Preferred citation style

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Direct Demand models: A new lease of life ?

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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

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

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

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 ?

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

What do we need ?

What does service planning and pricing need ?

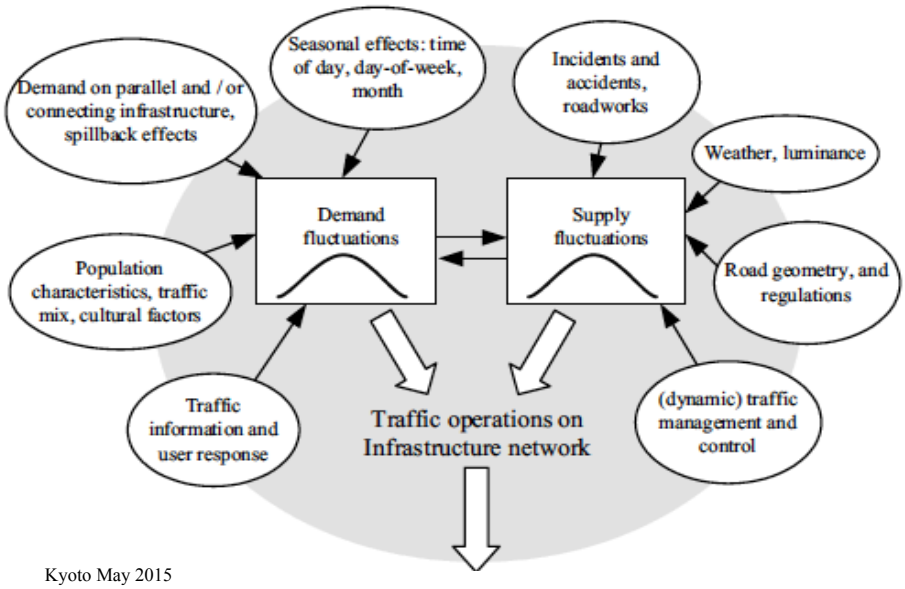
- Basic:
  - $\Delta volume_{ijmg}$
  - $\Delta travel\ time_{ijmg}$
  - $\Delta price_{ijmg}$
- Group g by
  - Income
  - (Distance)
  - Purpose
  - Age
  - Gender
  - Ethnicity

What does CBA need ?

- Basic:
  - $\Delta volume_m$
  - $\Delta speed_m$
- Advanced:
  - $\Delta volume_{ijm}$
  - $\Delta travel\ time_{ijm}$

Minimum requirements

Full requirements to explain observed travel time



Quelle: Van Lint et al. (2008)

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

Plus/Minus of regression approaches

Distadvantages:

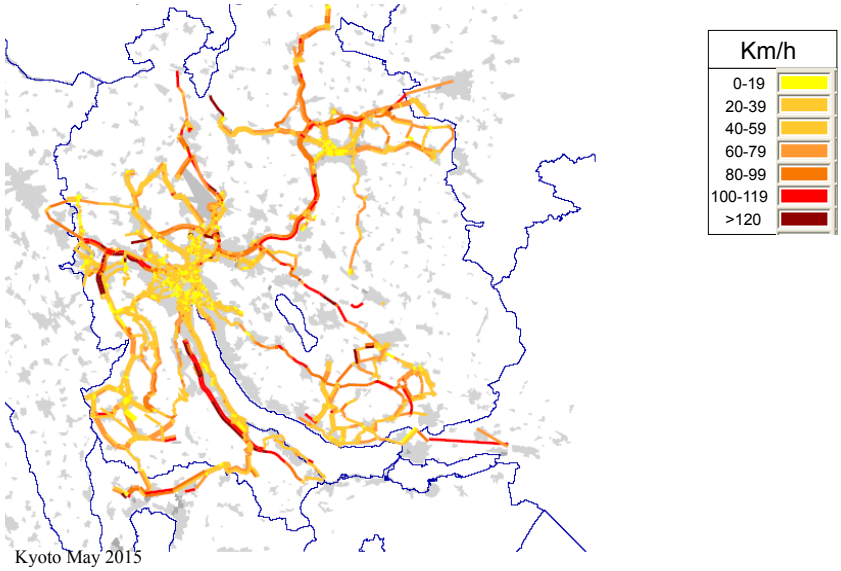
- Parametric assumptions
- Averaging over locations
- Uniformity of weighting (but there is GWR)

- 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)



