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Accessibility change and its impacts

KW Axhausen

IVT
ETH
Zürich

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Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Questions

- Why bother with accessibilities ?
- What are the trends for Switzerland ?
- What are ist impacts ?

The mistaken logic of public capital

The literature since Aschauer (1989) assumes:

$$\Delta y(t) = f(\Delta p(t), \Delta x(it))$$

with

$\Delta y(t)$	:	GNP, productivity change
$\Delta p(t)$	:	Road or other transport capital change
$\Delta x(it)$	:	Change in other relevant variables

Does this work ?

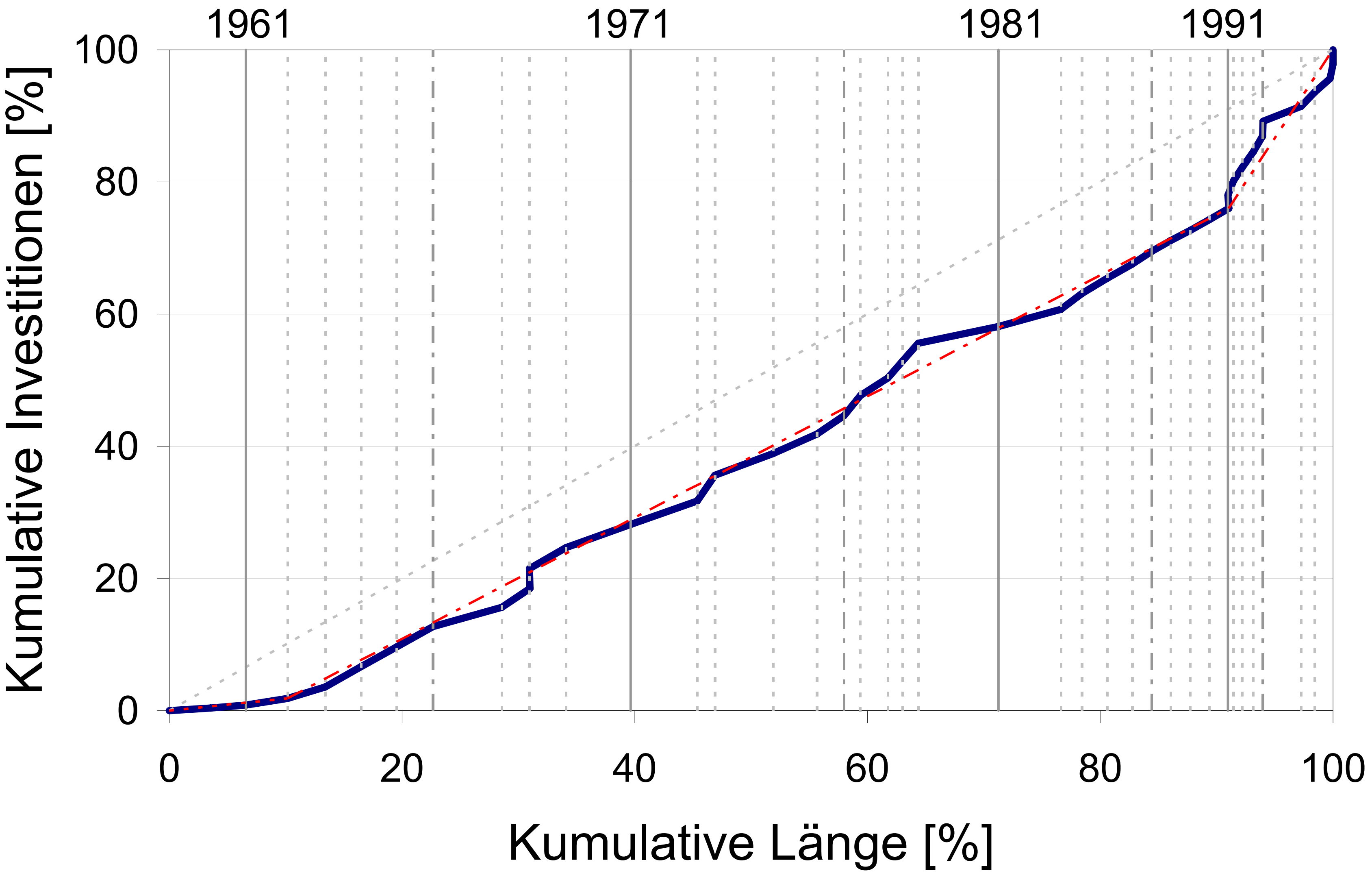
Implicit assumption:

$$\Delta p(t) \sim \Delta \text{Network services}(t)$$

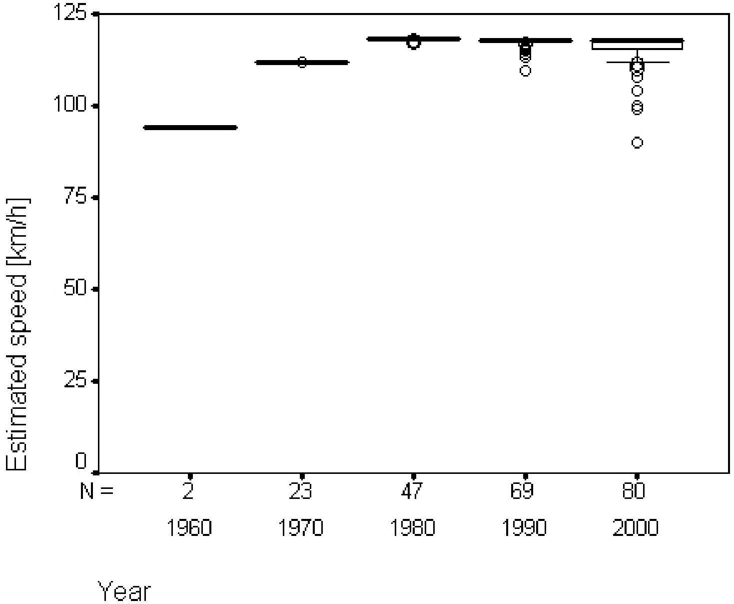
but this implies constant proportionalities for each of the following:

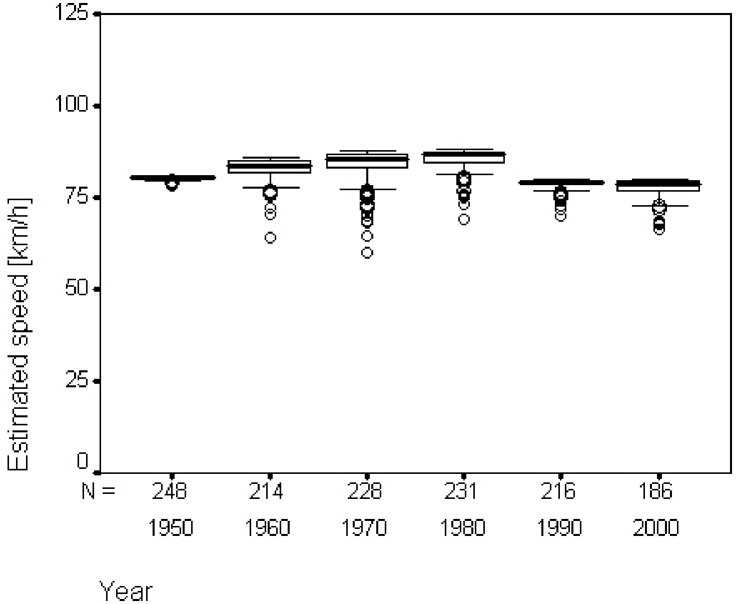
$$\Delta p(t) \sim \Delta \text{Lane miles}(t)$$
$$\Delta \text{Lane miles}(t) \sim \Delta \text{Capacity}(t)$$
$$\Delta \text{Capacity}(t) \sim \Delta \text{Speed}(t)$$
$$\Delta \text{Speed}(t) \sim \Delta \text{Accessibility}(t)$$
$$\Delta \text{Accessibility}(t) \sim \Delta \text{Network services}(t)$$

Switzerland: Changing costs of one km motorway



Switzerland: Changing speed gain of capacity expansion

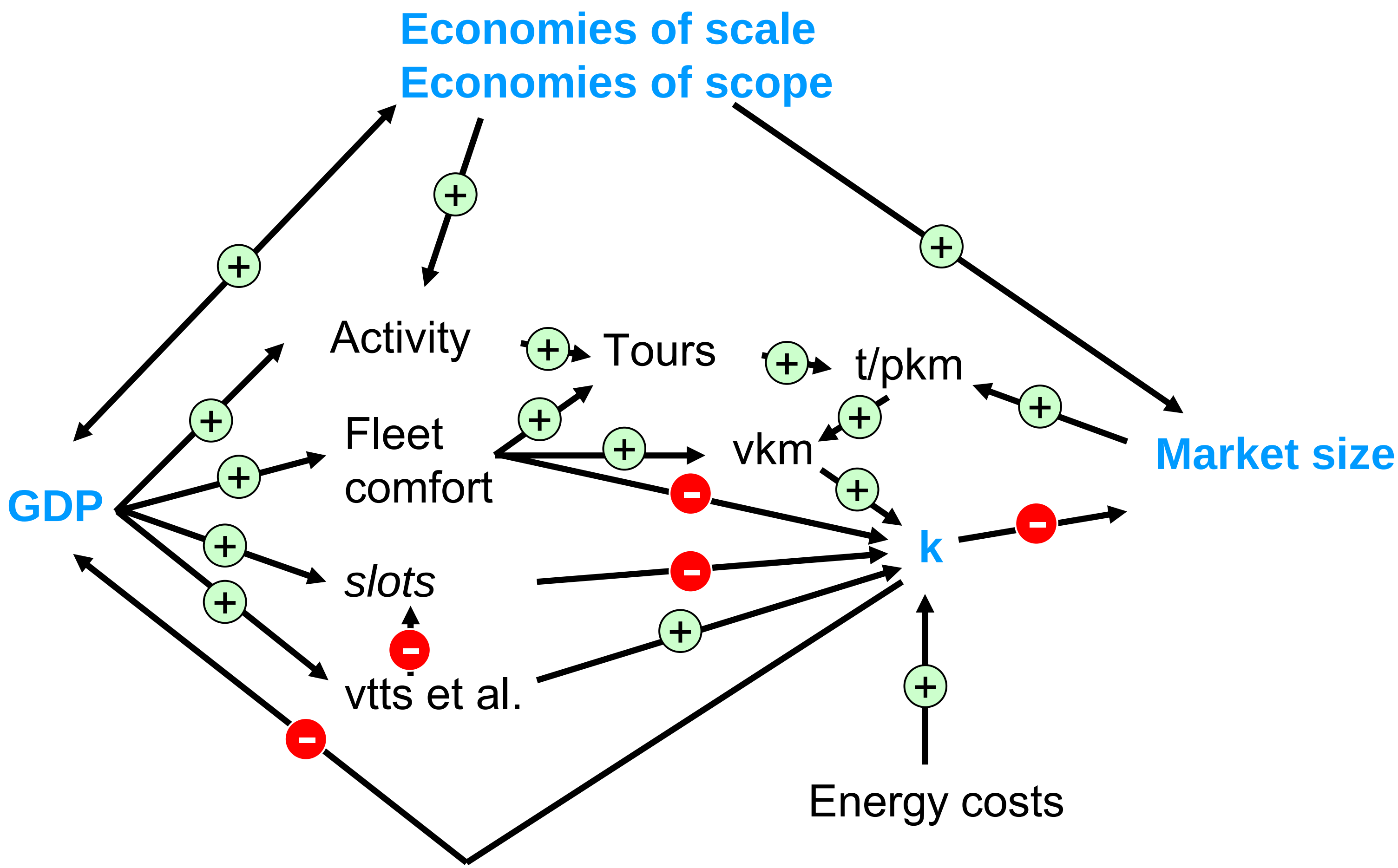




Two-lane motorways

Trunk roads

Size of goods markets and productivity: A hypothesis



Elasticity > 0
Elasticity < 0

Slots: possibilities to move goods or people
For a given infrastructure and commercial and private fleet

Accessibility as the log-sum term of a choice model

In line with the literature we use:

$$Acc_i = \ln \sum_{\forall ij} X_j \, e^{-\beta c_{ij}}$$

Using:

- Weighting parameter (β) of 0.2
- Travel time as the only generalised cost element (c_{ij})
- Population as number of opportunities (X_j)

Description of Elements: Overview

Study area:	Switzerland and surrounding jurisdictions in a 350 km band
Spatial resolution:	Municipality equals one zone/Bezirk Larger municipalities are subdivided Zones outside Switzerland on regional or county level
Intrazonal travel times:	Dependent on equivalent radius of the size of the built up area

Description of Elements: Road transport

Network resolution:	All major road developments inside Switzerland and motorway development outside
Link description:	Assumed mean speeds by 51 link types based on a detailed historical review
Centroid connectors:	Fixed speeds
Travel time calculation:	Shortest-time paths

