A latent route choice model in Switzerland

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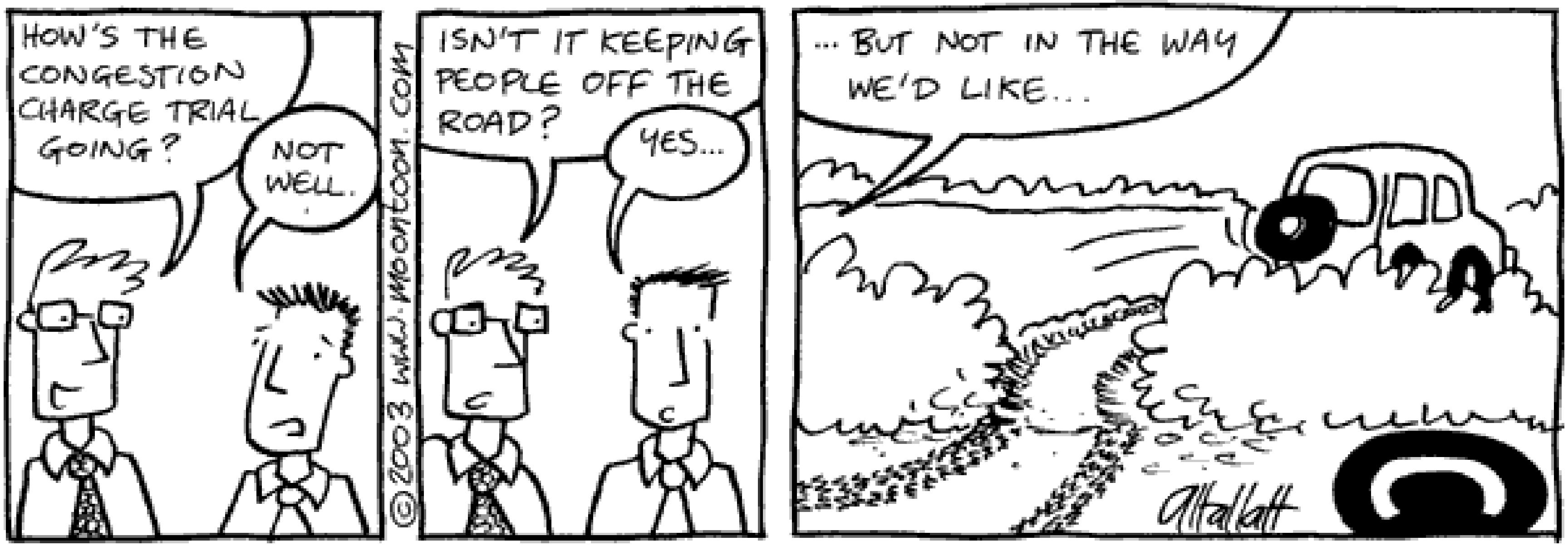
Outline

- Swiss mobility pricing project
- Aggregate observations and latent choices
- Modeling approach
- Empirical results
- Conclusion

Mobility Pricing



Swiss Mobility Pricing Project

- A part of a major study on various mobility pricing scenarios in Switzerland
- A collaboration with ETH Zurich and USI Lugano
- Revealed Preferences (RP) and Stated Preferences (SP) data has been collected
- RP data concern long distance route choice by car
    - Route descriptions are approximative
    - Route choices are latent

Objective

- Estimate route choice models based on latent chosen routes
- Literature on latent choice models
  - Ben-Akiva et al. (1984), label path approach
  - Ben-Akiva and Lerman (1985), destination choice
  - Toledo et al. (2003), lane choice

