

Transport and spatial economies

Presentation

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Transport and spatial economies

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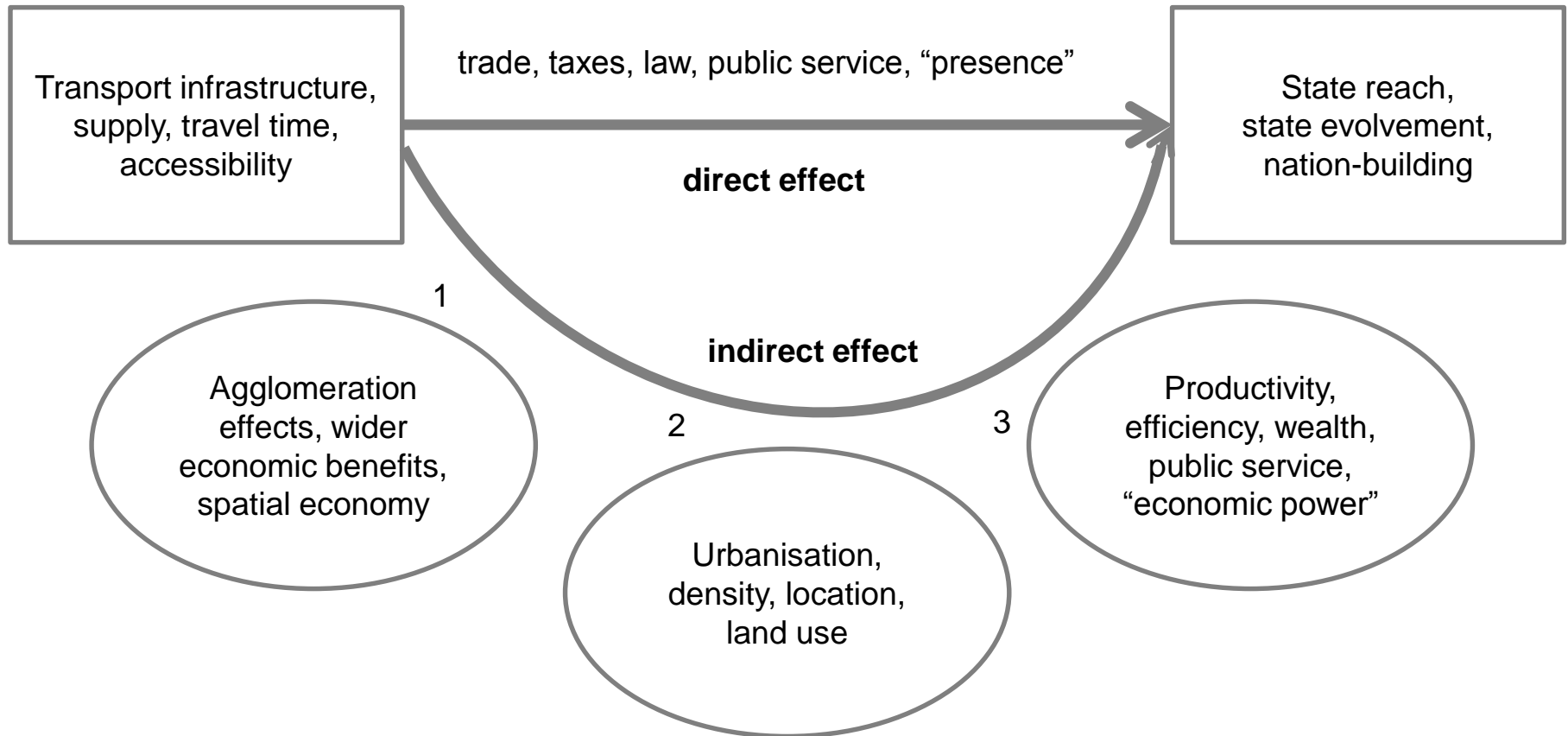
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Research question

What was the role of transport supply in the evolvment of states in Europe?



From transport infrastructure to state reach



Transport and space in the humanities

Fernand Braudel: space – enemy number one

«Aujourd’hui, l’espace nous manque, il se rétrécit autour de nous.
Au XVIe siècle, il surabonde et cette richesse est à la fois
avantage et obstacle.»

Charles Tilly: trust networks

«Cities differ from strictly agricultural settlements, furthermore, by
virtue of substantial populations, differentiated and specialized
activities, and location as nodes in far-reaching networks of
trade and political coordination.»

Tim Blanning: communications

«For most Europeans in the seventeenth and eighteenth century, it
was the condition of the roads which dictated the pace of
communications and the degree of mobility.»

Deirdre McCloskey: the power of persuasion

«That is, ideas, or “rhetoric”, enriched us.»

Overview: Accessibility and Related Data Models

$$A_i = \sum_j O_j \times e^{-\beta \times C_{ij}}$$

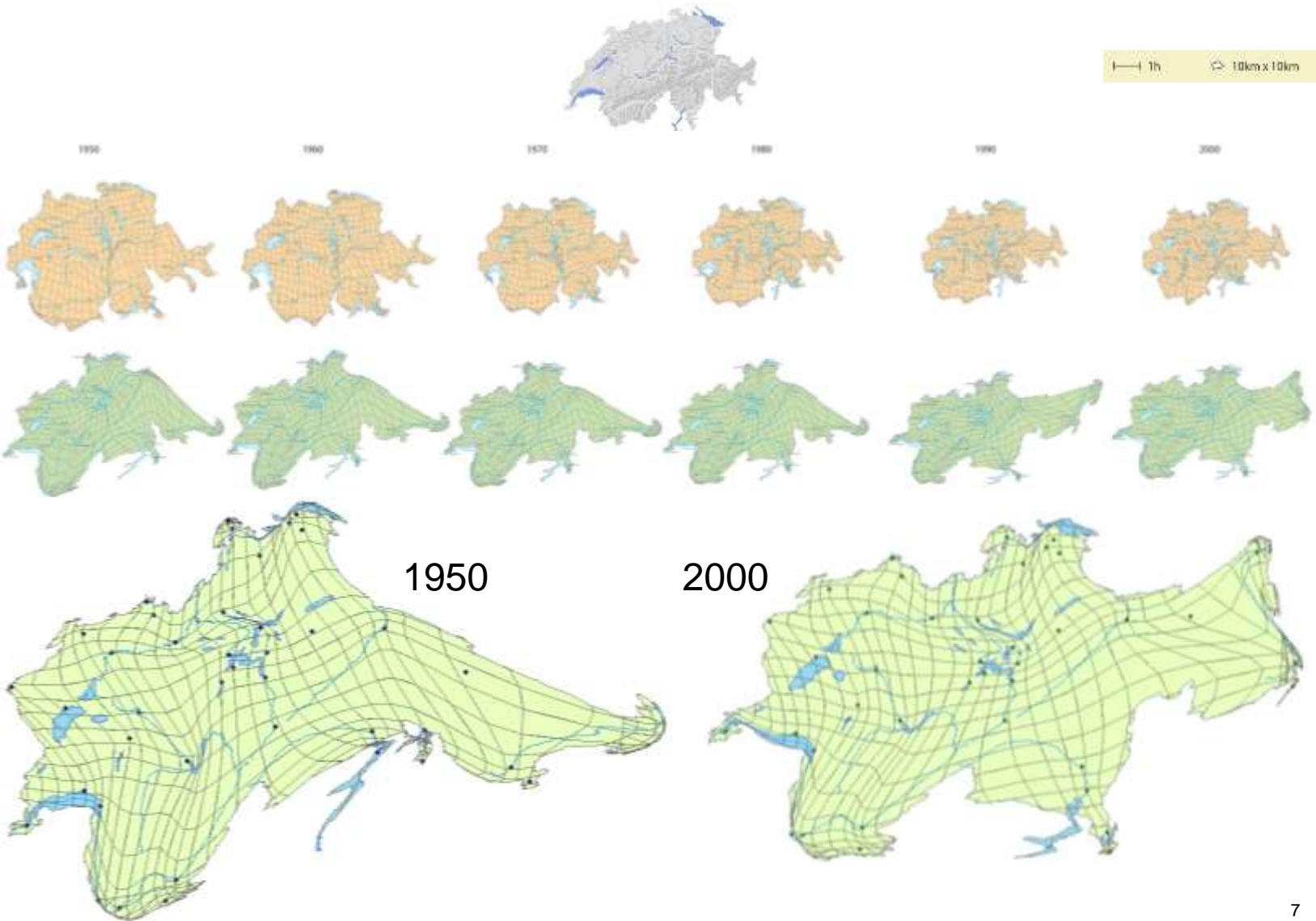
| | | | |
|---|------------------------------------|---------|----------------------------------|
| A | Accessibility of location i | O | Opportunity points in a location |
| i | Location you are looking at | β | Impedance factor |
| j | i + all other considered locations | C | Generalised costs (travel time) |