Description of Elements: Public transport

Timetables:	Detailed time tables for all regular interurban trains (without S-Bahn) Coaches and interurban buses, where relevant
Station connectors:	Fixed speeds
Travel time calculation:	Shortest-time paths (including transfer times)

Description of Elements: Years

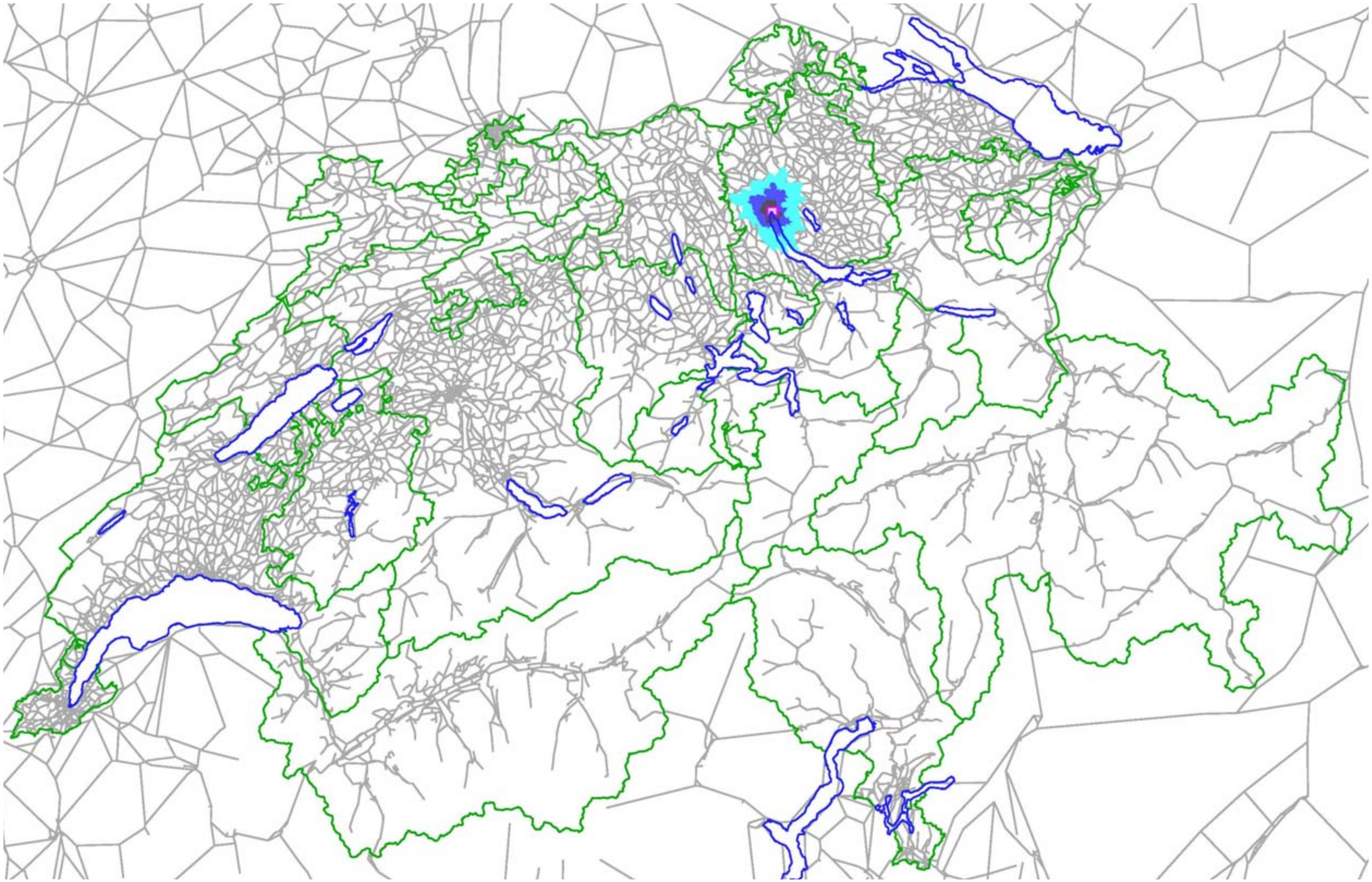
Matching the census the reference areas are:

• 1850, 1888, 1910, 1930	Only Bezirke
• 1950 and then each decade	Municipalities and Bezirke

Road network models

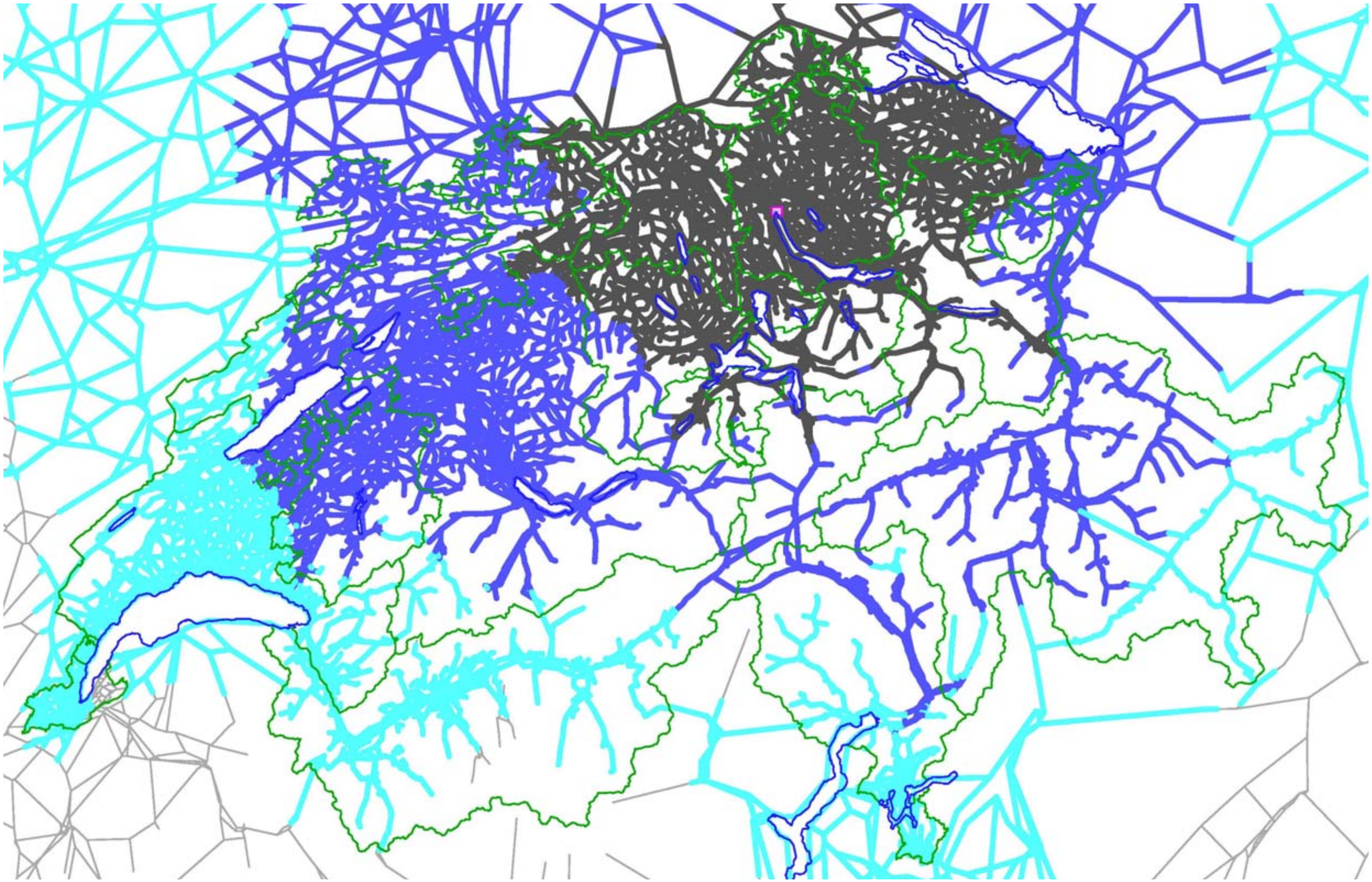
Year	mod. Links CH	Total CH Links CH	mod. Links EU	Total Links EU
1950	3’527	17’698	136	29’248
1960	3’589	17’760	195	29’307
1970	4’147	18’318	422	29’534
1980	4’810	18’981	747	29’859
1990	5’215	19’386	896	30’008
2000	-	19’700	-	30’053

Road travel times from Zürich (1850)

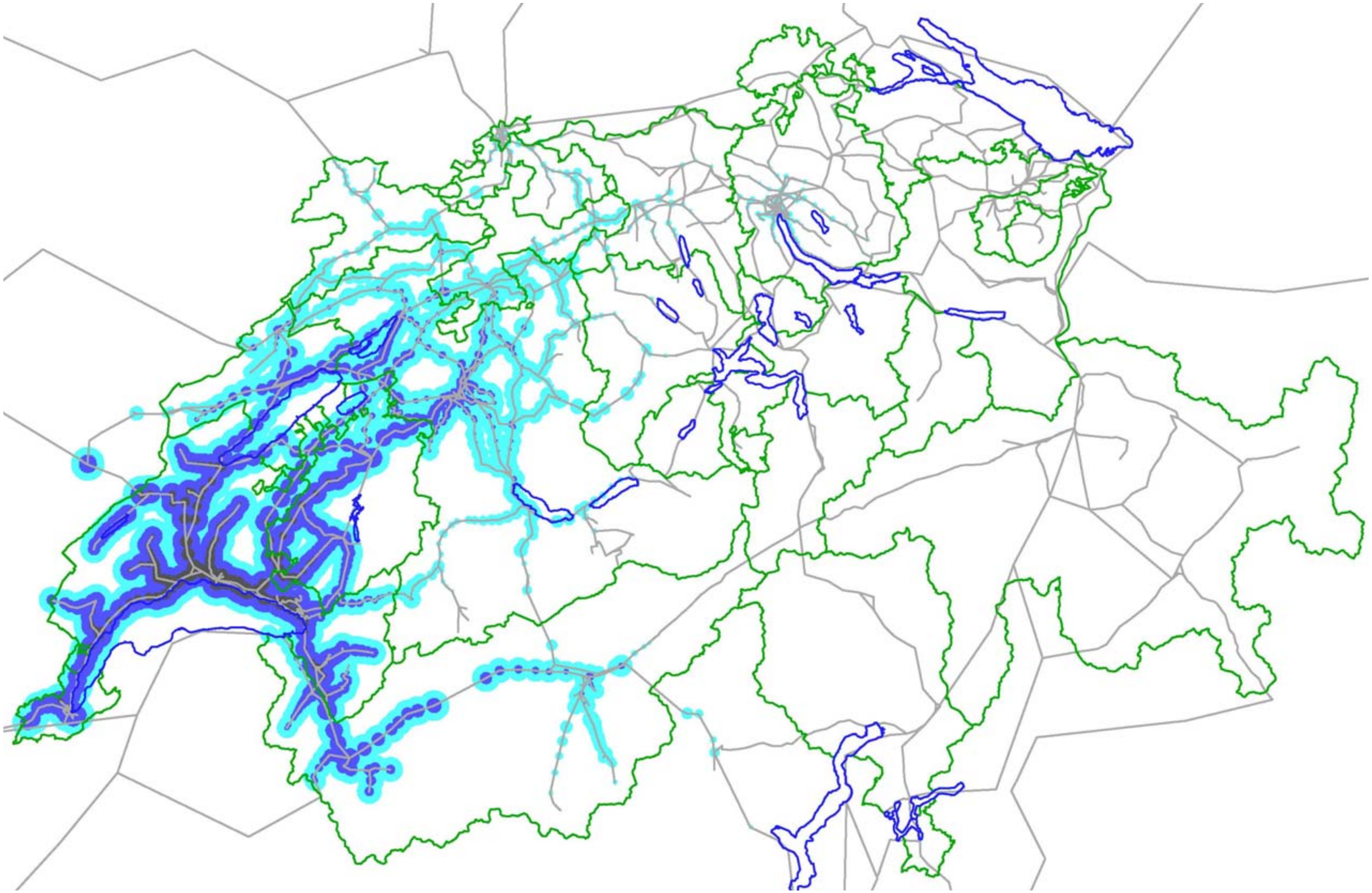


Public transport travel times from Lausanne (1850)

