A route choice model suitable for traffic simulation

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Outline

- Route choice modelling in traffic simulation
- Subnetwork approach
    - Methodology
    - Example
- Empirical results
    - Borlänge GPS data set
    - Estimation results
    - Forecasting results
- Conclusion and future work

Route Choice and Traffic Simulation

- Route choice modelling is critical in traffic simulation
- Models need to meet the following criteria:
    - Applicable to real size networks
    - Capture correlation among alternatives
    - Use available data
- C-Logit and Path Size Logit models most commonly used in traffic simulation
  Idea: Multinomial Logit model with deterministic correction of the utility for overlapping paths

Route Choice and Traffic Simulation

- C-Logit (Cascetta et al., 1996)
  - Several formulations but no guidance on which to use
  - Path Size Logit outperforms C-Logit (Ramming, 2001)
- Path Size Logit (Ben-Akiva and Bierlaire, 1999)
  - Theoretical foundation
  - Original formulation should be used (Frejinger and Bierlaire, 2006)

Route Choice Models

- In addition to Path Size Logit (PSL) and C-Logit, few models capturing correlation among alternatives have been used for real size route choice analysis
  - Link-Nested Logit (Vovsha and Bekhor, 1998)
    Difficult to define nesting parameters, outperformed by PSL (Ramming, 2001)
  - Logit Kernel model adapted to route choice situation (Bekhor et al., 2002)
    Large number of random terms (one per link in a choice set)
- In general, too heavy for traffic simulation

Subnetworks

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- Which are the behaviourally important decisions?
- Our hypothesis: choice of specific parts of the network (e.g. main roads, city centre)
- Concept: subnetwork

Subnetworks

- Subnetwork approach designed to be behaviourally realistic and convenient for the analyst
- Subnetwork component is a set of links corresponding to a part of the network which can be easily labelled
- Paths sharing a subnetwork component are assumed to be correlated even if they are not physically overlapping