Spatially referenced data (models) of

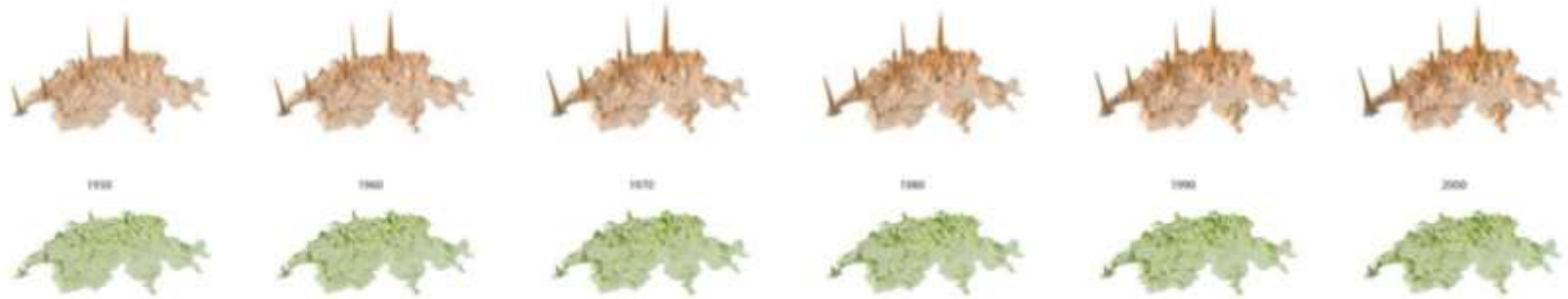
- a transport network (structure, modes, speeds etc.)
- inhabitants, work places and other points of interests

Accessibility as a measure of the importance of one location in a greater area: economical strength, attractiveness, centrality, participation in development

Changes in Travel Time 1950 to 2000 in Switzerland

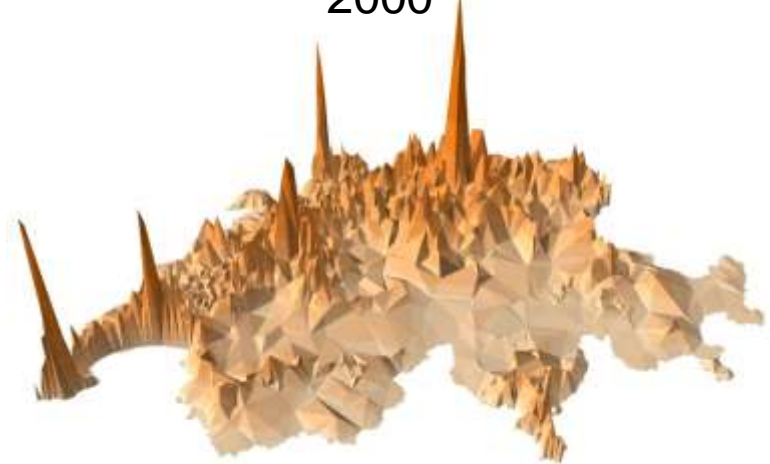
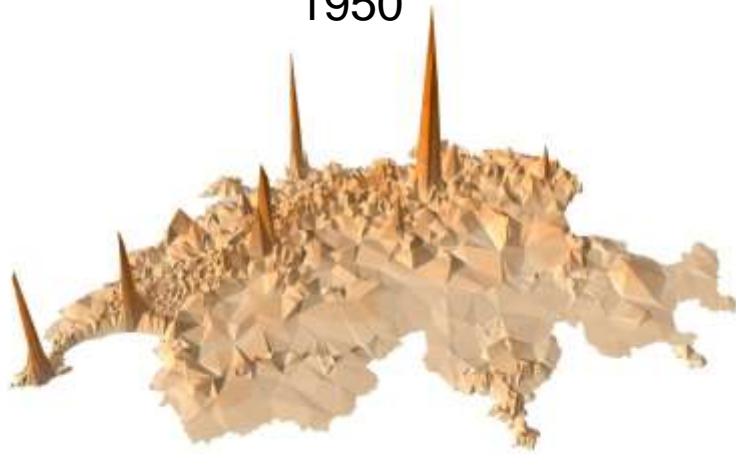