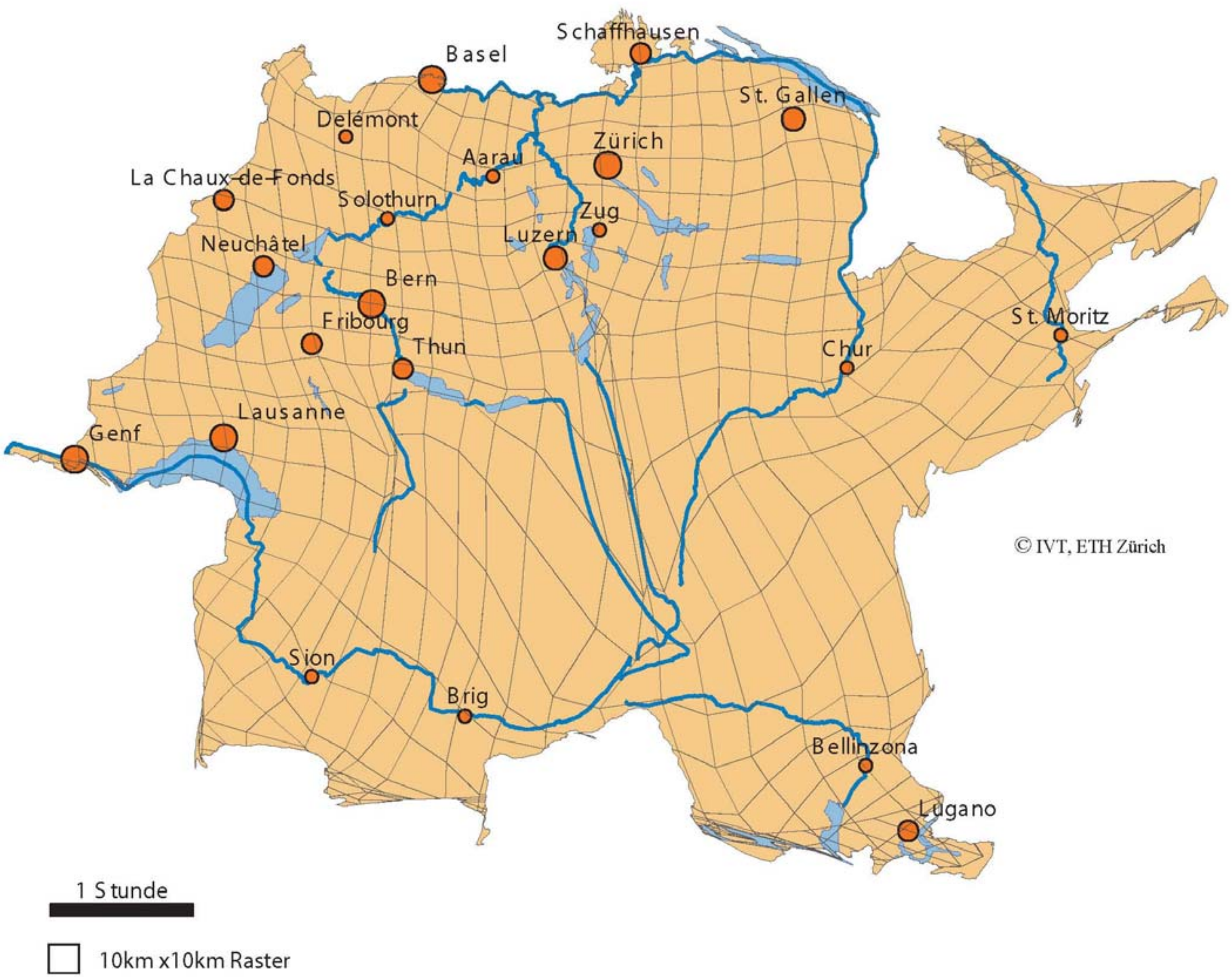
Road travel times from Zürich (2000)



Public transport travel times from Lausanne (2000)