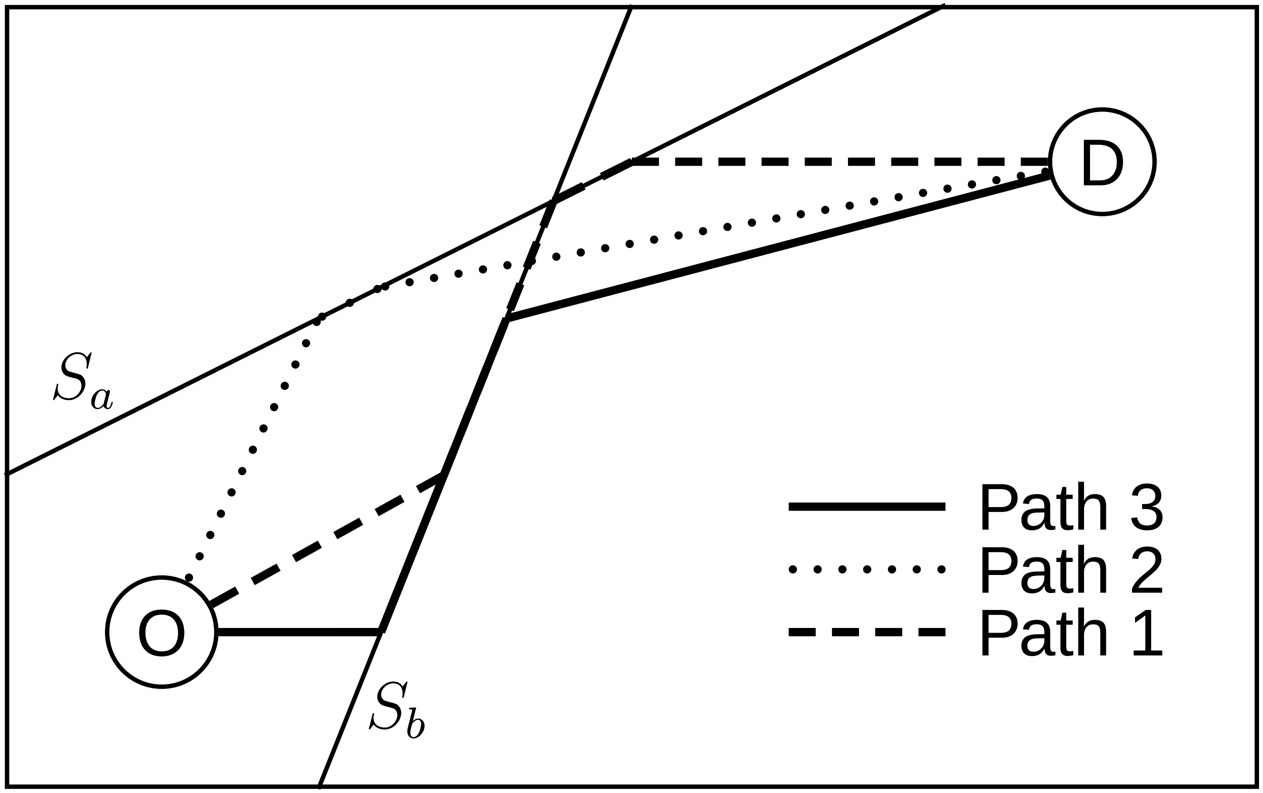
Subnetworks - Methodology

- Factor analytic specification of an error component model (based on model presented in Bekhor et al., 2002)

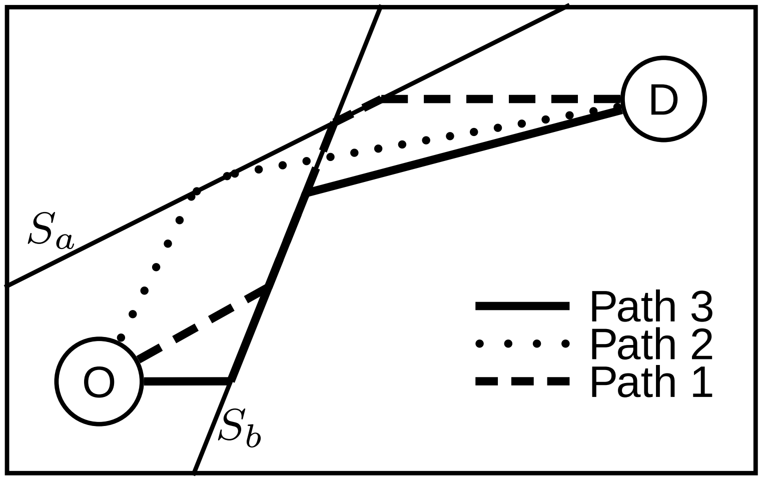
$$\mathbf{U}_n = \beta^T \mathbf{X}_n + \mathbf{F}_n \mathbf{T} \zeta_n + \nu_n$$

  - $\mathbf{F}_{n\ (J\text{x}Q)}$: factor loadings matrix
  - $(f_n)_{iq} = \sqrt{l_{niq}}$
  - $\mathbf{T}_{(Q\text{x}Q)} = \text{diag}\left(\sigma_1, \sigma_2, \ldots, \sigma_Q\right)$
  - $\zeta_{n\ (Q\text{x}1)}$: vector of i.i.d. N(0,1) variates
  - $\nu_{(J\text{x}1)}$: vector of i.i.d. Extreme Value distributed variates