Accessibility Change in Swiss Municipalities 1950-2000

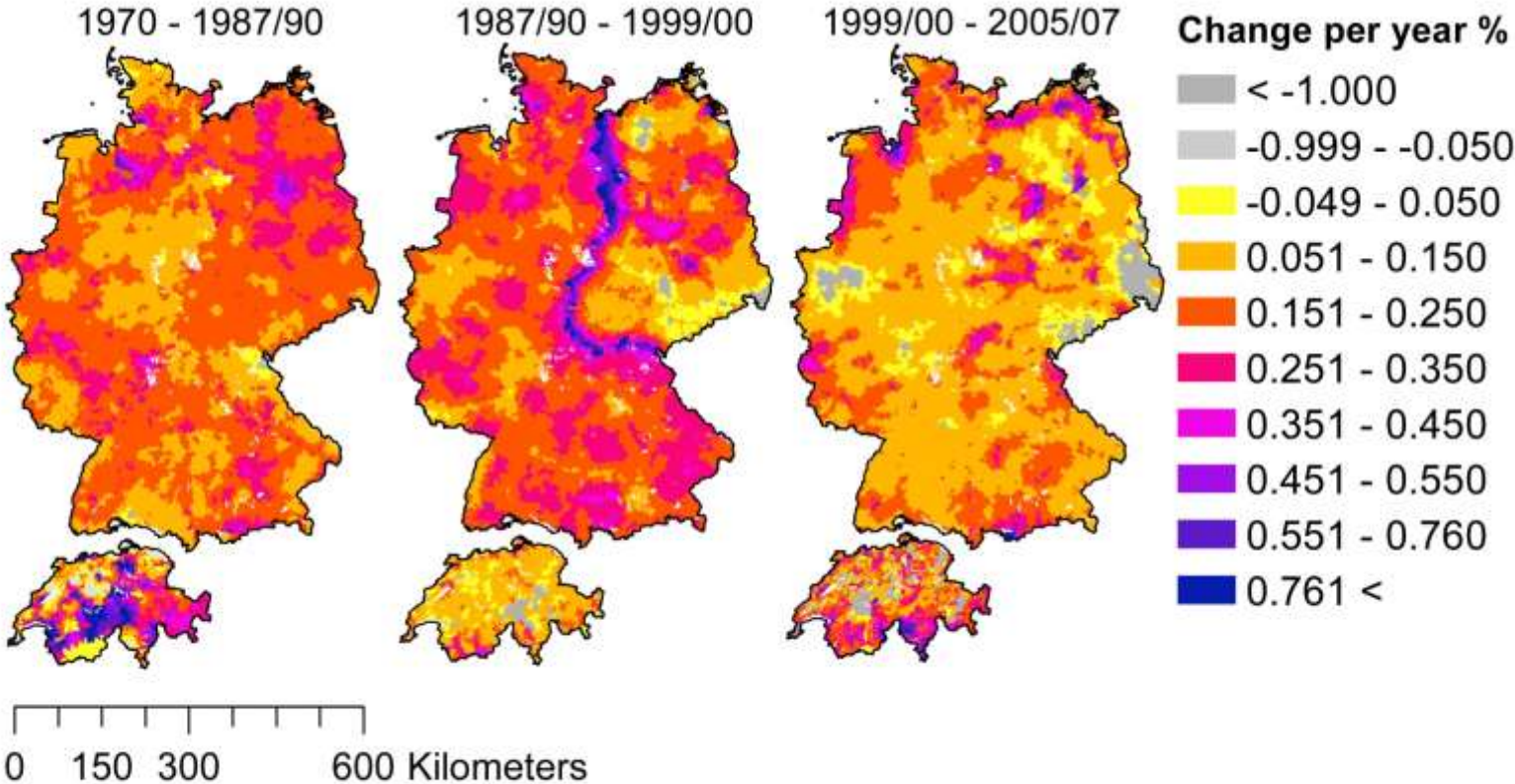


1950

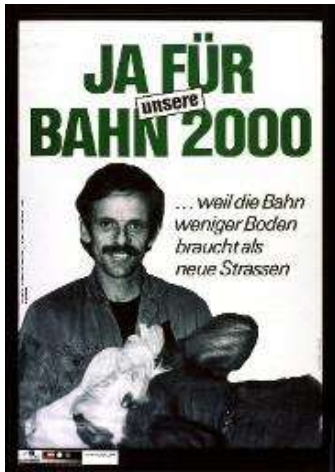
2000



Accessibility Changes in Germany and Switzerland



1987: Yes to a new public transport system Switzerland



30,5bn (~£20 billion) federal budget
??,?bn cantonal contributions

Environmental protection
not a high-speed train project
connect a ever mobile society



Majorities to win:

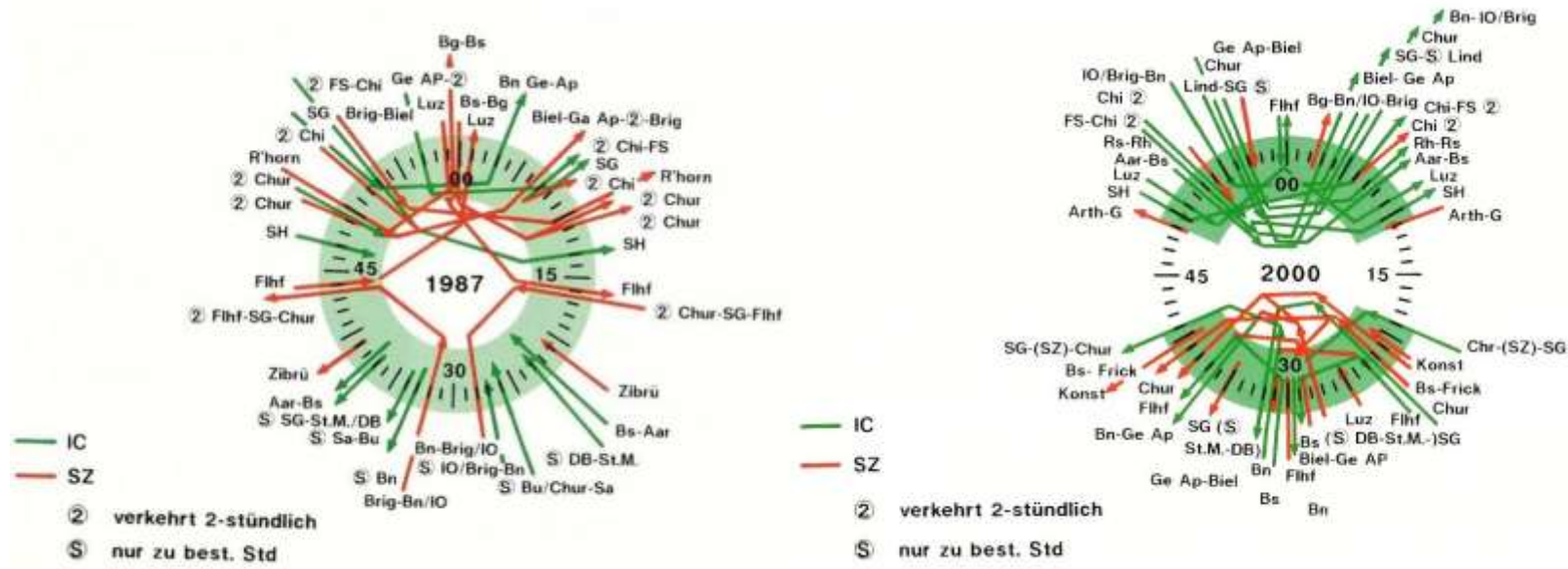
- Federal government
- National council and council of states
- Voters by votes and cantons