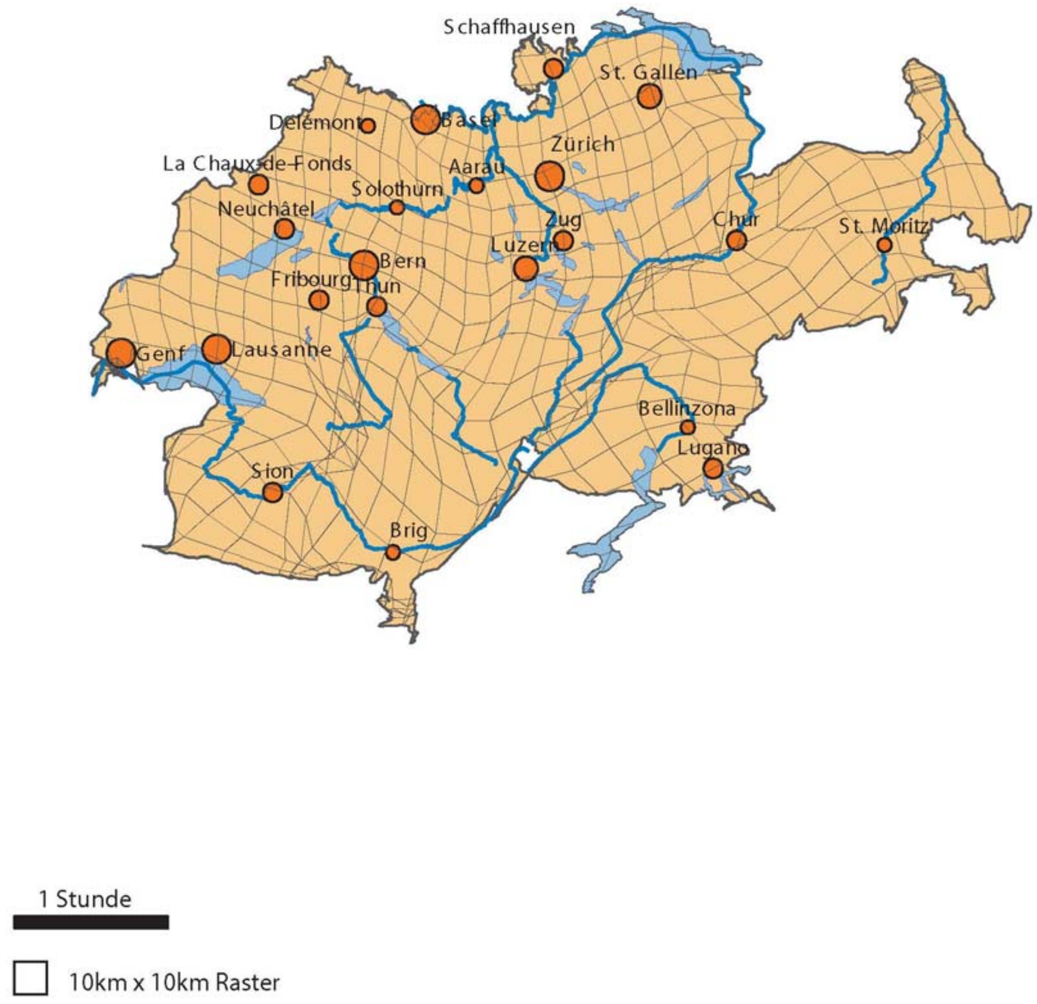


Road travel time-scaled map of Switzerland 1950



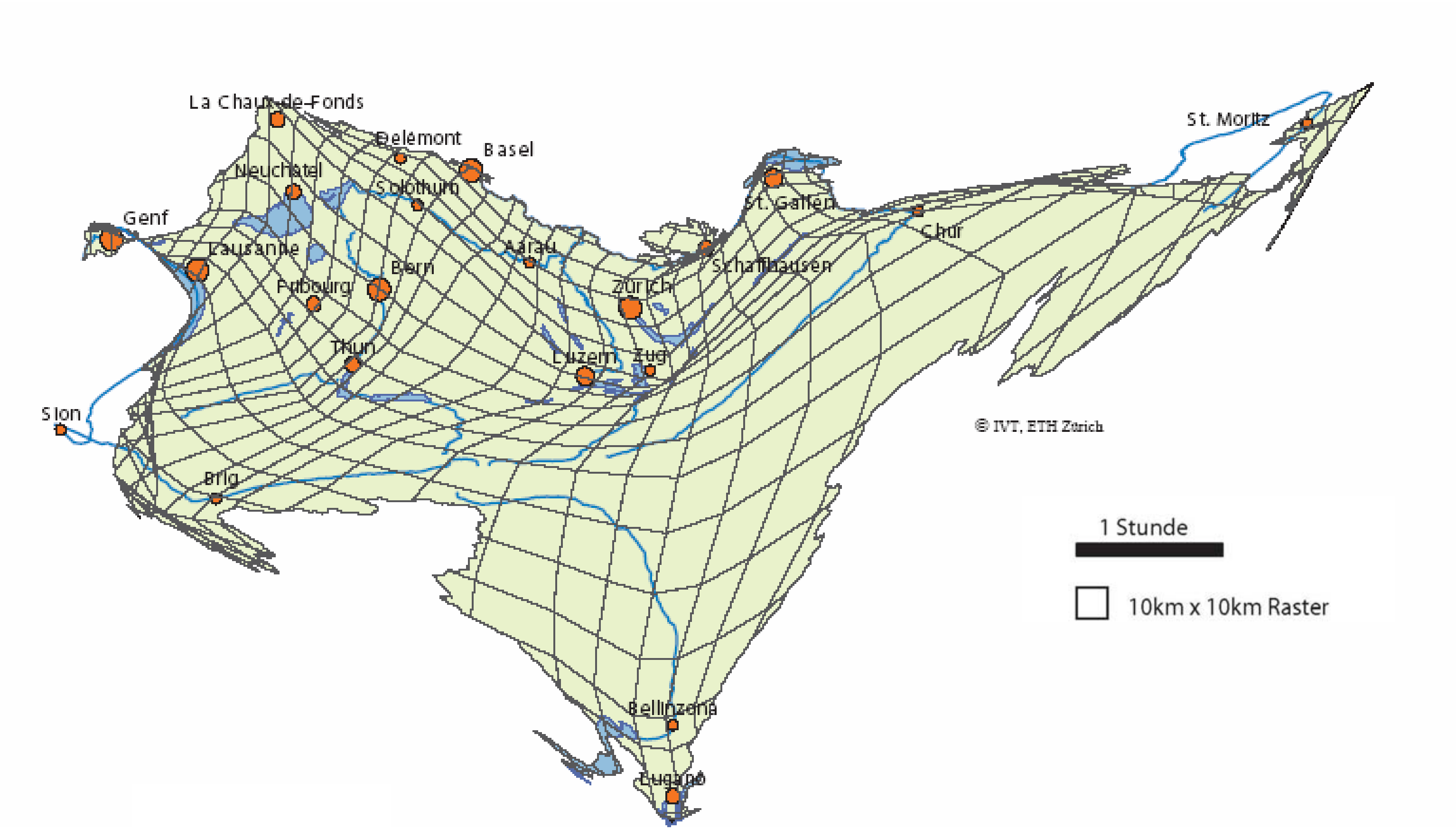
Scherer, 2004

Road travel time-scaled map of Switzerland 2000

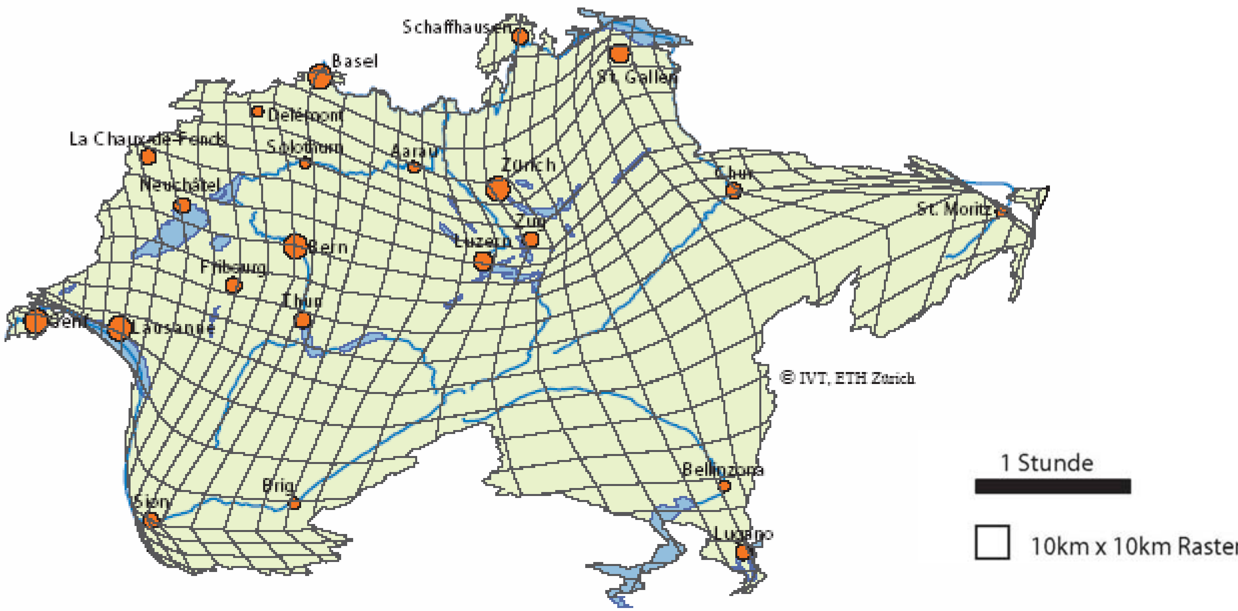


Scherer, 2004

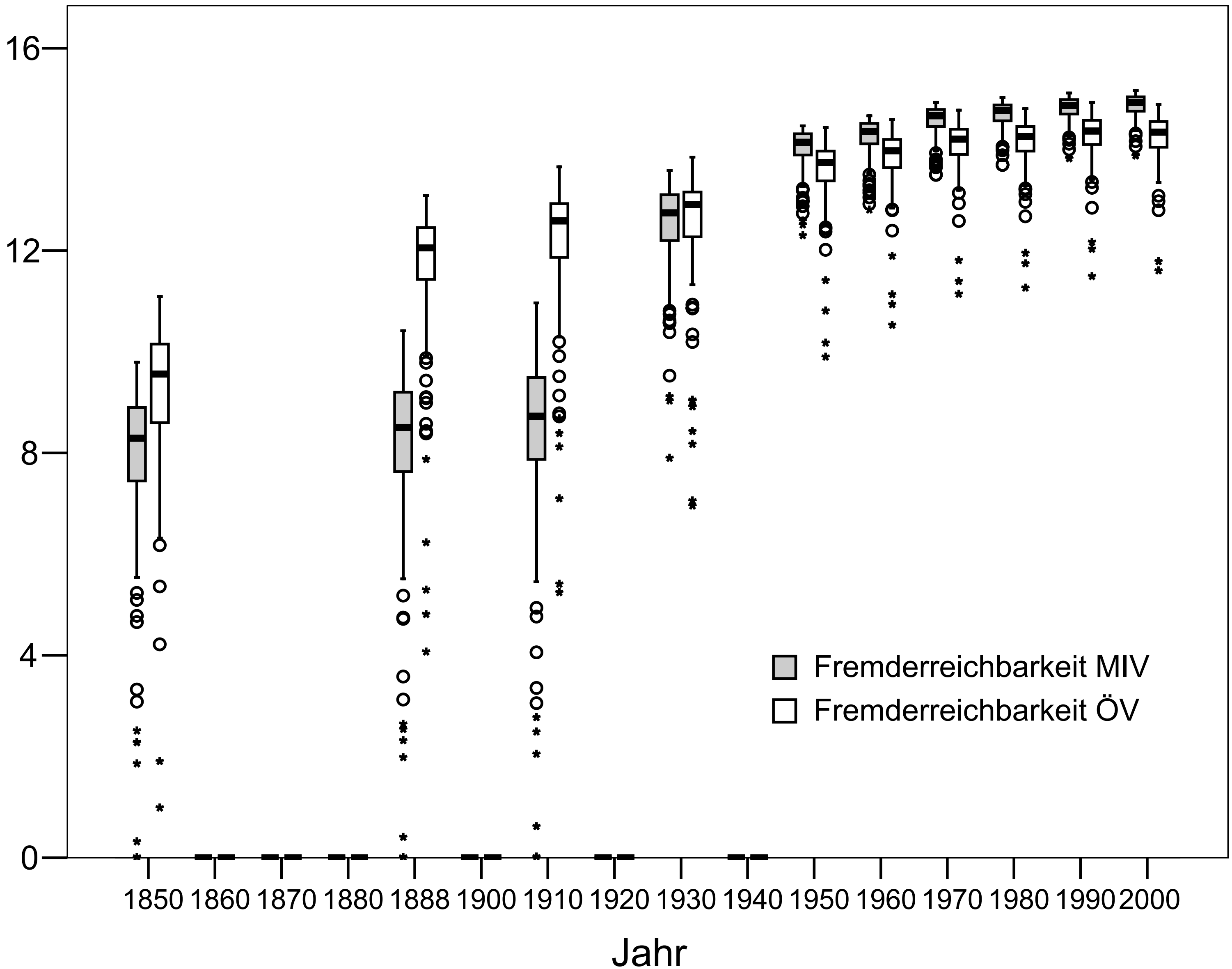
Rail travel time-scaled map of Switzerland 1950



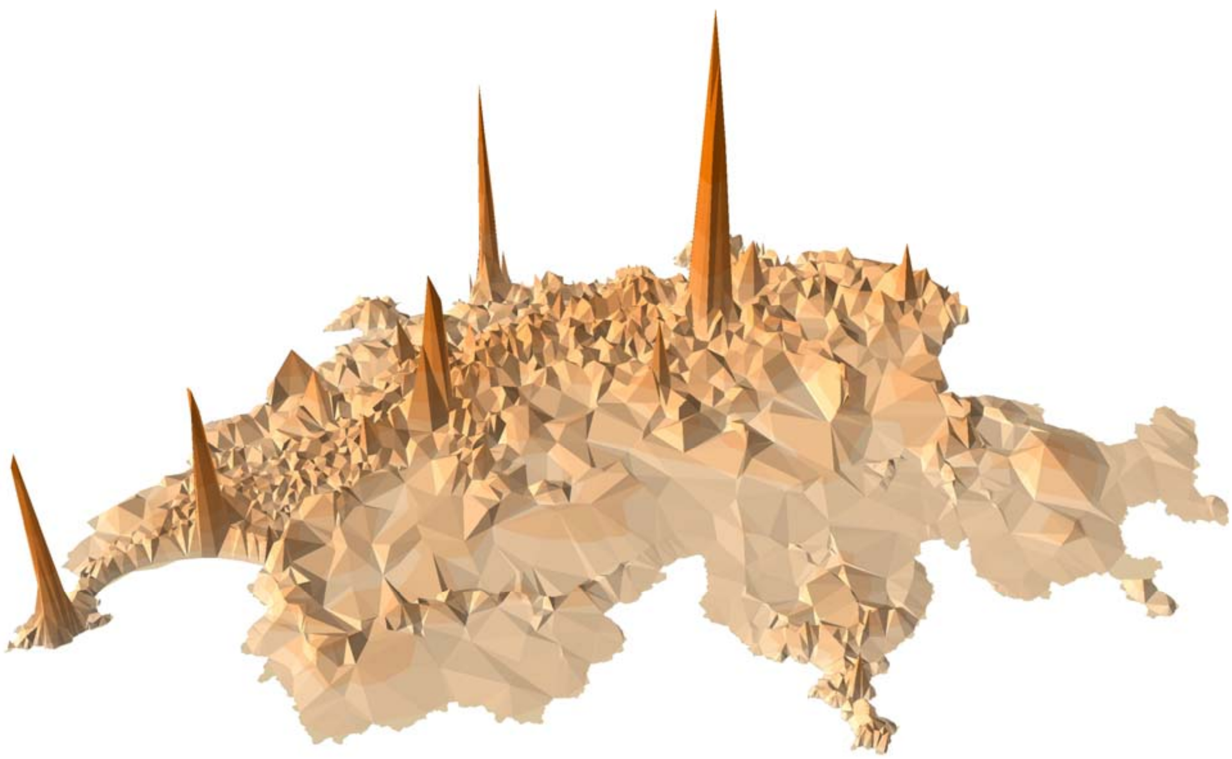
Rail travel time-scaled map of Switzerland 2000



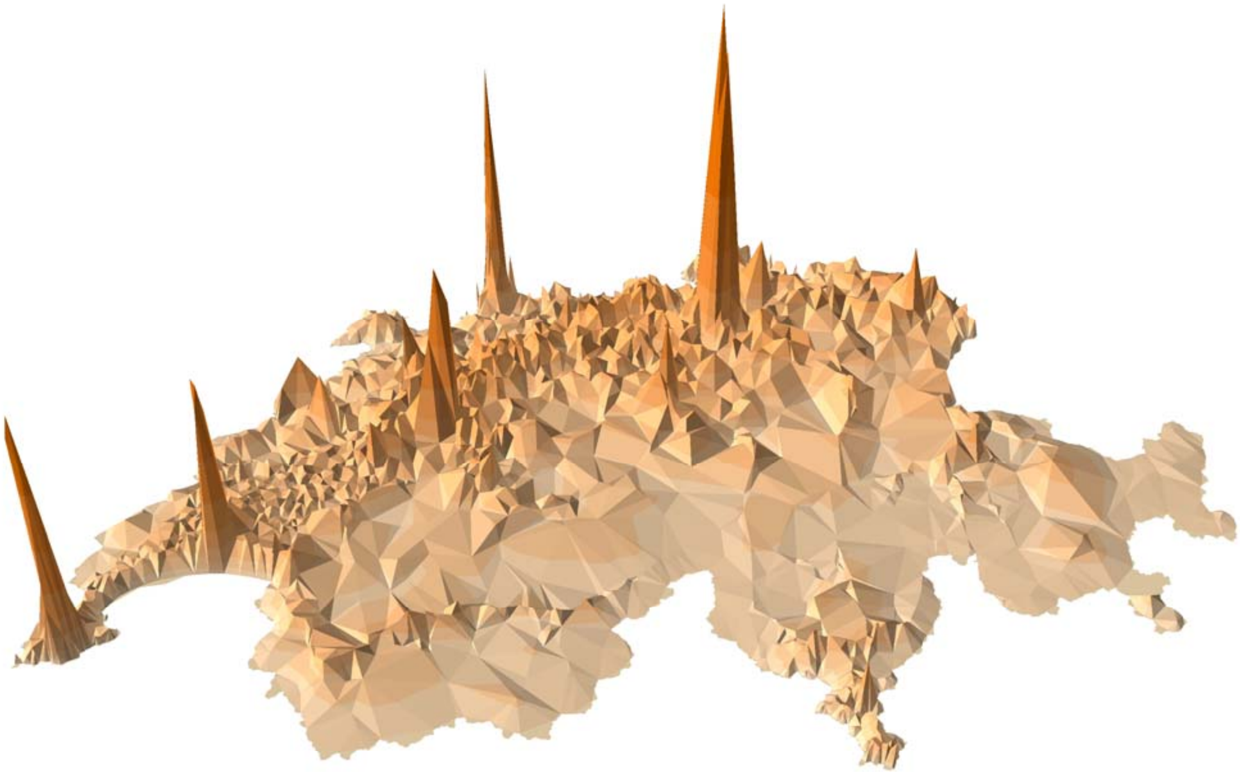
Accessibilities of the Bezirke since 1850



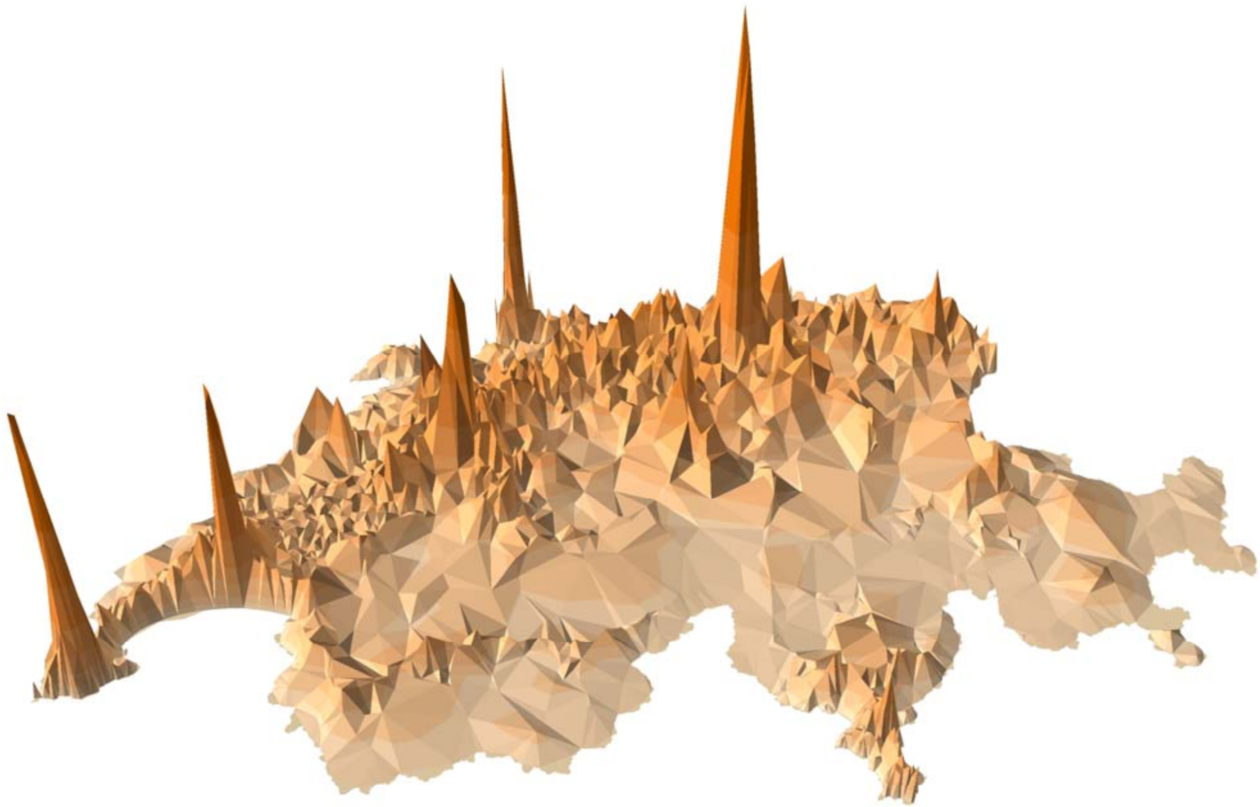
Road based accessibilities 1950 (without log)