Subnetworks - Example



Subnetworks - Example



$$U_1 = \beta^T X_1 + \sqrt{l_{1a}}\sigma_a\zeta_a + \sqrt{l_{1b}}\sigma_b\zeta_b + \nu_1$$

$$U_2 = \beta^T X_2 + \sqrt{l_{2a}}\sigma_a\zeta_a + \nu_2$$

$$U_3 = \beta^T X_3 + \sqrt{l_{3b}}\sigma_b\zeta_b + \nu_3$$

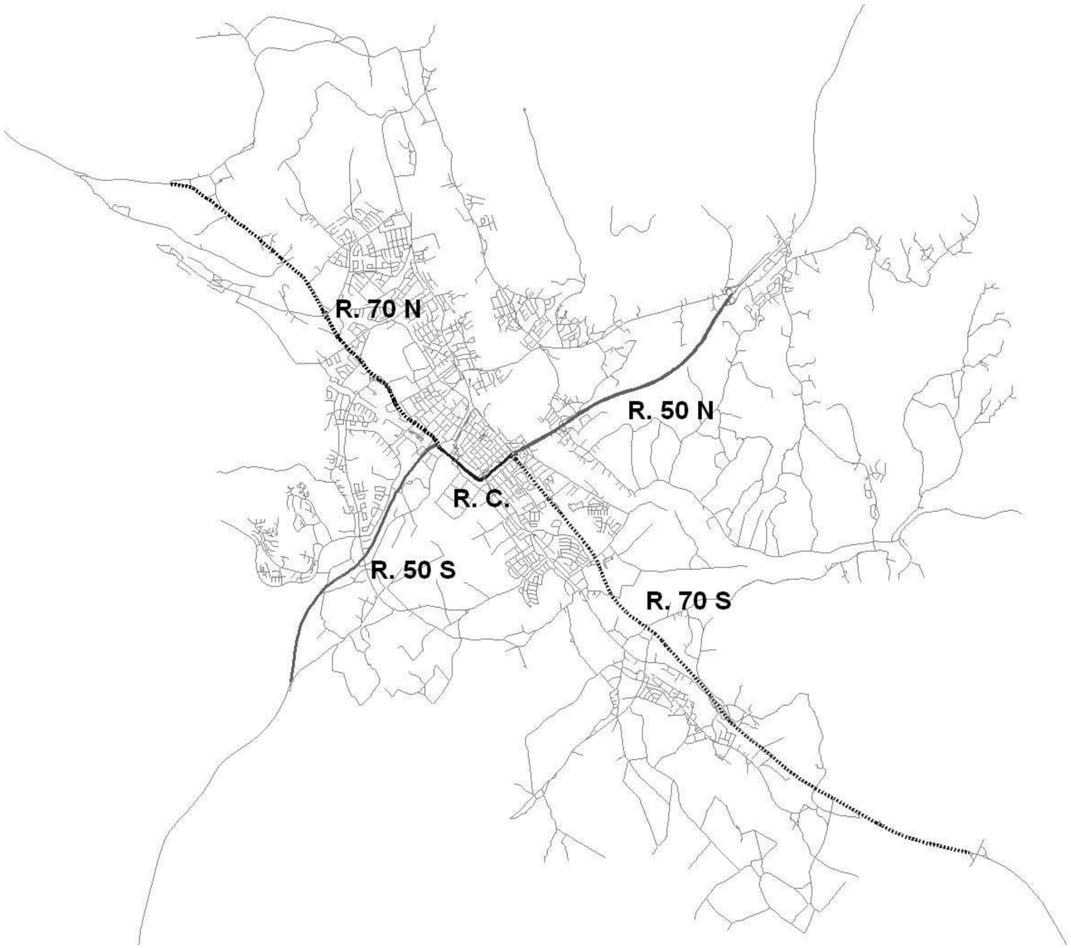
$$\mathbf{FTT}^T\mathbf{F}^T =$$

$$\begin{bmatrix} l_{1a}\sigma_a^2 + l_{1b}\sigma_b^2 & \sqrt{l_{1a}}\sqrt{l_{2a}}\sigma_a^2 & \sqrt{l_{1b}}\sqrt{l_{3b}}\sigma_b^2 \\ \sqrt{l_{1a}}\sqrt{l_{2a}}\sigma_a^2 & l_{2a}\sigma_a^2 & 0 \\ \sqrt{l_{3b}}\sqrt{l_{1b}}\sigma_b^2 & 0 & l_{3b}\sigma_b^2 \end{bmatrix}$$