57% yes and 64% yes respectively (NEAT, 1992)

130 major infrastructure projects & hundreds of smaller measures

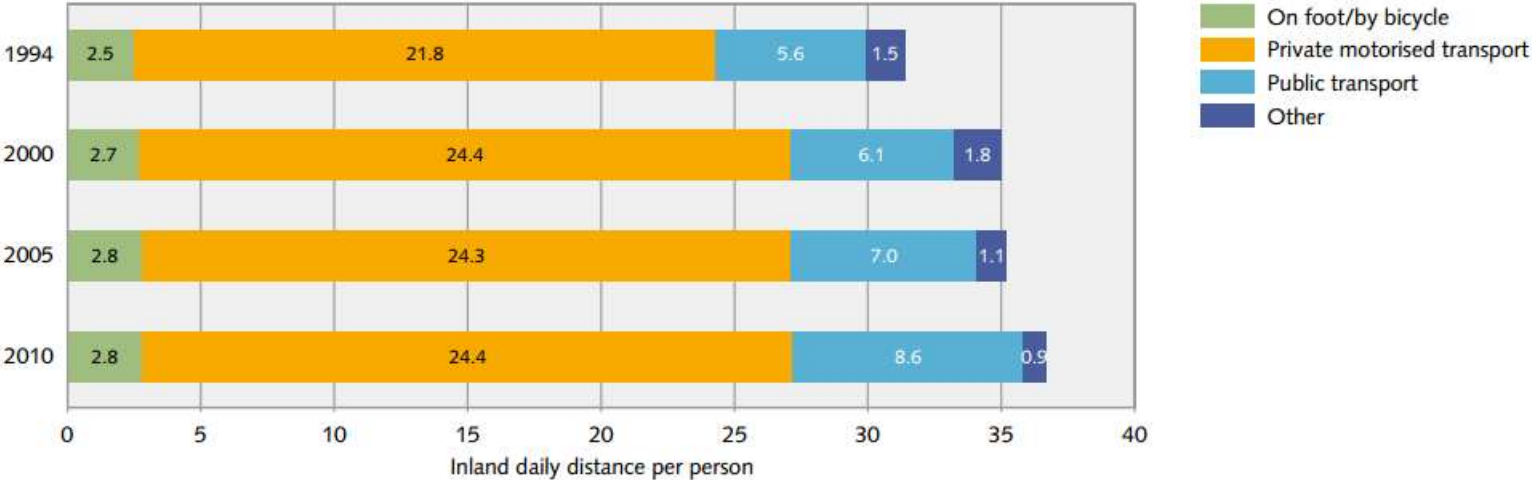
How it works

Robert Fechtig and Max Glättli: 1990; own calculation on GVM by ARE



Additional mobility is 100% in public transport

Kilometres per person per day within Switzerland 1994–2010



© FSO/ARE

Does Rail 2000 lead to productivity gains?

$$P_i = \alpha + \beta_{PTaccessibility} P T a_i + \beta_{ni} x_{ni} + u_{mi}$$

Productivity: paid wages per employee, averaged per municipality

Temporal: 2000, 2005 and 2010

Spatial: municipality

Accessibility regarding population

Variables: individual (e.g. age) and municipality (e.g. sector),
averaged per municipality

Models:

OLS, single and pooled

Panel (fixed time effect), balanced

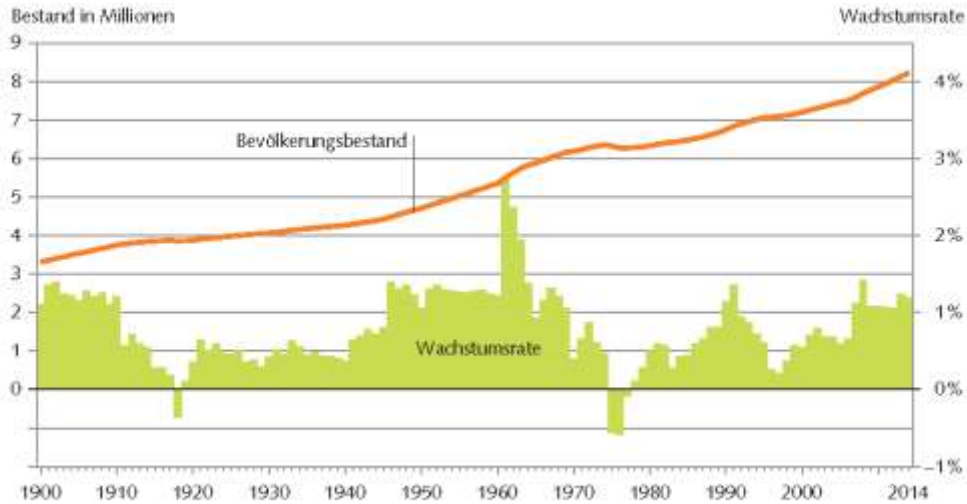
GWR

SAR (spatial error)

SER panel, pooled and time effect

Switzerland 2000 - 2010

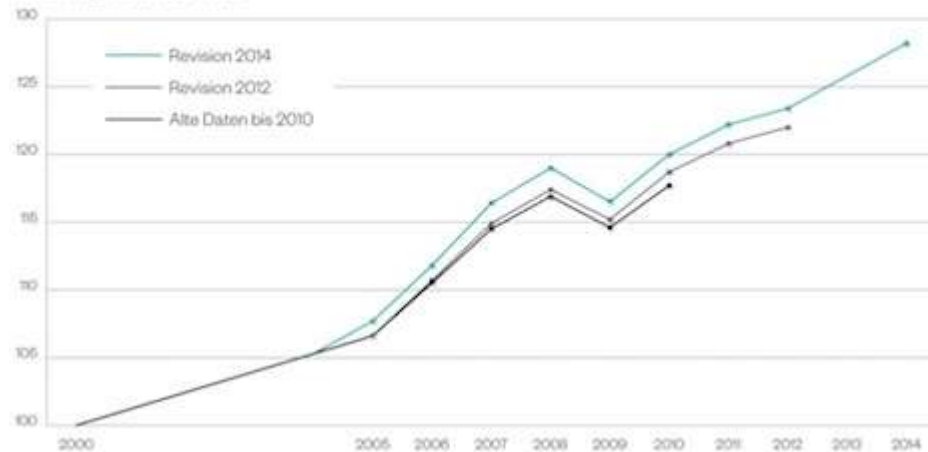
Bevölkerungswachstum und -bestand



Quellen: BFS - VZ, ESPOP, STATPOP

BIP-Wachstum von Revision zu Revision

Entwicklung des teuerungsbereinigten Bruttoinlandsprodukts (BIP real) von 2000 bis 2013, alles indiziert: 2000 = 100.