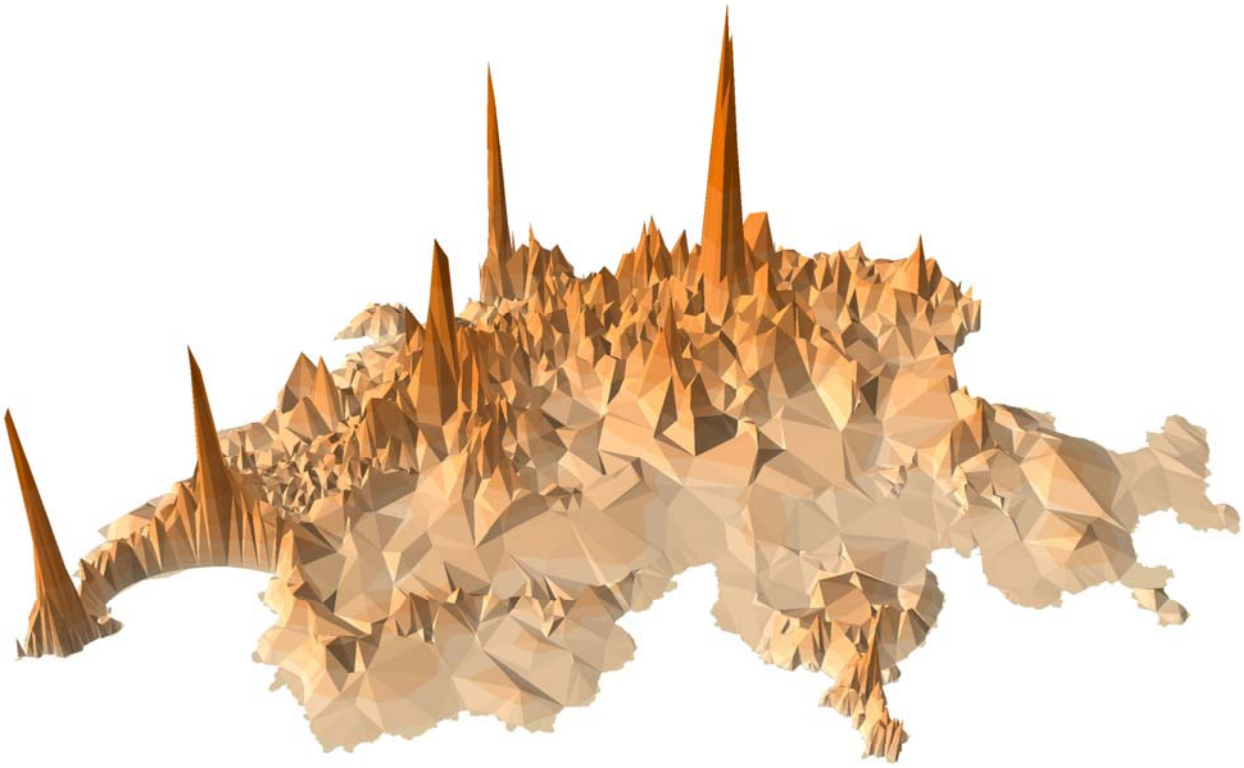
Road based accessibilities 1960 (without log)



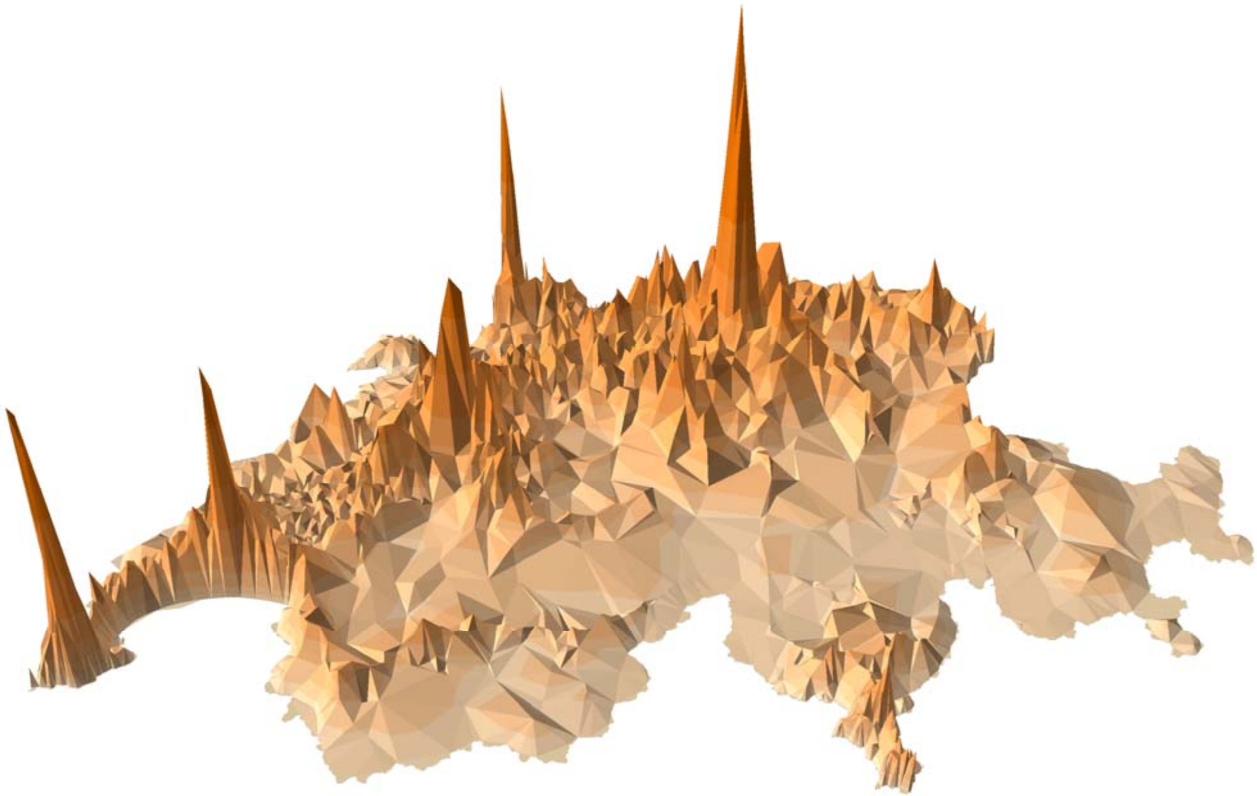
Road based accessibilities 1970 (without log)



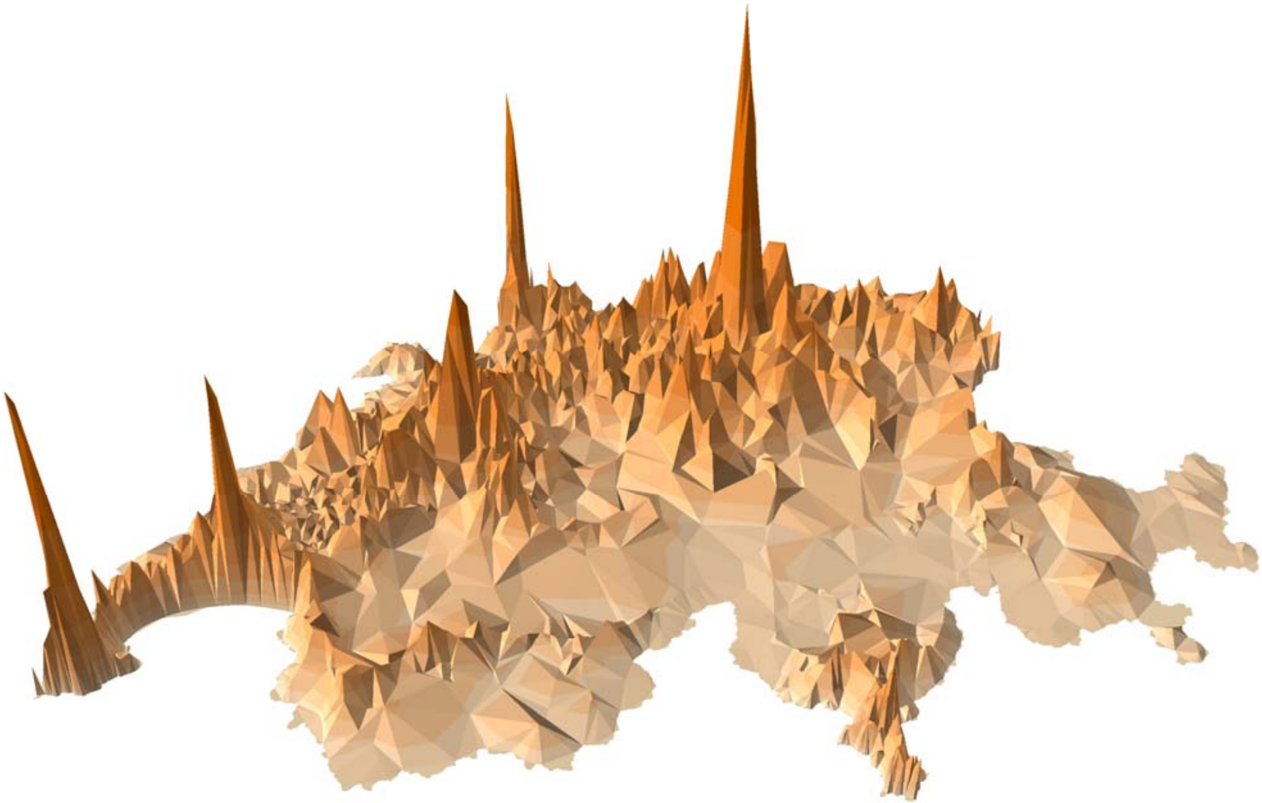
Road based accessibilities 1980 (without log)



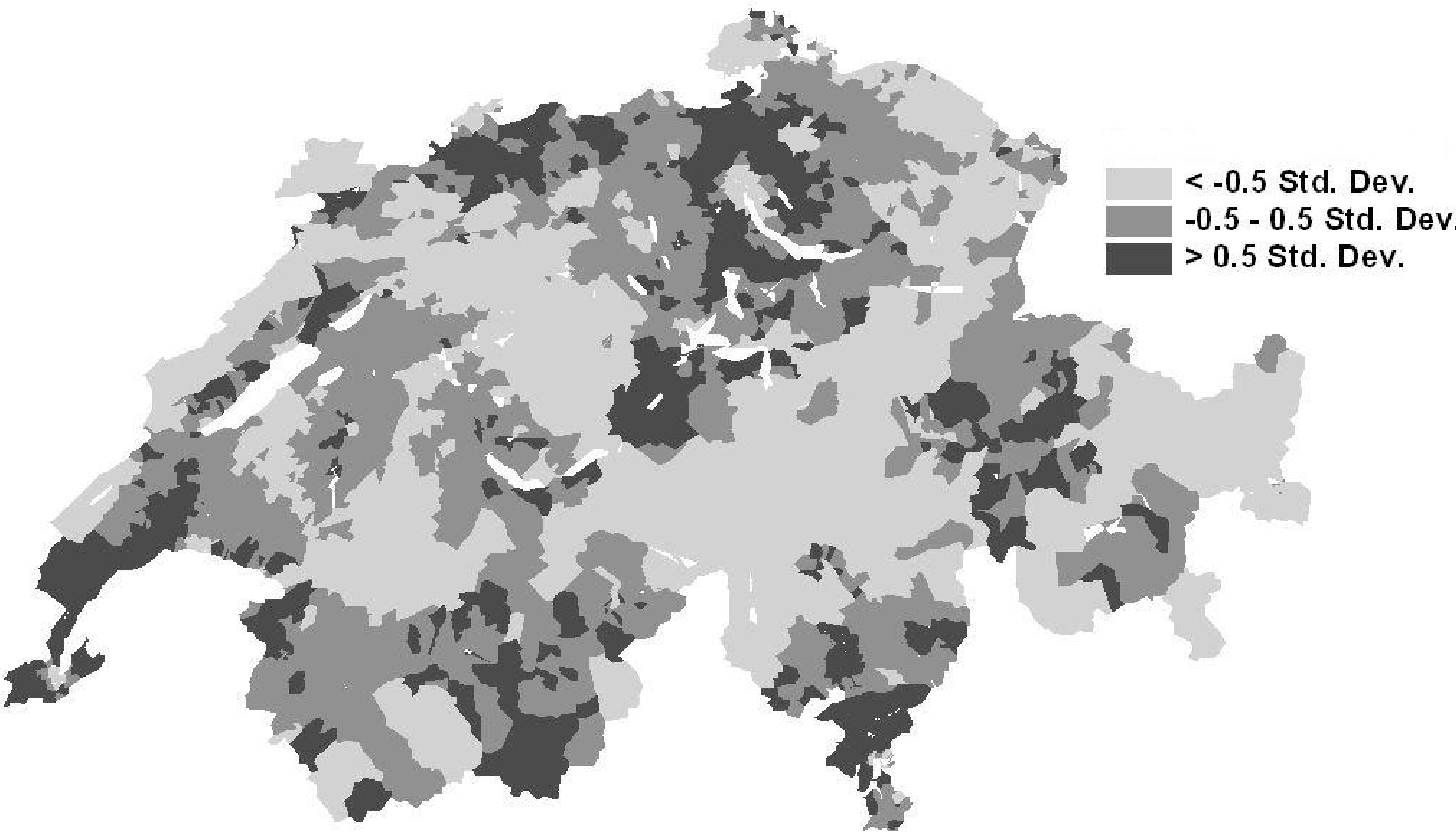
Road based accessibilities 1990 (without log)