Hackney and Bernard, 2005

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Alternative approach and its model formulation

	$\rho W_a Y$	$\lambda W_e \varepsilon$	$u \sim N(o, \sigma)$
OLS			✔
Spatial error model (SEM)		✔	✔
Spatial autoregressive model (SAR)	✔		✔
General spatial model (SAC)	✔	✔	✔

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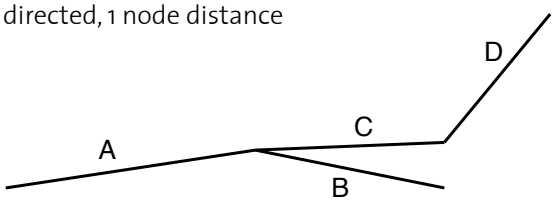
Spatial weighting matrix W (1) – Example of assembly

Contiguity: directed, 1 node distance



Contiguity matrix:

sum(rows)=1

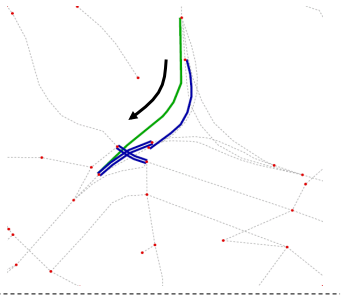
W	A	B	C	D
A	0	0.5	0.5	0
B	0.5	0	0.5	0
C	0.33	0.33	0	0.33
D	0	0	1	0

Spatial weighting matrix (2) – Spatial/network neighbour

Spatial neighbour:

- n closest links from centre of link

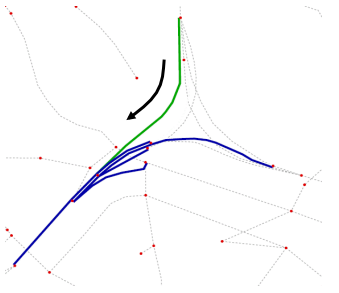
5 spatial neighbours
(Euclidian distance)



Network neighbour:

- reachable links passing n (max.) intersections

2 intersections → ~5 neighbours
(network distance)

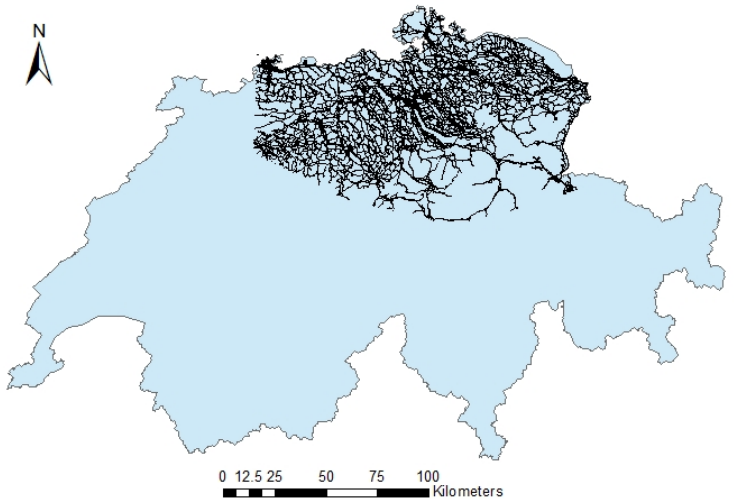


Best spatial weighting

Model	Best W-matrix	$\overline{R}^2$
Weighted least squares (WLS)	*not needed*	0.5347
Spatial error model (SEM)	W_a: *not needed* W_e: 3 network neighbours	0.5749
Spatial autoregressive model (SAR)	W_a: 4 network neighbours W_e: *not needed*	0.5518
General spatial model (SAC)	W_a: 4 network neighbours W_e: 3 network neighbours	0.5827

Sarlas on Swiss speeds

Case study



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Estimation and comparison of models of average v