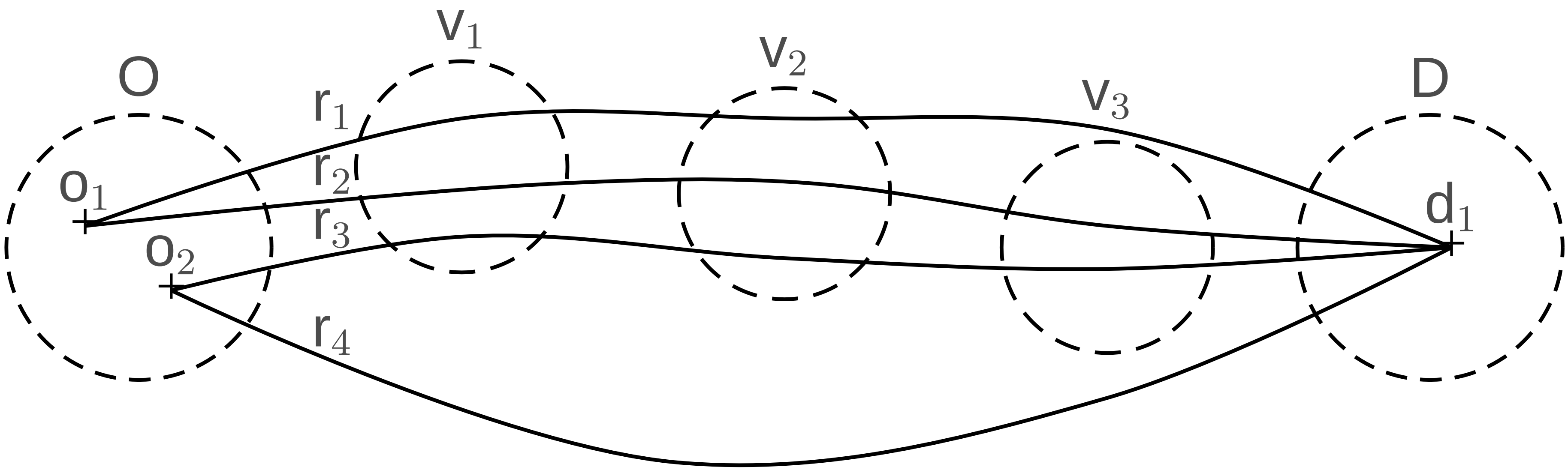
Observations

- Exact descriptions of chosen routes are difficult and expensive to obtain
- The concept of path and network as we need for modeling is abstract for respondents
- Here, a chosen route is described by a sequence of cities and locations
- *Aggregate observations* (several paths in the network can correspond to the same observation)

Observations

- Better quality of the observations
- Travelers do not need to refer to the network used by the analyst
- Exact origin-destination pairs are not necessarily known
- Exact route is not known

Observations - Example



Modeling Approach

- Several possible modeling approaches
  - Construction of paths from the aggregate observations
    - Involves subjective judgments and generate noise
  - Alternatives in the model are aggregates instead of physical paths
    - Estimated model is of little use in practice
- Our approach: compute the likelihood of an aggregate observation for a classical route choice model

Modeling Approach

- Probability of an aggregate observation i:

$$P(i) = \sum_{s \in S} P(s|i) \sum_{r \in C_s} P(r|i) P(r|C_s)$$

  - s: origin-destination pair
  - S: set of all origin-destination pairs
  - r: route
  - C_s: set of all routes for origin-destination pair s

Modeling Approach

- Probability of an aggregate observation i:

$$P(i) = \sum_{s \in S} P(s|i) \sum_{r \in C_s} P(r|i) P(r|C_s)$$

  - $P(s|i)$ and $P(r|i)$ can be modeled in several ways
  - $P(r|C_s)$: route choice model that is identifiable if
    1. at least one of the routes in C_s crosses the observed zones, and
    2. at least one route in C_s does not cross the observed zones.
- This type of models can be estimated with BIOGEME

Empirical Results

- Simplified Swiss network (39411 links and 14841 nodes)
- RP data collection through telephone interviews
- Long distance car travel
- The chosen routes are described with the origin and destination cities as well as 1 to 3 cities or locations that the route pass by
- 940 observations available after data cleaning and verification

Empirical Results

Empirical Results

- This application is one of few presented in the literature that are based on RP data
- The network is to our knowledge the largest one used for evaluation of route choice modeling approaches