Used variables in regression models

| Variable | Min. | 1 st Quart. | Median | Mean | 3 rd Quart. | Max. |
|---|------|------------------------|--------|-------|------------------------|-------|
| Ln mean salary | 7.86 | 8.58 | 8.69 | 8.68 | 8.79 | 9.67 |
| Ln car accessibility | 1.78 | 8.81 | 9.45 | 9.25 | 9.93 | 12.01 |
| Ln public transport accessibility | 5.51 | 10.07 | 10.70 | 10.56 | 11.21 | 13.13 |
| Ln number of local employed | 1.10 | 5.34 | 6.38 | 6.42 | 7.33 | 11.00 |
| Commuters from outside Switzerland | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.91 |
| Short residence permit | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.73 |
| Average duration in-post | 0.16 | 7.69 | 9.19 | 9.40 | 10.80 | 23.60 |
| Ln (average age) | 3.13 | 3.69 | 3.73 | 3.72 | 3.76 | 4.05 |
| Men | 0.00 | 0.46 | 0.56 | 0.56 | 0.67 | 1.00 |
| Tertiary education | 0.00 | 0.00 | 0.01 | 0.04 | 0.05 | 0.82 |
| Professional training | 0.00 | 0.00 | 0.03 | 0.05 | 0.06 | 1.00 |
| Further vocational training | 0.00 | 0.04 | 0.07 | 0.08 | 0.11 | 1.00 |
| Teaching degree | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 1.00 |
| Highschool diploma | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.42 |
| Vocational training | 0.00 | 0.40 | 0.53 | 0.52 | 0.63 | 1.00 |
| Positions with highest demands | 0.00 | 0.02 | 0.05 | 0.05 | 0.07 | 0.92 |
| Positions with qualified independent work | 0.00 | 0.15 | 0.24 | 0.26 | 0.33 | 1.00 |
| Positions with professional skills | 0.00 | 0.33 | 0.41 | 0.42 | 0.50 | 1.00 |
| Working (private sector) | 0.00 | 0.68 | 0.85 | 0.77 | 0.94 | 1.00 |
| Working (manufacturing) | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 1.00 |
| Working (FIRE) | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 1.00 |
| Working (hotel, restaurants) | 0.00 | 0.00 | 0.00 | 0.04 | 0.02 | 1.00 |

Result: spatial error, pooled and with time effect

| Independent variable: Ln mean salary | SER pooled | | SER with TE | |
|--------------------------------------|------------|----------|-------------------|----------|
| | Estimate | Pr(> t) | Estimate | Pr(> t) |
| Intercept | 5.388 | *** | 6.257 | *** |
| Year 2005 dummy (time-effect) | | | 0.081 | *** |
| Year 2010 dummy (time-effect) | | | 0.118 | *** |
| Ln car accessibility | 0.015 | *** | 0.012 | *** |
| Ln public transport accessibility | 0.009 | ** | 0.017 | *** |
| Ln number of local employed | 0.018 | *** | 0.015 | *** |
| Commuters from outside Switzerland | -0.055 | *** | -0.097 | *** |
| Short residence permit | -0.056 | | -0.146 | *** |
| Average duration in-post | 0.000 | | 0.003 | *** |
| Ln average age | 0.672 | *** | 0.406 | *** |
| Men | 0.136 | *** | 0.140 | *** |
| Tertiary education | 0.766 | *** | 0.759 | *** |
| Professional training | 0.408 | *** | 0.371 | *** |
| Further vocational training | 0.310 | *** | 0.232 | *** |
| Teaching degree | 0.362 | *** | 0.346 | *** |
| Highschool diploma | 0.420 | *** | 0.341 | *** |
| Vocational training | 0.073 | *** | 0.070 | *** |
| Positions with highest demands | 0.636 | *** | 0.448 | *** |
| Positions with qualified indep. work | 0.378 | *** | 0.244 | *** |
| Positions with professional skills | 0.239 | *** | 0.166 | *** |
| Working (3rd sector) | 0.065 | * | 0.182 | *** |
| Working (private sector) | -0.069 | *** | -0.077 | *** |
| Working (manufacturing) | -0.176 | *** | -0.211 | *** |
| Working (FIRE) | 0.018 | | 0.134 | *** |
| Working (hotel, restaurants) | -0.129 | *** | -0.120 | *** |
| Rho | 0.241 | *** | 0.277 | *** |
| Balanced panel observations | | | 1374 (total 4122) | |

*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Zusammenfassung der Modellresultate

| Model | Estimated Public transport elasticity | | |
|-------------------------------------|---------------------------------------|----------------------|-------------|
| | Year 2000 | Year 2005 | Year 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 | | 0.7% (insignificant) | |
| Time-effects | | 2.00% | |
| Time-effects for 2005-2010 | | | 1.50% |
| SER pooled OLS | | 0.90% | |
| SER pooled OLS for 2005-2010 | | 0.2% (insignificant) | |
| SER with time-effects | | 1.70% | |
| SER with time-effects for 2005-2010 | | | 1.20% |
| GWR | -0.4 - 3.25% | 0.4 - 3% | -0.3 - 2.7% |

| Model | Estimated Public transport elasticity | | |
|-------------------------------------|---------------------------------------|-----------|-----------|
| | Year 2000 | Year 2005 | Year 2010 |
| OLS | 2.10% | 3.90% | 2.70% |
| Spatial error | 1.70% | 3.70% | 2.60% |
| Pooled OLS | | 1.80% | |
| Pooled OLS for 2005-2010 | | | 2.60% |
| Time-effects | | 2.70% | |
| Time-effects for 2005-2010 | | | 3.30% |
| SER pooled OLS | | 1.70% | |
| SER pooled OLS for 2005-2010 | | | 2.20% |
| SER with time-effects | | 2.40% | |
| SER with time-effects for 2005-2010 | | | 2.90% |

Conclusion

- Full improvement of public transport accessibility explains circa 1.4% of productivity increase (paid salaries)
- Similar to elasticity of car accessibility
- Accessibility metric used here instead of density or population size which are common explanatory variables

- Estimated elasticities at earlier times tend to be higher (but fade away over time ?) (Kline and Moretti, 2014; Maggi et al., 1985)
- Unlike investments in skills, investments in infrastructure is persistent
- Question causality

Back to truly historical data...

... Roman road network was the main transport network for centuries after the collapse of the Roman empire.