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

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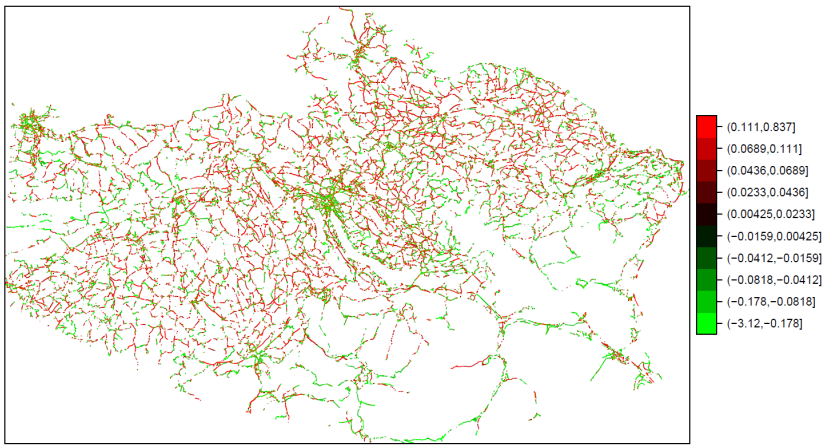
Estimation and comparison of models (cont.)

Y = Average daily speed	SAR error	SAR lag	SAC
Lamda	0.928	-	0.742
Rho	-	0.459	0.215
Log-likelihood	-705197	-733084	-694294
AIC	1410453	1466226	1388647
Residuals spatial auto-correlation	0.013	0.342	-0.034
OLS AIC		*1615760*	
OLS Log-likelihood		-807851.8	

Comparison of models

Model	2% range	5% range	15% range	30% range	SDE	ME
OLS	8.01%	20.35%	57.07%	84.69%	27.25%	-5.13%
SARerror	21.25%	47.20%	81.07%	93.68%	16.81%	-2.05%
SARlag	14.57%	35.27%	75.31%	90.88%	19.33%	-2.58%
Durbin	20.63%	46.19%	81.18%	93.95%	16.81%	-2.05%
SAC	21.09%	47.26%	81.92%	94.05%	17.04%	-1.92%

Comparison of models: Residuals of SAC model



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Lu on travel time reliability in Germany

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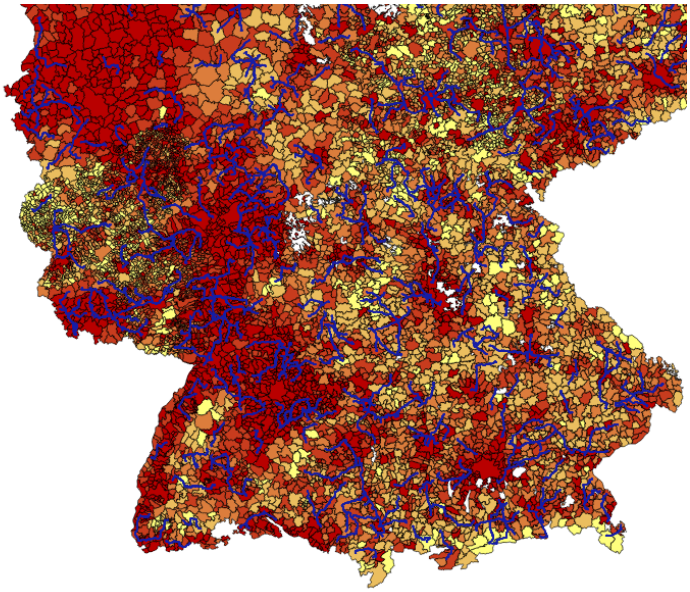
Map of some of the 635 elected routes (635)



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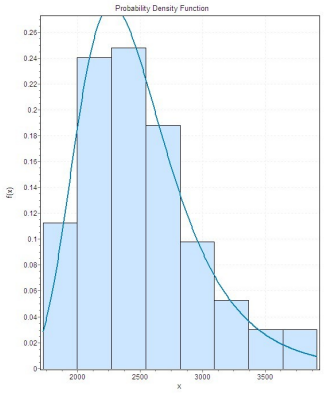
Best fitting GEV distribution



$\mu \in \mathbf{R}$ location param
$\sigma > 0$ scale param
$\xi \in \mathbf{R}$ shape param

