads: ln(employ, r=2km, kernel)</td>
<td>-3.429</td>
<td>-2.04</td>
<td>-3.452</td>
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<tr>
<td>Distributor roads: ln(employ, 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(employ, 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>
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<tr>
<td>Urban roads: Road density, r=100 m</td>
<td>-0.112</td>
<td>-0.093</td>
<td>-0.115</td>
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</tbody>
</table>

*length dummies*
Estimation and comparison of models (cont.)

\[ Y = \text{Average daily speed} \]

<table>
<thead>
<tr>
<th>Model</th>
<th>( \lambda )</th>
<th>( \rho )</th>
<th>Log-likelihood</th>
<th>AIC</th>
<th>Residuals spatial auto-correlation</th>
<th>OLS AIC</th>
<th>OLS Log-likelihood</th>
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</thead>
<tbody>
<tr>
<td>SAR error</td>
<td>0.928</td>
<td>-0.742</td>
<td>-705197</td>
<td>1410453</td>
<td>0.013</td>
<td>1615760</td>
<td>-807851.8</td>
</tr>
<tr>
<td>SAR lag</td>
<td>-</td>
<td>0.459</td>
<td>-733084</td>
<td>1466226</td>
<td>0.342</td>
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<tr>
<td>SAC</td>
<td>0.742</td>
<td>0.215</td>
<td>-694294</td>
<td>1388647</td>
<td>-0.034</td>
<td></td>
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</tr>
<tr>
<td>OLS</td>
<td>8.01%</td>
<td>20.35%</td>
<td>57.07%</td>
<td>84.69%</td>
<td>27.25%</td>
<td>-5.13%</td>
<td></td>
</tr>
<tr>
<td>SAR error</td>
<td>21.25%</td>
<td>47.20%</td>
<td>81.07%</td>
<td>93.68%</td>
<td>16.81%</td>
<td>-2.05%</td>
<td></td>
</tr>
<tr>
<td>SAR lag</td>
<td>14.57%</td>
<td>35.27%</td>
<td>75.31%</td>
<td>90.88%</td>
<td>19.33%</td>
<td>-2.58%</td>
<td></td>
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<tr>
<td>Durbin</td>
<td>20.63%</td>
<td>46.19%</td>
<td>81.18%</td>
<td>93.95%</td>
<td>16.81%</td>
<td>-2.05%</td>
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</tr>
<tr>
<td>SAC</td>
<td>21.09%</td>
<td>47.26%</td>
<td>81.92%</td>
<td>94.05%</td>
<td>17.04%</td>
<td>-1.92%</td>
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</tr>
</tbody>
</table>

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Comparison of models

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Comparison of models: Residuals of SAC model

Lu on travel time reliability in Germany
Map of some of the 635 elected routes (635)

Best fitting GEV distribution

\[ F(x; \mu, \sigma, \xi) = \exp\left\{ -\left[ 1 + \xi \frac{x - \mu}{\sigma} \right]^{-1/\xi} \right\} \]

\[ f(x; \mu, \sigma, \xi) = \frac{1}{\sigma} \left[ 1 + \xi \left( \frac{x - \mu}{\sigma} \right) \right]^{-1-1/\xi} \exp\left\{ -\left[ 1 + \xi \left( \frac{x - \mu}{\sigma} \right) \right]^{-1/\xi} \right\} \]

\( \mu \in \mathbb{R} \) location param
\( \sigma > 0 \) scale param
\( \xi \in \mathbb{R} \) shape param

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Multiple linear regression for GEV parameters:

<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
<th>Std.</th>
<th>Pearson</th>
<th>Percentile</th>
<th>Route length</th>
<th>Road Density 50m</th>
<th>Road Density 1km</th>
<th>Origin CTK density</th>
<th>Contour Diff</th>
<th>Intersections</th>
<th>Intersection density</th>
<th>Population Density</th>
<th>Employment density</th>
</tr>
</thead>
</table>

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Path analysis

- Road density
- Emp density
- Pop density
- VKTdensity
- Intersections
- ...