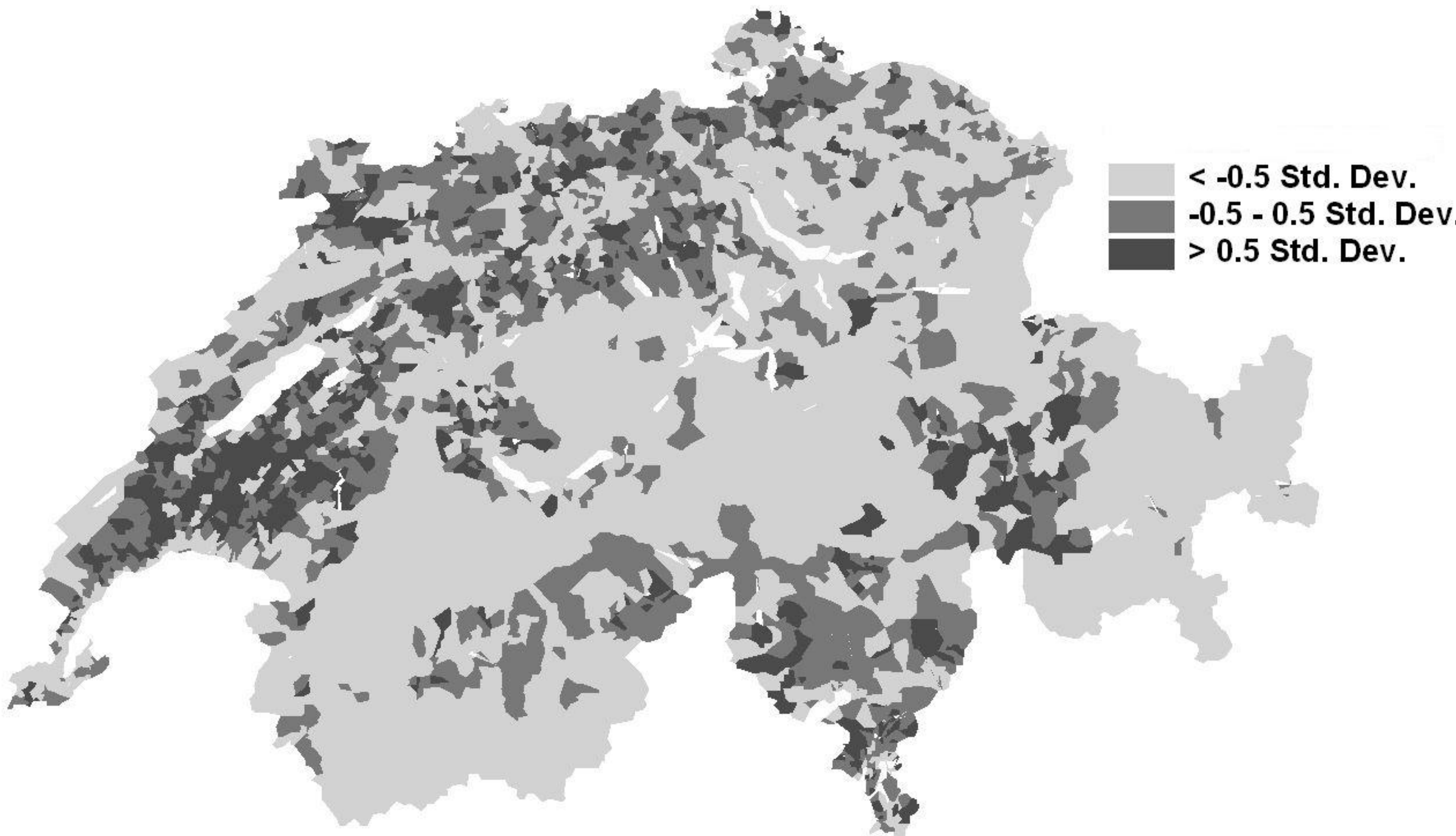
Road based accessibilities 2000 (without log)



Growth of the road based accessibilities 1950 to 2000



Ratio of road to public transport accessibilities 2000



First set of conclusions

Tracking the road-based accessibility changes is possible over a long period of time.

It seems advisable to concentrate only on the developments of the motorways and similar high capacity roads.

Public transport requires full timetables.

Public transport accessibilities underestimated due to the ommissions of schedule delay effects (headways)

First set: continued

Need to track not only infrastructure, but also regulations and the vehicle fleet.

Policy impetus to the equalisation of speeds

Winners are the suburban municipalities between the major centres

Saturation effects visible

How to model the impacts ?

Regression approaches:

- OLS
- Hierarchical multilevel models
- Spatial error and lag models

Starting point

OLS assumes:

$$y = X\beta + \varepsilon$$
$$\varepsilon \sim iid\; N(0, \sigma)$$

y	Dependent variable
β	Vector of parameters
X	Matrix of independent variables
ε	Error
σ	Variance of the error

What can go wrong ?

Heteroscedacity 1

$$\varepsilon \sim \hat{y}$$

Heteroscedacity 2

$$\varepsilon \sim x$$

Collinearity

$$\operatorname{cov}(x_i, x_j) \neq \begin{Bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & \dots & 0 & 1 \end{Bmatrix}$$

What else can go wrong ?

Spatial or temporal vicinity

$$\mathrm{cov}(\varepsilon_n, \varepsilon_m) \neq \begin{Bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & \dots & 0 & 1 \end{Bmatrix}$$

Spatial regression models

Spatial autoregressive model (SAR):

$$y = \rho W_A y + X\beta + \varepsilon \qquad \varepsilon \sim iid\ N(0,\sigma)$$

Spatial error model (SEM)

$$y = X\beta + u \qquad u = \lambda W_E u + \varepsilon$$

Spatial autoregressive and spatial error model combined (SAC):

$$y = \rho W_A y + X\beta + u \qquad u = \lambda W_E u + \varepsilon$$

with W: neighborhood matrix (contiguity matrix) with row sum=1

ρ: influence factor of spatial autoregressive dependence

λ: influence factor of spatial dependence of error

Hierarchical regression (Simplest 2-level model)

$$y_{ij} = \beta_{0ij} x_0 + \beta_{1ij} x_{1ij}$$

with:

fixed part random part

$$\beta_{0ij} = \underbrace{\beta_0}_{\text{fixed part}} + \underbrace{u_{0j} + \varepsilon_{0ij}}_{\text{random part}}$$

and:

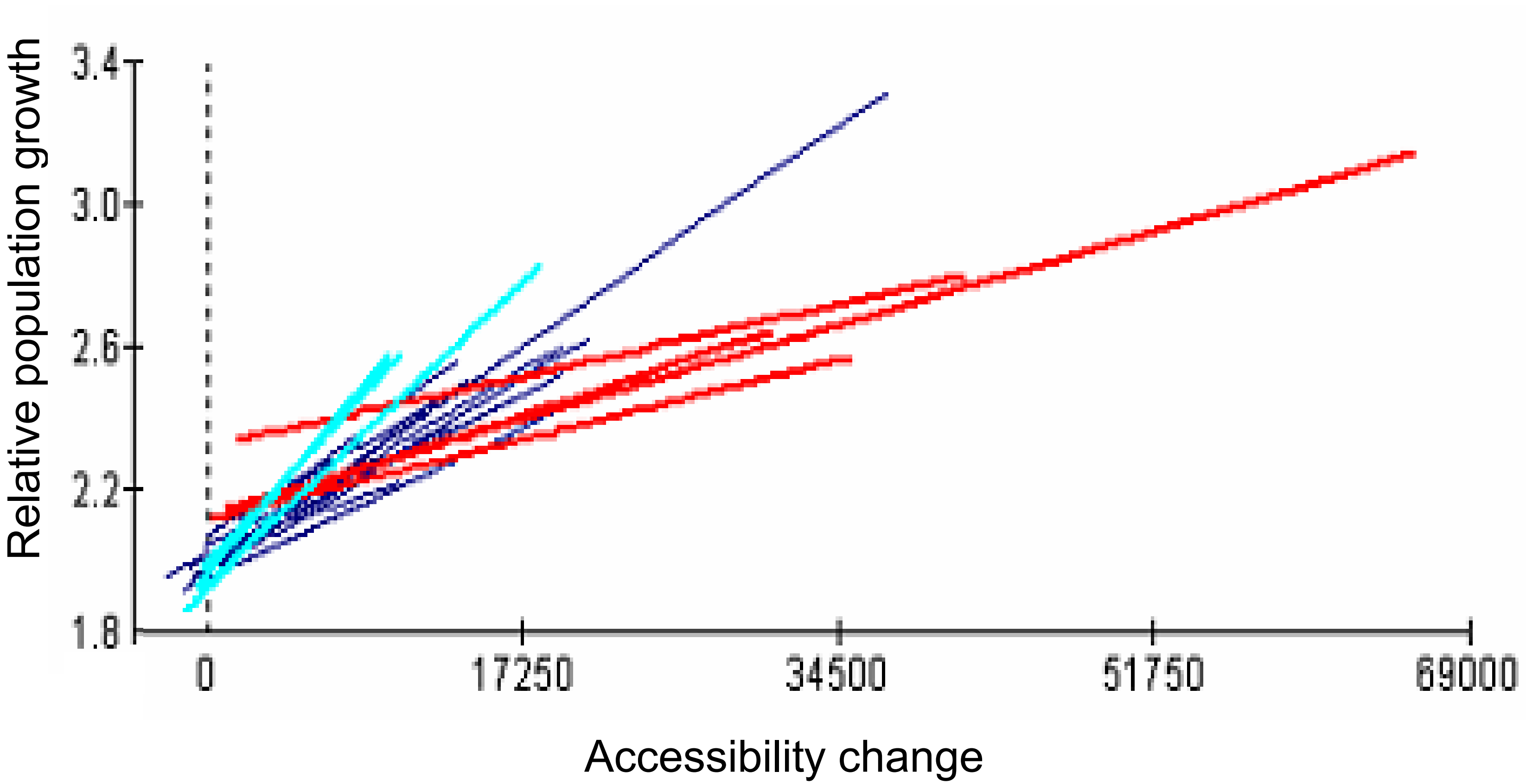
fixed part random part

$$\beta_{1ij} = \underbrace{\beta_1}_{\text{fixed part}} + \underbrace{u_{1j} + \varepsilon_{1ij}}_{\text{random part}}$$