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

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

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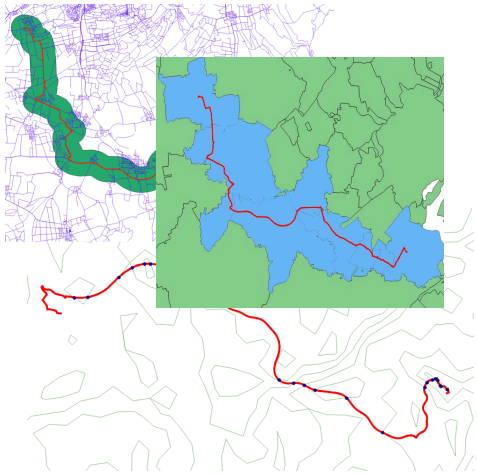
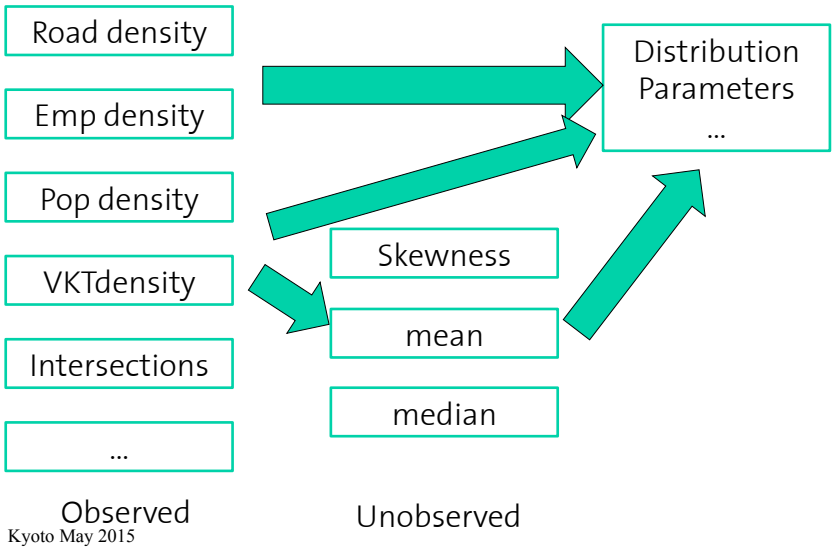
Multiple linear regression for GEV parameters:

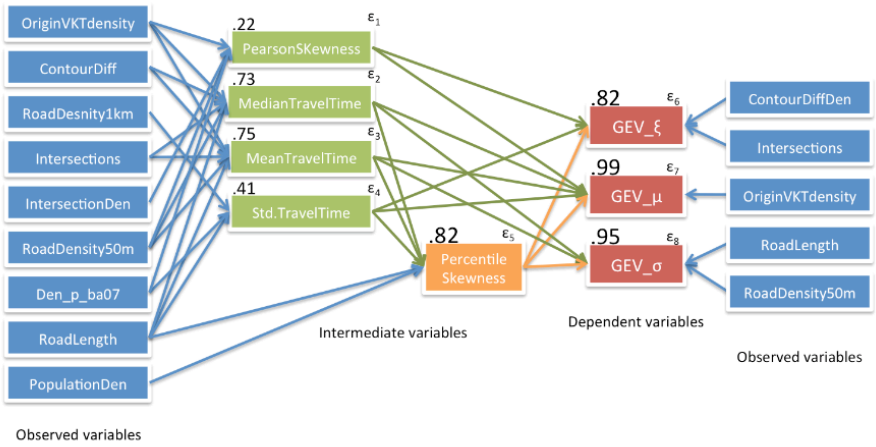
Mean
Median
Std.
Pearson
Percentile
Route length
Road Density 50m
Road Density 1km
Origin CKT density
Contour Diff
Intersections
Intersection density
Population Density
Employment density