Distribution Parameters

- Skewness
- mean
- median

Observed

Unobserved

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Path analysis – path chart

Sarlas & Fuhrer on Swiss wages
Reduced form: mean salary sensitive to density

- Intensity of land use by
  - Population

- Network
  - Accessibility (road)
  - Accessibility (rail)

- Population composition
  - Gender
  - Education
  - Type of position
  - Time in post
  - In-commuters from abroad

- Industry
  - Share of industry

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Mean salaries by municipality

Grau: Weniger als 10 Observationen pro Verkehrszone
Helleste Farbe: Tiefster Lohndurchschnitt
Dunkelste Farbe: Höchster Lohndurchschnitt
Accessibility: Public transport 2010

Accessibility change: Public transport 2000-2010
Accessibility change: Road 2000-2010

Analyses

- Panel 2000-2010
- Pooled OLS (balanced, unbalanced)
- Spatial error model (SER)
- SER panel (2000-2010)
- GWR
### Spatial panel 2000-2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>beta (All)</th>
<th>beta (Agglo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.26</td>
<td>6.18</td>
</tr>
<tr>
<td>Year 2005 dummy (time-effect)</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Year 2010 dummy (time-effect)</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Ln car accessibility</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Ln public transport accessibility</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Ln number of local employed</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Commuter from outside Switzerland</td>
<td>-0.10</td>
<td>-0.12</td>
</tr>
<tr>
<td>Short residence permit</td>
<td>-0.15</td>
<td>0.06</td>
</tr>
<tr>
<td>Average duration in-post</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Ln average age</td>
<td>0.41</td>
<td>0.34</td>
</tr>
<tr>
<td>Men</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>N</td>
<td>1374</td>
<td></td>
</tr>
<tr>
<td>Rho</td>
<td>0.28</td>
<td>0.28</td>
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</table>

### Spatial panel 2000-2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>beta (All)</th>
<th>beta (Agglo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary education</td>
<td>0.76</td>
<td>0.70</td>
</tr>
<tr>
<td>Professional training</td>
<td>0.37</td>
<td>0.33</td>
</tr>
<tr>
<td>Further vocational training</td>
<td>0.23</td>
<td>0.19</td>
</tr>
<tr>
<td>Teaching degree</td>
<td>0.35</td>
<td>0.43</td>
</tr>
<tr>
<td>Highschool diploma</td>
<td>0.34</td>
<td>0.43</td>
</tr>
<tr>
<td>Vocational training</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>Positions with highest demands</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>Positions with qualified indep. work</td>
<td>0.24</td>
<td>0.30</td>
</tr>
<tr>
<td>Positions with professional skills</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Working (3rd sector)</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td>Working (private sector)</td>
<td>-0.08</td>
<td>-0.03</td>
</tr>
<tr>
<td>Working (manufacturing)</td>
<td>-0.21</td>
<td>-0.21</td>
</tr>
<tr>
<td>Working (FIRE)</td>
<td>0.13</td>
<td>0.17</td>
</tr>
<tr>
<td>Working (hotel, restaurants)</td>
<td>-0.12</td>
<td>-0.16</td>
</tr>
</tbody>
</table>
### Public transport accessibilities 2000-2010 elasticities

<table>
<thead>
<tr>
<th>Model</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>1.80%</td>
<td>1.60%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Spatial error</td>
<td>1.60%</td>
<td>1.30%</td>
<td>1.20%</td>
</tr>
<tr>
<td>Pooled OLS</td>
<td></td>
<td></td>
<td>1.20%</td>
</tr>
<tr>
<td>Pooled OLS for 2005-2010</td>
<td></td>
<td></td>
<td>0.70%</td>
</tr>
<tr>
<td>Time-effects</td>
<td></td>
<td></td>
<td>2.00%</td>
</tr>
<tr>
<td>Time-effects for 2005-2010</td>
<td></td>
<td></td>
<td>1.50%</td>
</tr>
<tr>
<td>SER pooled OLS</td>
<td></td>
<td></td>
<td>0.90%</td>
</tr>
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<td>SER pooled OLS for 2005-2010</td>
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<td></td>
<td>0.20%</td>
</tr>
<tr>
<td>SER with time-effects</td>
<td></td>
<td></td>
<td>1.70%</td>
</tr>
<tr>
<td>SER with time-effects for 2005-2010</td>
<td></td>
<td></td>
<td>1.20%</td>
</tr>
</tbody>
</table>

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### GWR estimates: public transport accessibility 2010

![GWR estimates: public transport accessibility 2010](image)
What is next?

What is the benchmark?

- MATSim for Switzerland
  - Agent-based equilibrium model
  - Simple demand model system

- VISUM based national model
  - Aggregate assignment model
  - Detailed four stage model with EVA

- New spatial regression models of speed and flow
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


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Literature and references


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