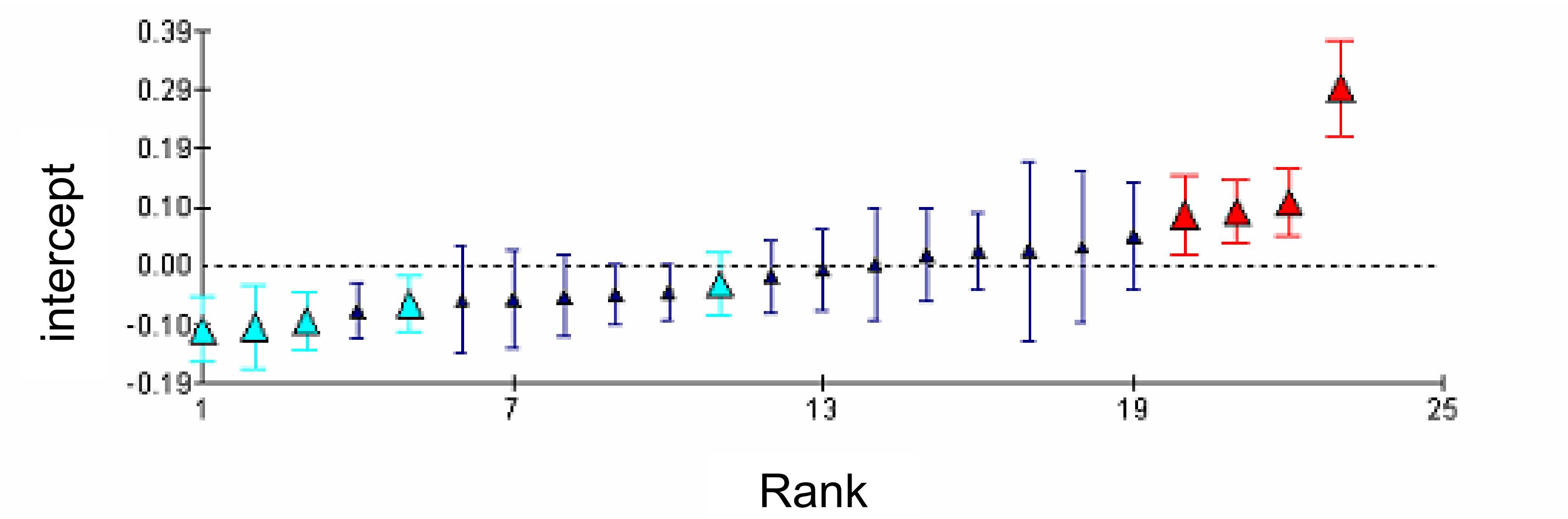
Example:

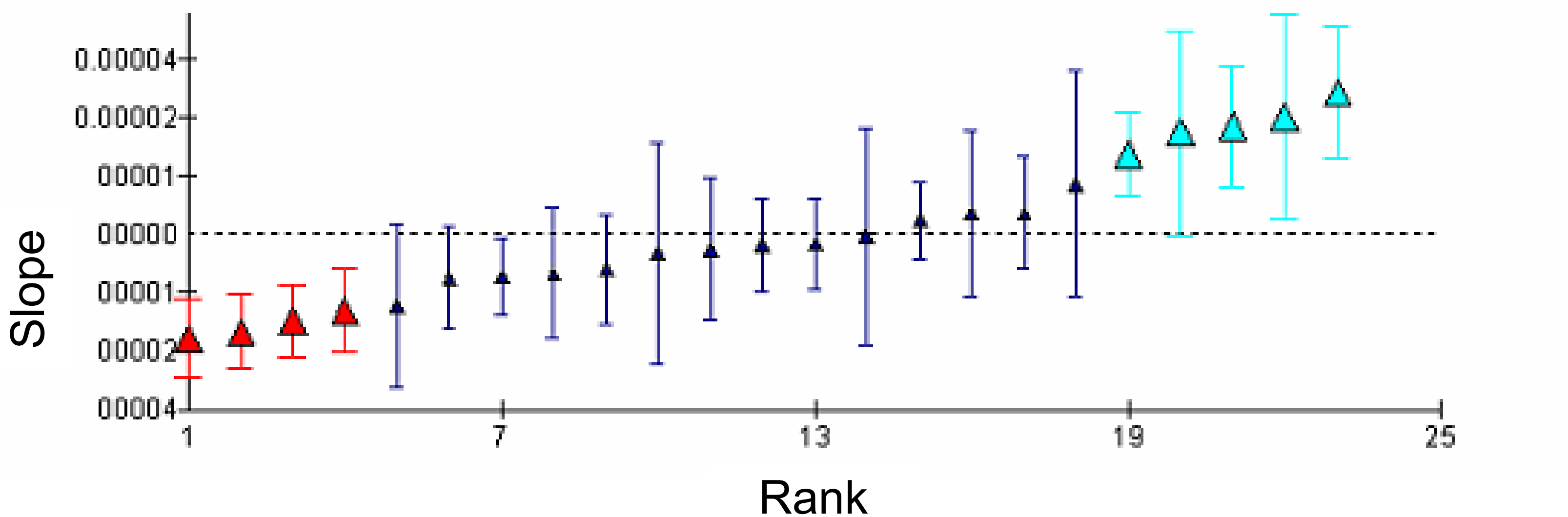
y	Relative population growth
$\beta_{0,1}$	Parameter
x_0	Constant
x_1	Change in accessibility
u	Systematic error (departure of the *j*-th Cantons intercept (slope) from the overall value)
ε	Error (departure of the *i*-th municipality‘s actual score from the predicted score) $\varepsilon \sim iid\ N(0,\sigma)$
i	Level 1 (Municipality)
j	Level 2 (Kanton)

Population growth by municipality

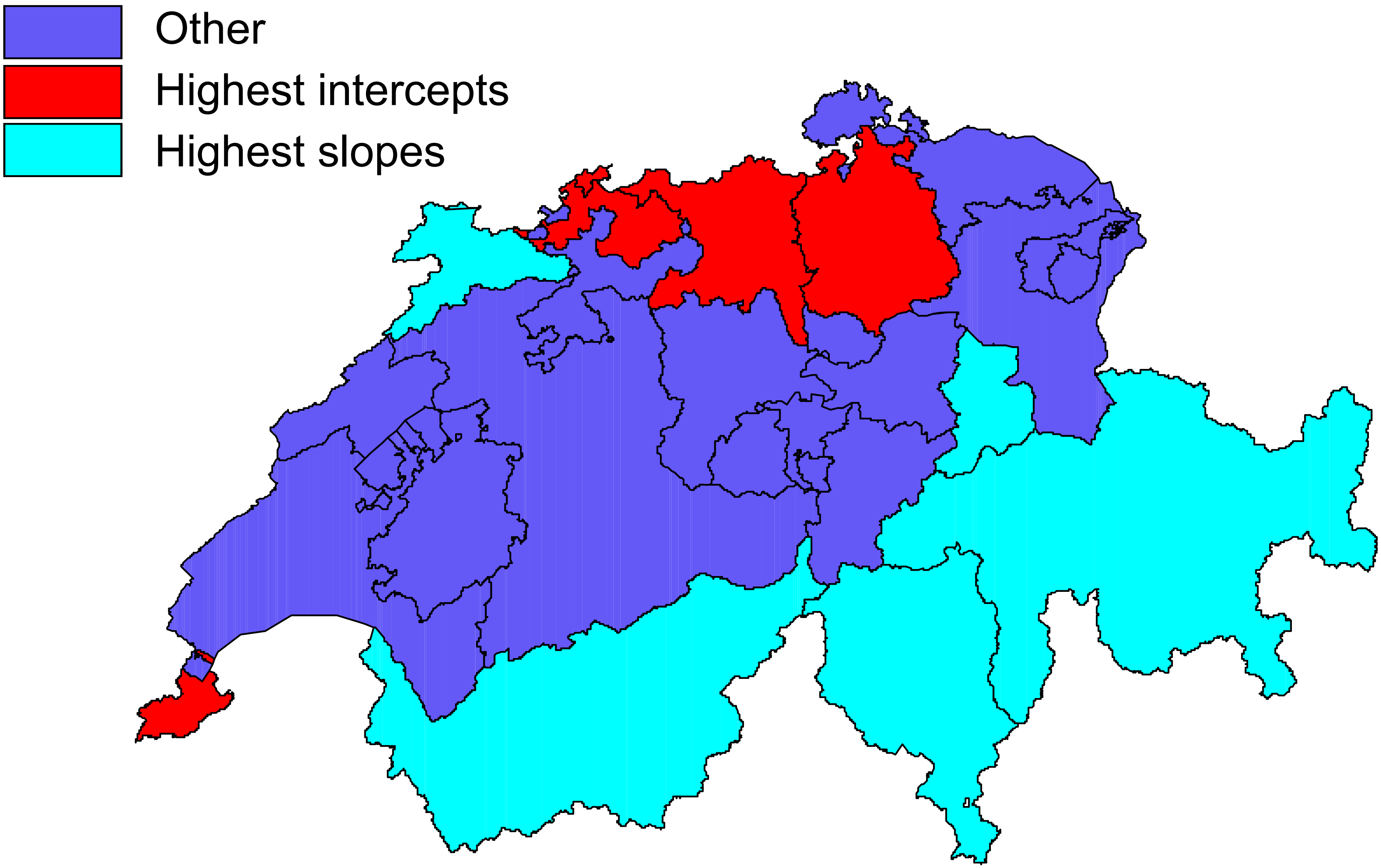


Analysis of the “systematic errors”