Path analysis



Path analysis – path chart

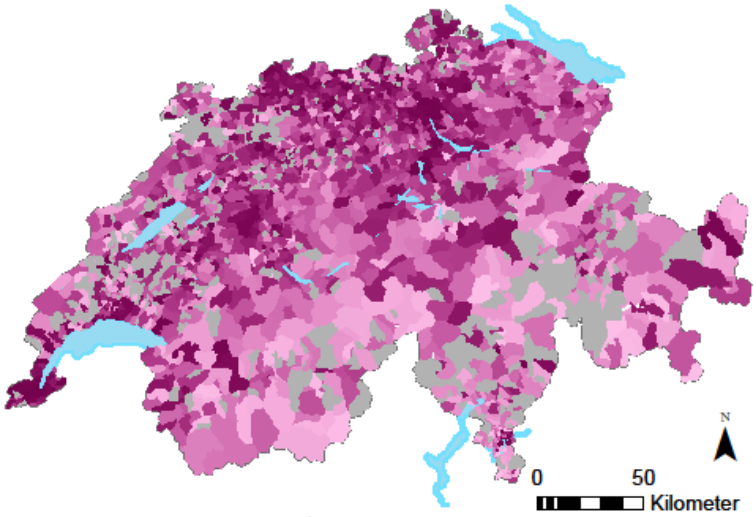


Sarlas & Fuhrer on Swiss wages

Reduced form: mean salary sensitive to density

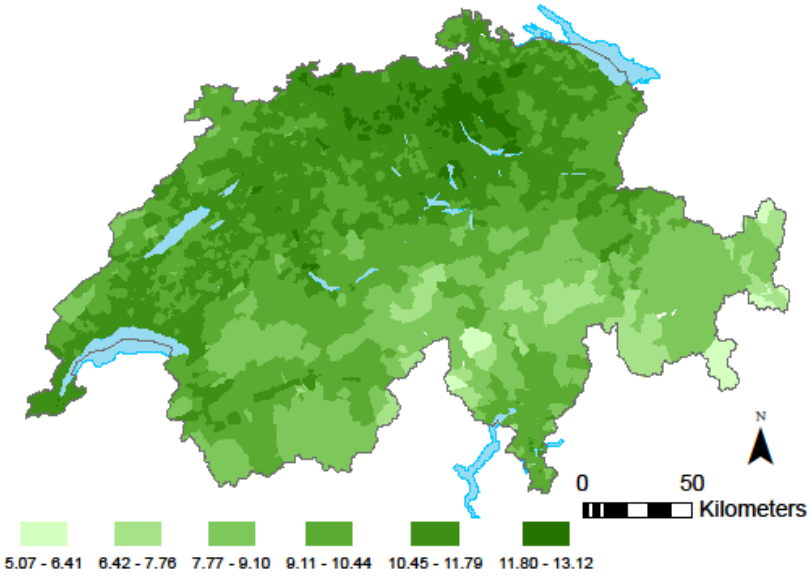
- Intensity of land use by
  - Population
- Network
  - Accessibility (road)
  - Accessibility (rail)
- Population composition
  - Gender
  - Education
  - Type of position
  - Time in post
  - In-commuters from abroad
- Industry
  - Share of industry

Mean salaries by municipality



Grau: Weniger als 10 Observationen pro Verkehrszone
Hellste Farbe: Tiefster Lohndurchschnitt
Dunkelste Farbe: Höchster Lohndurchschnitt

Accessibility: Public transport 2010



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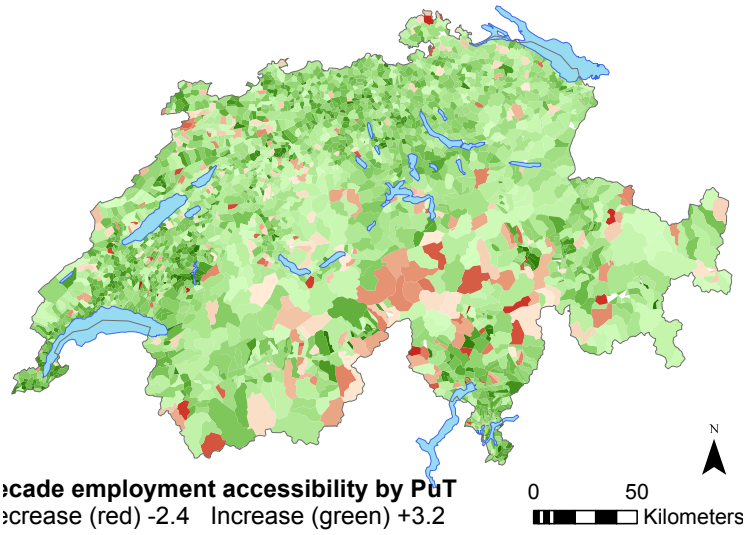
Accessibility change: Public transport 2000-2010