Empirical Results

- The approach has been tested on two datasets: Boston (Ramming, 2001) and Boränge
- Deterministic choice set generation
  Link elimination
- GPS data from 24 individuals
  2978 observations, 2179 origin-destination pairs
- Borlänge network
  3077 nodes and 7459 links
- BIOGEME (biogeme.epfl.ch, Bierlaire, 2003) has been used for all model estimations

Borlänge Road Network



Subnetwork Components

	R.50 S	**R.50 N**	**R.70 S**	**R.70 N**	**R.C.**
Component length [m]	5255	4966	11362	7028	1733
Nb. of Observations	173	153	261	366	209
Weighted Nb. of Observations (N_q) $N_q = \sum_{o \in O} \frac{l_{oq}}{L_q}$	36	88	65	73	116

Model Specifications

- Six different models: MNL, PSL, EC_1, EC'_1, EC_2 and EC'_2
- EC_1 and EC'_1 have a simplified correlation structure
- EC'_1 and EC'_2 do not include a Path Size attribute
- Deterministic part of the utility

$$
\begin{aligned}
V_i = \; & \beta_{\text{PS}} \ln(\text{PS}_i) + \beta_{\text{EstimatedTime}}\text{EstimatedTime}_i + \\
& \beta_{\text{NbSpeedBumps}}\text{NbSpeedBumps}_i + \beta_{\text{NbLeftTurns}}\text{NbLeftTurns}_i + \\
& \beta_{\text{AvgLinkLength}}\text{AvgLinkLength}_i
\end{aligned}
$$

Estimation Results

- Parameter estimates for explanatory variables are stable across the different models
- Path size parameter estimates

Parameter	**PSL**	**EC$_1$**	**EC$_2$**
Path Size	-0.28	-0.49	-0.53
Scaled estimate	-0.33	-0.53	-0.56
Rob. T-test 0	-4.05	-5.61	-5.91

- All covariance parameters estimates in the different models are significant except the one associated with R.50 S

Estimation Results

Model	Nb. σ Estimates	Nb. Estimated Parameters	Final L-L	Adjusted Rho-Square
MNL	-	12	-4186.07	0.152
PSL	-	13	-4174.72	0.154
EC_1 EC'_1	1 1	14 13	-4142.40 -4165.59	0.161 0.156
EC_2 EC'_2	5 5	18 17	-4136.92 -4162.74	0.161 0.156
EC_3	5	18	-4109.73	0.166

1000 pseudo-random draws for Maximum Simulated Likelihood estimation

2978 observations

Null log likelihood: -4951.11

BIOGEME (biogeme.epfl.ch) has been used for all model estimations.