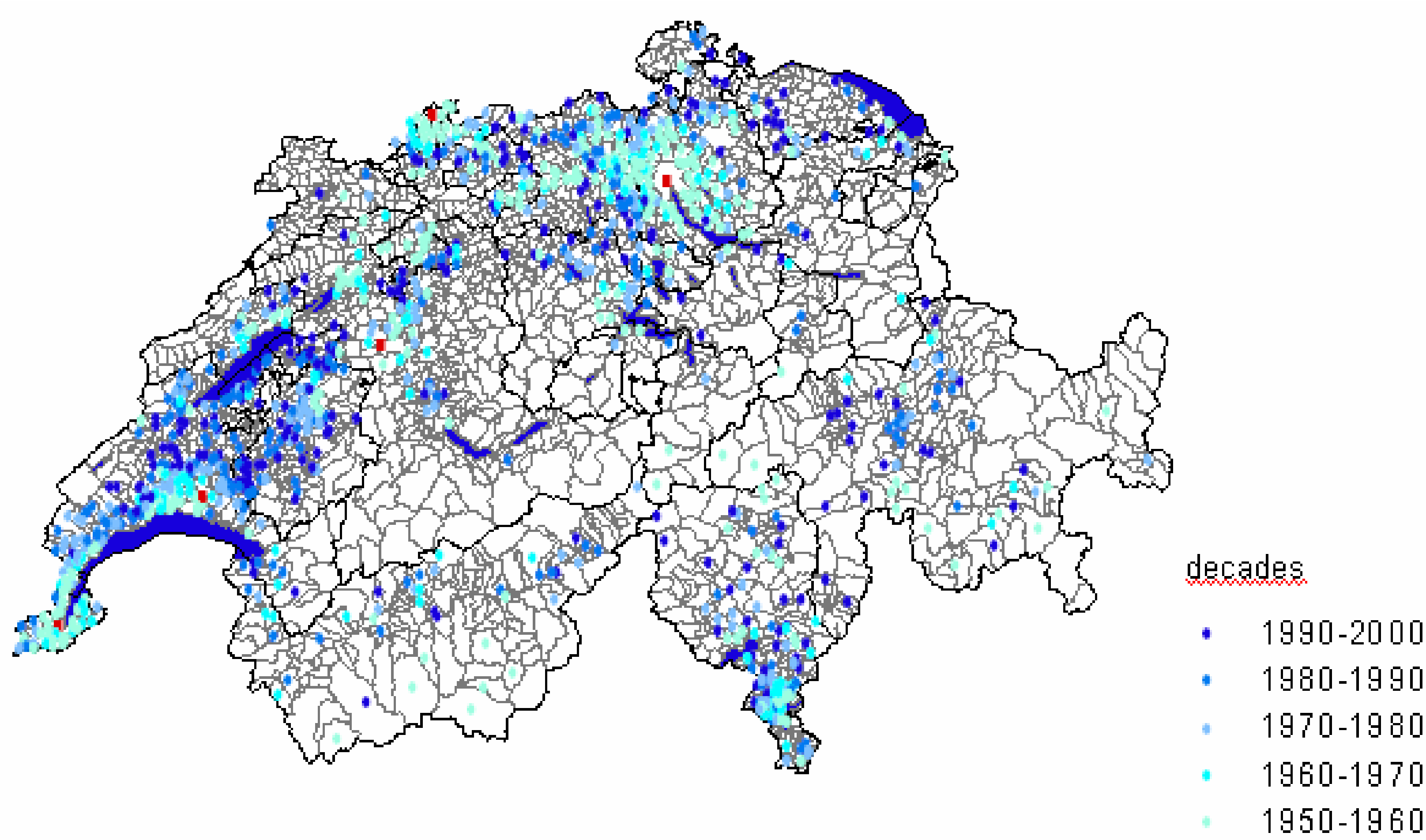




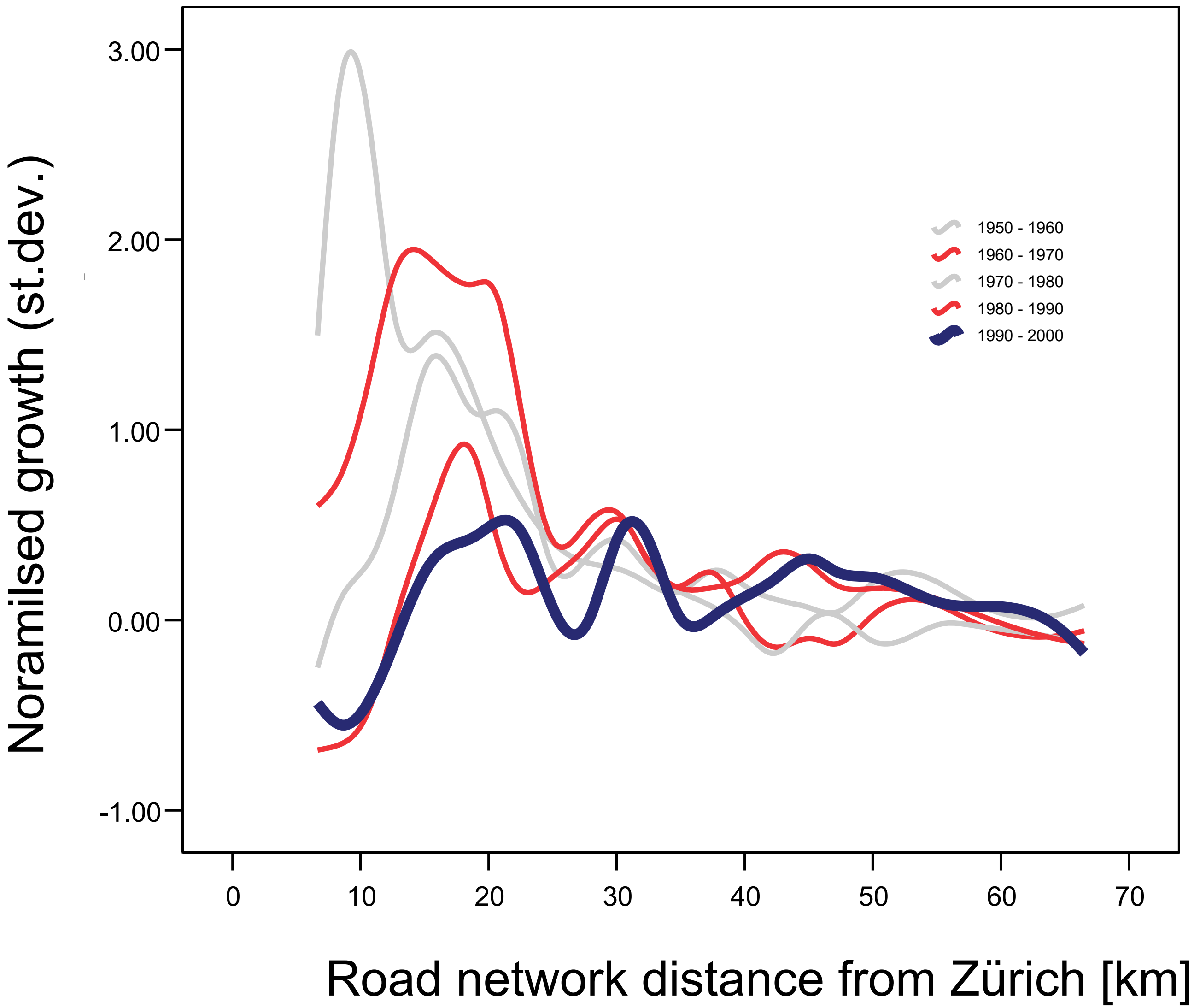
Neighbourhoods in Swiss population growth patterns



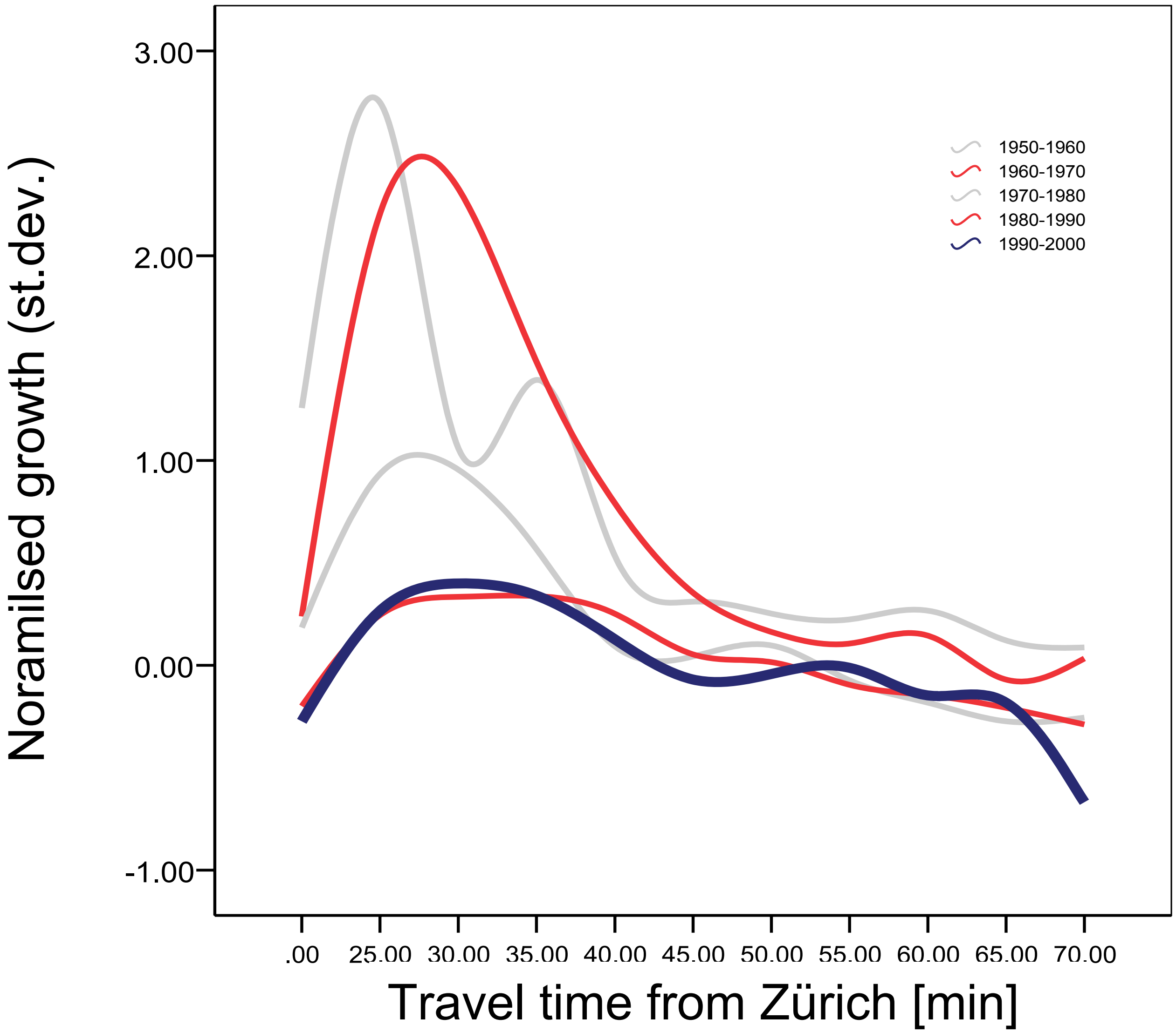
Above average (> one st dev.) population growth



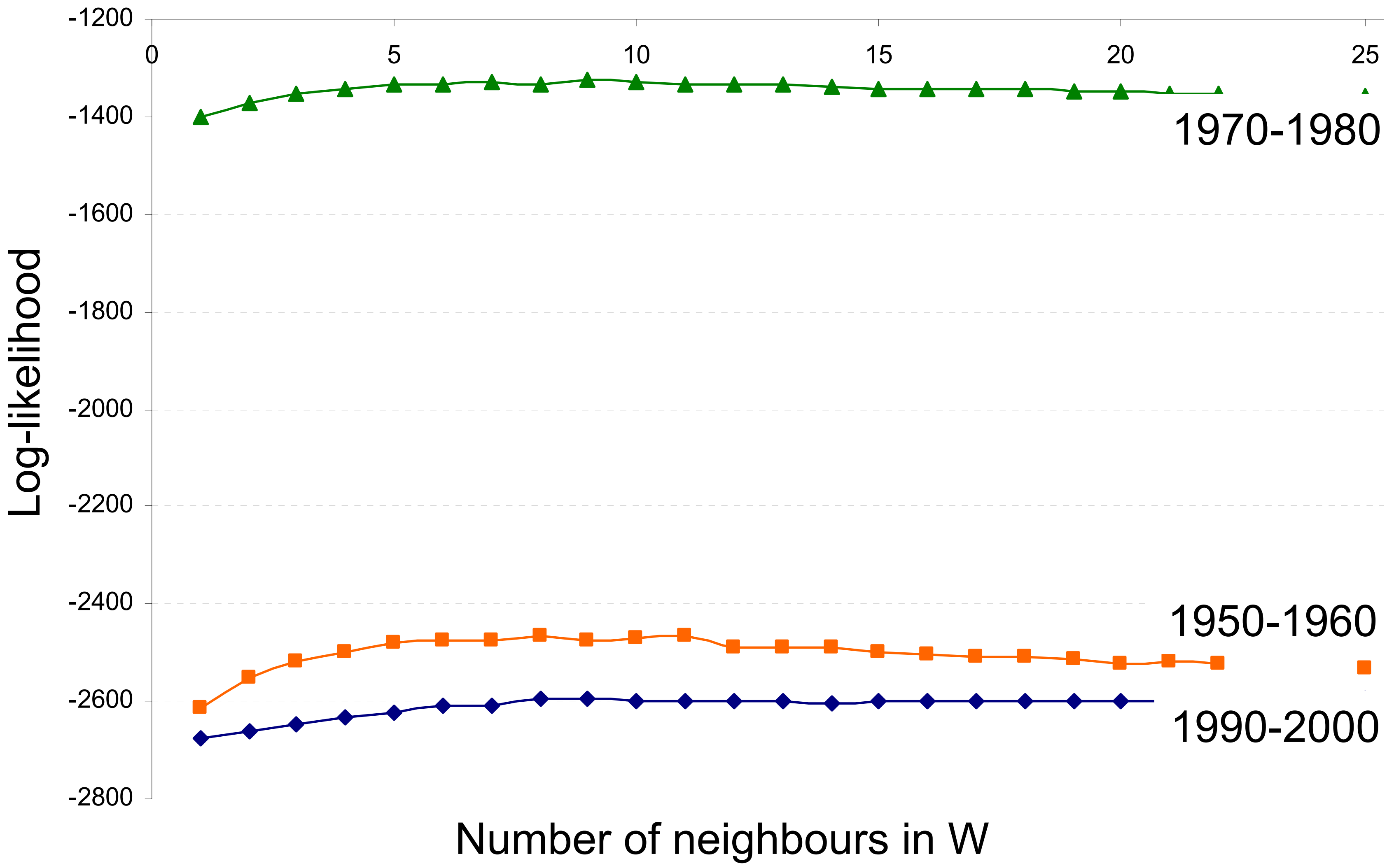
Growth wave (from Zürich)



Growth wave (from Zürich)



Size of W



-1200
-1400
-1600
-1800
-2000
-2200
-2400
-2600
-2800
0
5
10
15
20
25
Log-likelihood
1970-1980
1950-1960
1990-2000
Number of neighbours in W

SEM Population growth

Variable	1950-60	1970-80	1990-2000
R^2	**0.383**	**0.715**	**0.309**
constant	*0.190*	*0.001*	*-0.007*
ΔEmployment 2^{nd} $sector_t$	*-0.025*	*0.013*	*0.014*
ΔEmployment 3^{nd} $sector_t$	**0.089**	**0.068**	*0.011*
ΔRoad $accessibility_t$	**0.246**	**0.082**	**0.150**
ΔTransit $accessibility_t$	**0.267**	**0.777**	**0.430**
lambda	**0.555**	**0.464**	**0.412**

Conclusions

- Modelling needs to account for spatial correlations
- Starting position makes a difference
- Strength of accessibility impacts change
- Saturation is observable for larger, but still small areas units

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Appendix

Mean ratios of road to public transport accessibility

	1950	1960	1970	1980	1990	2000
Mean	**1.31**	**1.33**	**1.38**	**1.38**	**1.37**	**1.36**
Median	**1.28**	**1.30**	**1.33**	**1.33**	**1.32**	**1.32**
Std. Dev.	**0.19**	**0.21**	**0.23**	**0.24**	**0.23**	**0.22**
25% percentil	**1.16**	**1.17**	**1.19**	**1.19**	**1.19**	**1.19**
75% percentil	**1.43**	**1.46**	**1.53**	**1.53**	**1.51**	**1.50**

Based on municipal accessibilities, with their own-accessibility included