ecade employment accessibility by PuT
ecrease (red) -2.4 Increase (green) +3.2

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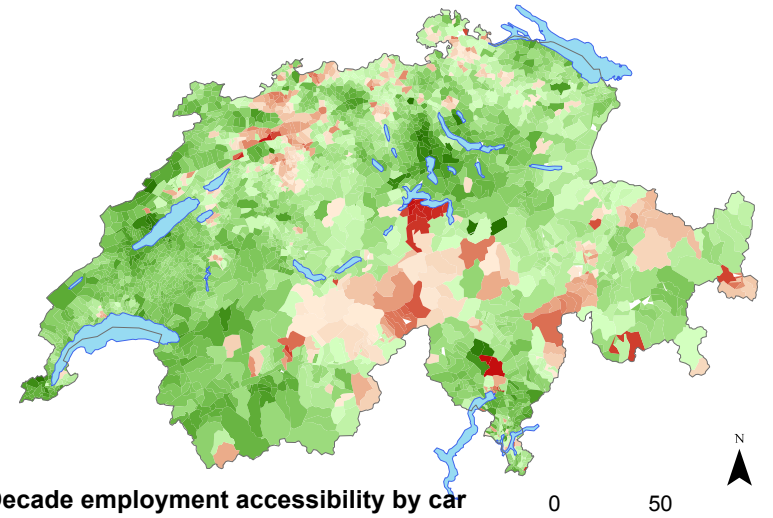
Accessibility change: Road 2000-2010



Decade employment accessibility by car
Decrease (red) -2.2 Increase (green) +1.1

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Analyses

- OLS (2000, 2005, 2010)
- Panel 2000-2010
- Pooled OLS (balanced, unbalanced)
- Spatial error model (SER)
- SER panel (2000-2010)
- GWR

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Spatial panel 2000-2010

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

Spatial panel 2000-2010

Variable	beta (All)		beta (Agglo)	
Tertiary education	0.76	***	0.70	***
Professional training	0.37	***	0.33	***
Further vocational training	0.23	***	0.19	***
Teaching degree	0.35	***	0.43	***
Highschool diploma	0.34	***	0.43	***
Vocational training	0.07	***	0.09	***
Positions with highest demands	0.45	***	0.55	***
Positions with qualified indep. work	0.24	***	0.30	***
Positions with professional skills	0.17	***	0.16	***
Working (3rd sector)	0.18	***	0.26	***
Working (private sector)	-0.08	***	-0.03	**
Working (manufacturing)	-0.21	***	-0.21	***
Working (FIRE)	0.13	***	0.17	***
Working (hotel, restaurants)	-0.12	***	-0.160	***

Public transport accessibilities 2000-2010 elasticities

Model	2000	2005	2010
OLS	1.80%	1.60%	1.50%
Spatial error	1.60%	1.30%	1.20%
Pooled OLS			1.20%
Pooled OLS for 2005-2010			0.70%
Time-effects			2.00%
Time-effects for 2005-2010			1.50%
SER pooled OLS			0.90%
SER pooled OLS for 2005-2010			0.20%
SER with time-effects			1.70%
SER with time-effects for 2005-2010			1.20%

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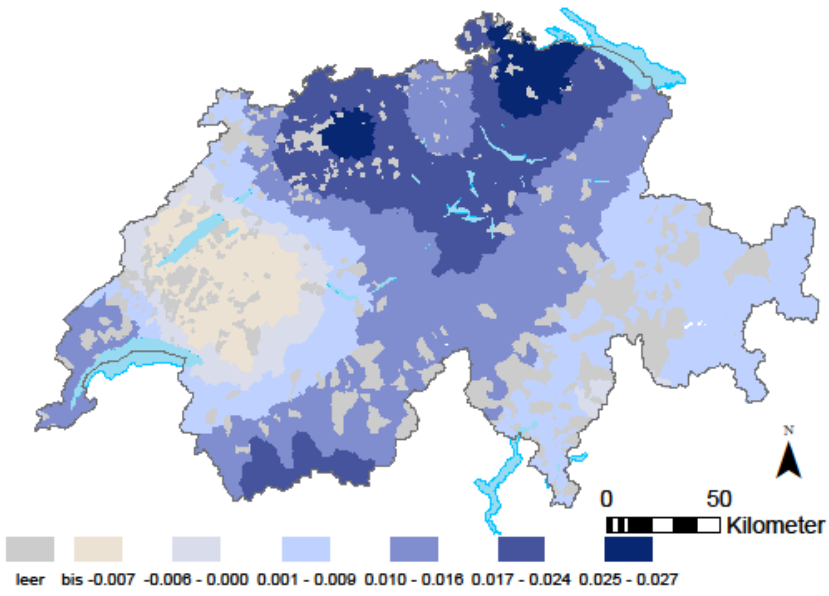
GWR estimates: public transport accessibility 2010



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 ?

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Literature and references

Hackney, J.K., M. Bernard, S. Bindra and K.W. Axhausen (2007) Predicting road system speeds using spatial structure variables and network characteristics, *Journal of Geographical Systems*, **9** (4) 397-417.

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