Advantages of historical analyses

- Network creator and network user are separate
- Several time steps allow to exploit temporal variance
- Integration of path-dependency
- Isolation of transport from other factors
- Real events, real data

At costs

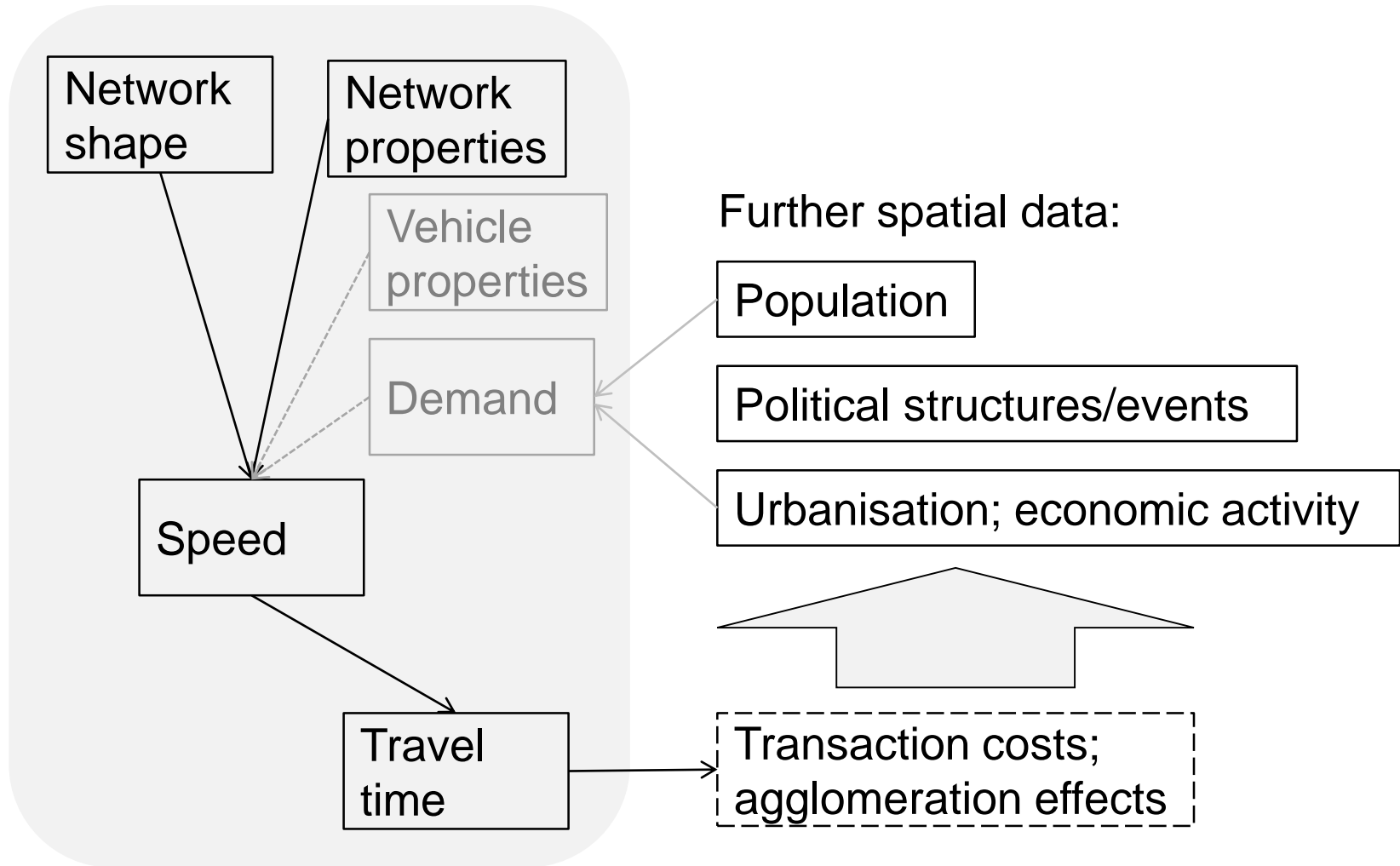
- Data availability and quality
- ‘Readability’; source criticism

Approach

Transport, accessibility -> state formation

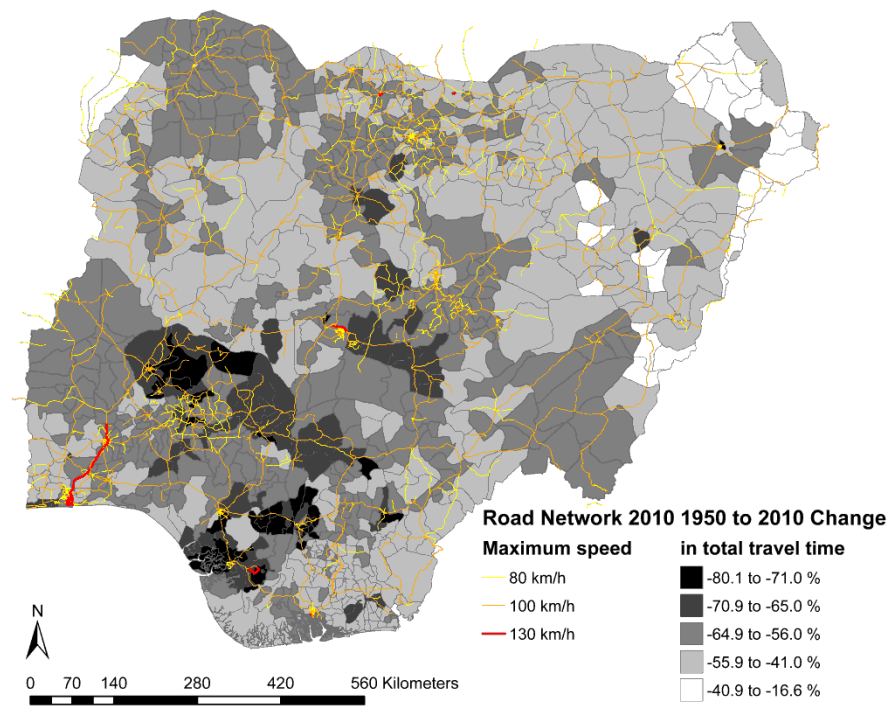
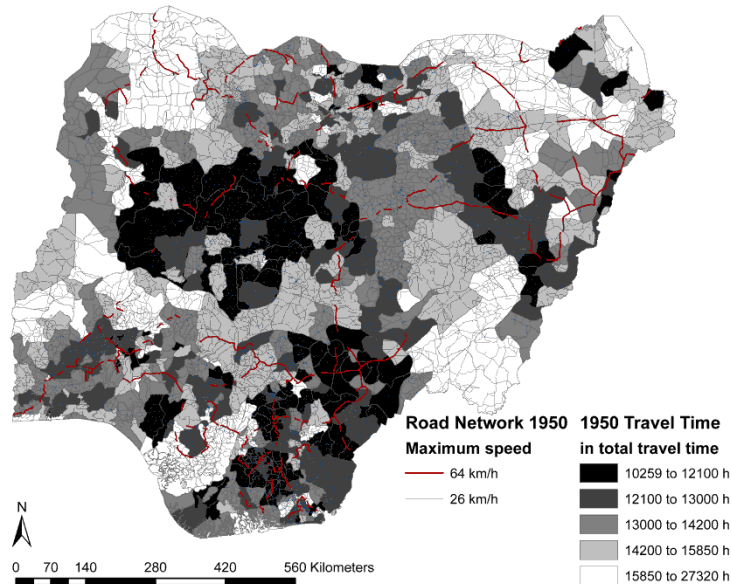
- In between: direct and indirect effect, interlinked
 - 1 military, 'presence' (Hunziker, 2015)
 - 2 trade
 - 3 wealth, economic strength
 - 4 land use, urbanisation, agglomeration economies
- Transport as multifunctional infrastructure
- See transport as proxy for 1 to 4