Empirical Results

- No information available on the exact origin destination pairs

$$P(s|i) = \frac{1}{|S_i|} \; \forall s \in S_i$$

- $P(r|i)$ is modeled with a binary variable

$$\delta_{ri} = \begin{cases} 1 & \text{if } r \text{ corresponds to } i \\ 0 & \text{otherwise} \end{cases}$$

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Empirical Results

- Two origin-destination pairs are randomly chosen for each observation
- 46 routes per choice set are generated with a choice set generation algorithm
- After choice set generation 780 observations are available
  - 160 observations were removed because either all or none of the generated routes crossed the observed zones

Empirical Results

- Probability of an aggregate observation i

$$P(i) = \sum_{s \in S_i} \frac{1}{|S_i|} \sum_{r \in C_s} \delta_{ri} P(r|C_s)$$

- We estimate Path Size Logit (Ben-Akiva and Bierlaire, 1999) and Subnetwork (Frejinger and Bierlaire, 2006) models
- BIOGEME (biogeme.epfl.ch) used for all model estimations

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Empirical Results - Subnetwork

- Subnetwork: main motorways in Switzerland
- Correlation among routes is explicitly modeled on the subnetwork
- Combined with a Path Size attribute
- Linear-in-parameters utility specifications

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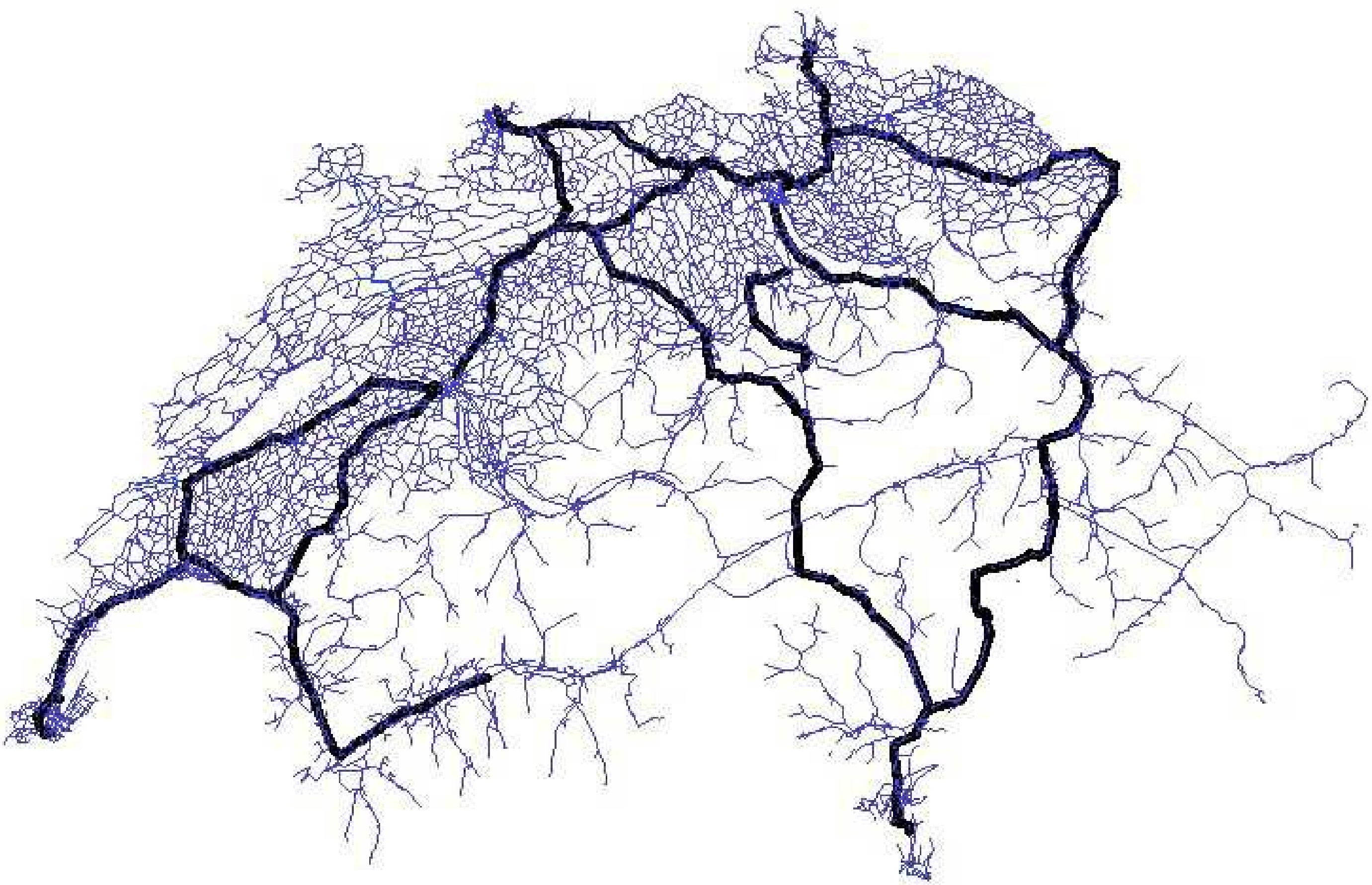
Empirical Results - Subnetwork