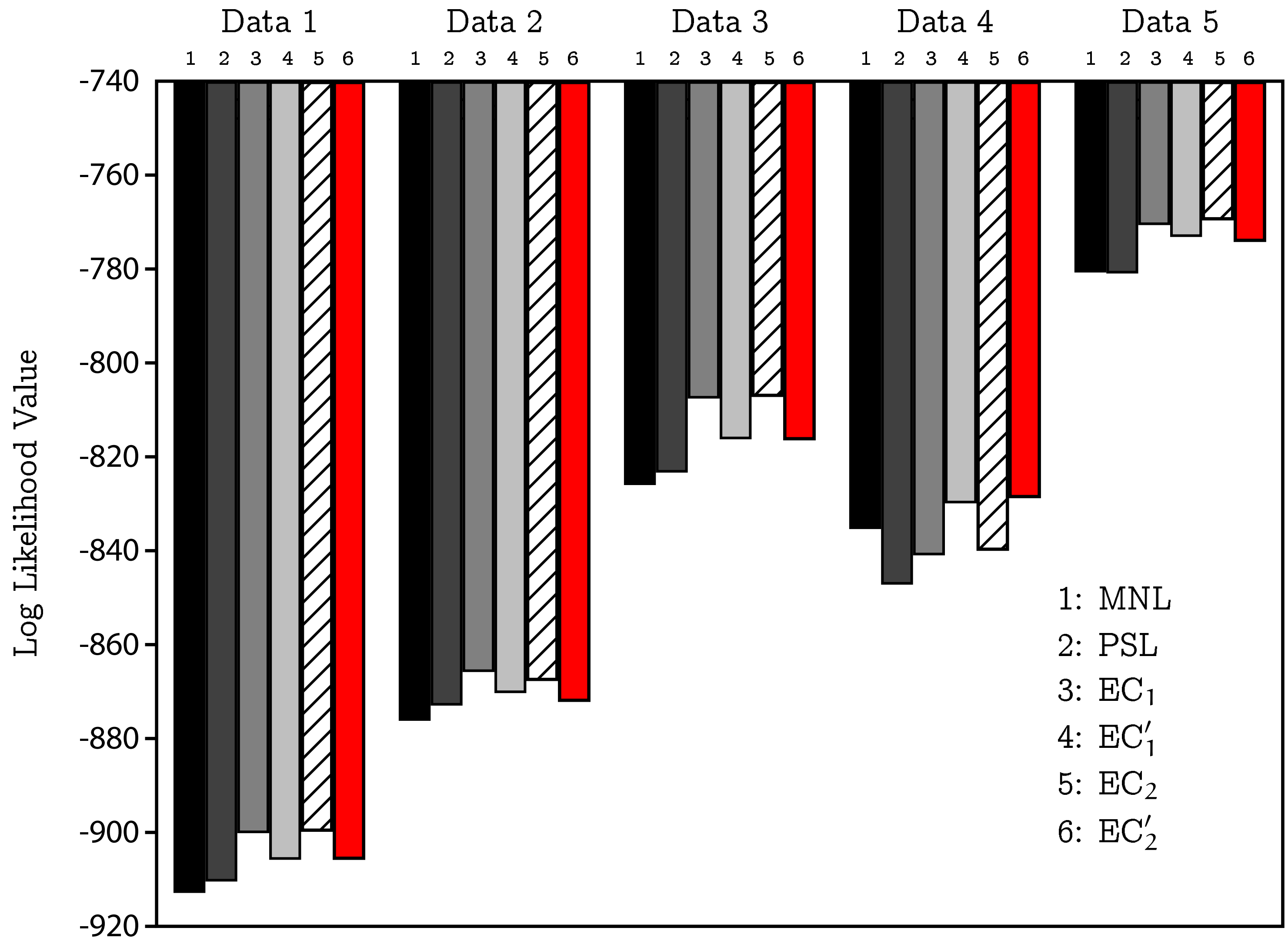
Forecasting Results

- Comparison of the different models in terms of their performance of predicting choice probabilities
- Five subsamples of the dataset
  - Observations corresponding to 80% of the origin destination pairs (randomly chosen) are used for estimating the models
  - The models are applied on the observations corresponding to the other 20% of the origin destination pairs
- Comparison of final log-likelihood values

Forecasting Results

- Same specification of deterministic utility function for all models
- Same interpretation of these models as for those estimated on the complete dataset
- Coefficient and covariance parameter values are stable across models

Forecasting Results



Conclusion

- Models based on subnetworks are designed for route choice modelling of realistic size
- Correlation on subnetwork is explicitly captured within a factor analytic specification of an Error Component model
- Estimation and prediction results clearly shows the superiority of the Error Component models compared to PSL and MNL

Conclusion

- The subnetwork approach is flexible and the trade-off between complexity and behavioural realism can be controlled by the analyst
- Paper to appear in Transportation Research Part B
  E. Frejinger, M. Bierlaire, Capturing correlation with subnetworks in route choice models, Transportation Research Part B (2006), doi:10.1016/j.trb.2006.06.003

Conclusion

- Future work
  - Analysis of the sensitivity of the results regarding the definition of the subnetwork
  - More validity tests on other datasets and larger networks
  - Influence of choice set generation algorithm