Accessibility



Outcome: Spatial effects of transport infrastructure

Case Study: Nigeria and Boko Haram 1950 and today



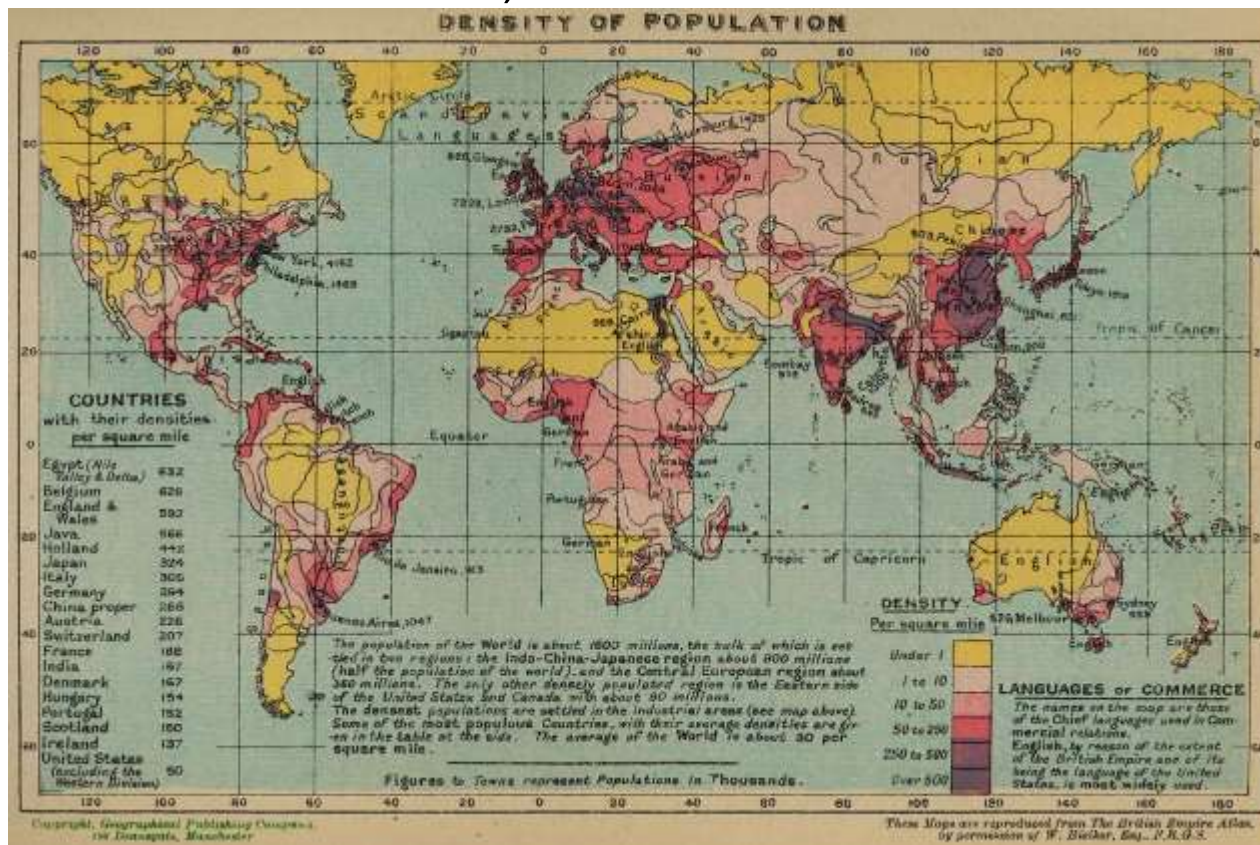
Lb: La Libération; Lu: AMS (network), own calc.; OSM (network), own calc.

Historical Transport Networks: AMS Maps

| | | | | | |
|---|---|--|---|--|--|
| Information | 1. Mapped road type | 2. Corresponding real road type | 3. Surface types | | 7. Maximum speed |
| Per unit | Per link | Per mapped type | Per mapped/real type | | Per surface type |
| Cases | <ul style="list-style-type: none"> • Main road • Secondary road (all other roads and trails) | Different terms, e.g. <ul style="list-style-type: none"> • Motorway • Track, path • Trail | <ul style="list-style-type: none"> • Hard • Loose • Gravel • Metalled | | <ul style="list-style-type: none"> • Paved: 80km/h • Gravel: 64km/h • Earth: 56km/h |
| Source | AMS map meta data | AMS map meta data | AMS map meta data | | World Bank |
| | | | | | |
| Information | 4. Total length of roads | 5. Pavement | 6. Weatherability | | |
| Per unit | Per real road type | Per country | Per mapped type | | |
| Cases | <ul style="list-style-type: none"> • Paved • Gravel/crushed stone • Earth graded • Unimproved | Percentage of paved road of the total length of all roads | <ul style="list-style-type: none"> • All weather • Dry only • Unclear | | |
| Source | IRF, network data | IRF | AMS map meta data | | |
| AMS: Army Map Service; IRF: International Road Federation | | | | | |