Parameter	PSL		Subnetwork	
ln(path size) based on free-flow time	**1.04**	(0.134) 7.81	**1.10**	(0.141) 7.78
Scaled Estimate	*1.04*		*1.04*	
Freeway free-flow time 0-30 min	**-7.12**	(0.877) -8.12	**-7.45**	(0.984) -7.57
Scaled Estimate	*-7.12*		*-7.04*	
Freeway free-flow time 30min - 1 hour	**-1.69**	(0.875) -1.93	**-2.26**	(1.03) -2.19
Scaled Estimate	*-1.69*		*-2.14*	
Freeway free-flow time 1 hour +	**-4.98**	(0.772) -6.45	**-5.64**	(1.00) -5.61
Scaled Estimate	*-4.98*		*-5.33*	
CN free-flow time 0-30 min	**-6.03**	(0.882) -6.84	**-6.25**	(0.975) -6.41
Scaled Estimate	*-6.03*		*-5.91*	
CN free-flow time 30 min +	**-1.87**	(0.331) -5.64	**-2.16**	(0.384) -5.63
Scaled Estimate	*-1.87*		*-2.04*	
Main free-flow travel time 10 min +	**-2.03**	(0.502) -4.05	**-2.46**	(0.624) -3.95
Scaled Estimate	*-2.03*		*-2.33*	
Small free-flow travel time	**-2.16**	(0.685) -3.16	**-2.75**	(0.804) -3.42
Scaled Estimate	*-2.16*		*-2.60*	
Proportion of time on freeways	**-2.2**	(0.812) -2.71	**-2.31**	(0.865) -2.67
Scaled Estimate	*-2.2*		*-2.18*	
Proportion of time on CN	**0 fixed**		**0 fixed**	
Proportion of time on main	**-4.43**	(0.752) -5.88	**-4.40**	(0.800) -5.51
Scaled Estimate	*-4.43*		*-4.16*	
Proportion of time on small	**-6.23**	(0.992) -6.28	**-6.02**	(1.03) -5.83
Scaled Estimate	*-6.23*		*-5.69*	
Covariance parameter			**0.217**	(0.0543) 4.00
Scaled Estimate			*0.205*	

Empirical Results

	PSL	Subnetwork
Covariance parameter		0.217
(Rob. Std. Error) Rob. T-test		(0.0543) 4.00
Number of simulation draws	-	1000
Number of parameters	11	12
Final log-likelihood	-1164.850	-1161.472
Adjusted rho square	0.145	0.147
Sample size: 780, Null log-likelihood: -1375.851		

Empirical Results

- All parameters have their expected signs and are significantly different from zero
- The values and significance level are stable across the two models
- The subnetwork model is significantly better than the Path Size Logit (PSL) model

Conclusion

- Aggregate observations are convenient to report paths
- They can be used for estimating route choice models
- Care must be taken about the level of aggregation
- Parameters of the RP model are significant and meaningful
- Available in Biogeme / Bioroute