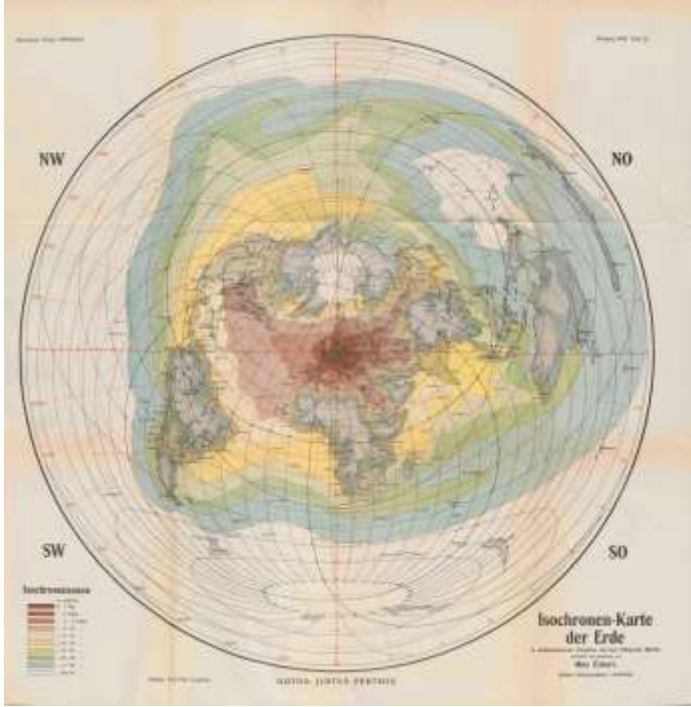
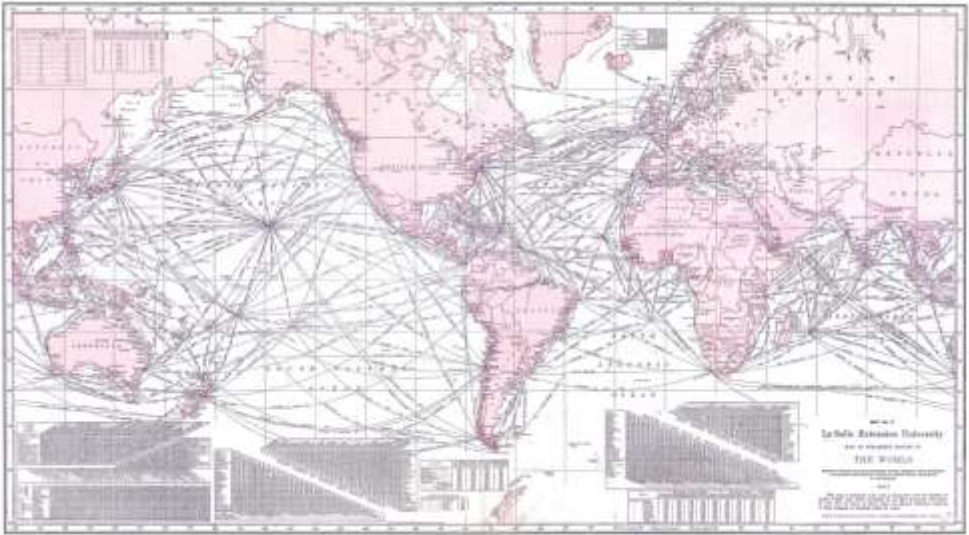
Historical Population Data

- De Vries (1984) provides numbers for European cities 1500-1800
- Spatial quantitative sources including rural areas are missing
- Approximations via alternative information (land use; baptism records; slave trade etc.)



The Temporal Aspects of Maps

L: Rand Mc Nally & Co (1914); r: Max Eckert (1909)



Maps With and Without Projection: Mercator

Peutinger map: based on itineraries (original map 13th century), the Roman road network is “mapped”.

Mercator projection transforms real distances into mapped information.



Additional Sources

All documents on journeys provide information

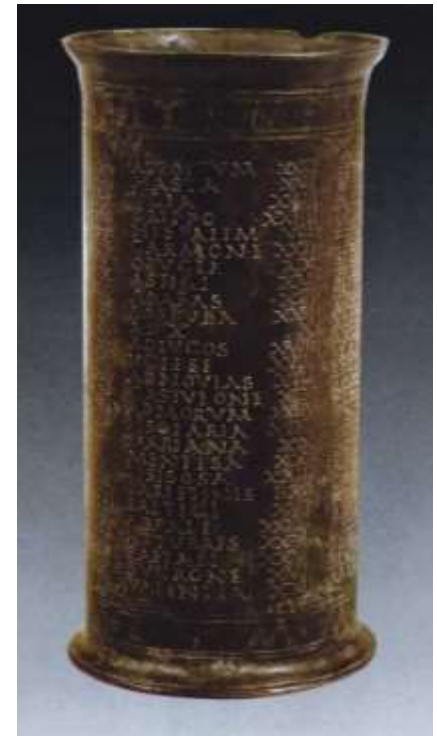
- To cross-check map-based models
- To replace missing or unprojected maps

Pilgrimage itineraries

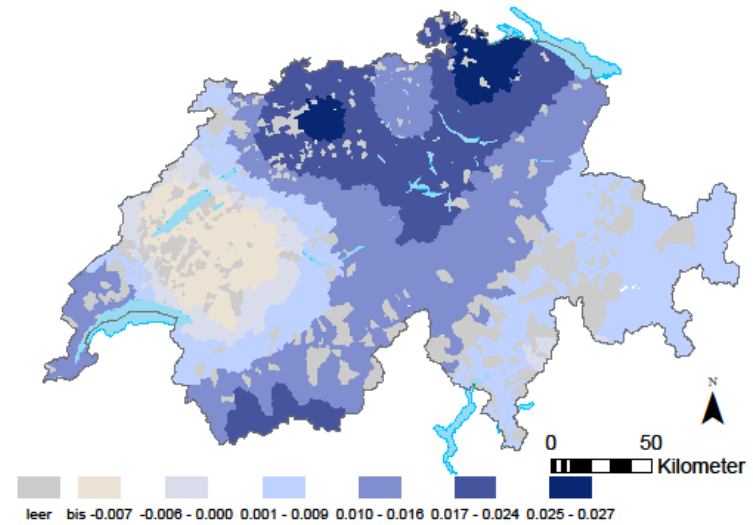
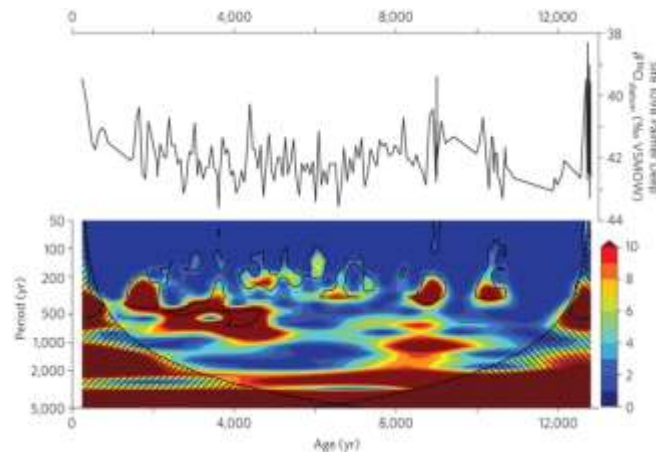
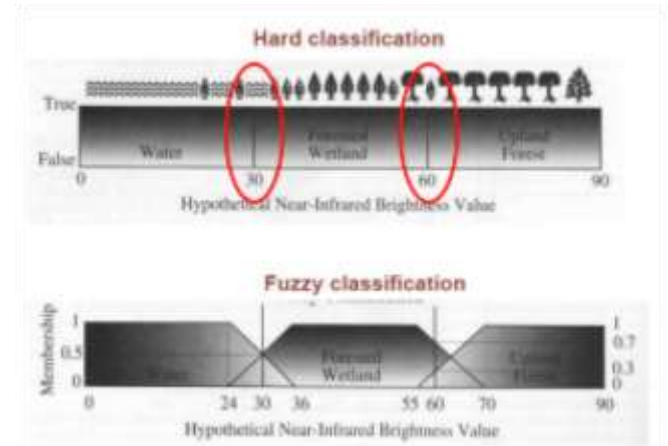
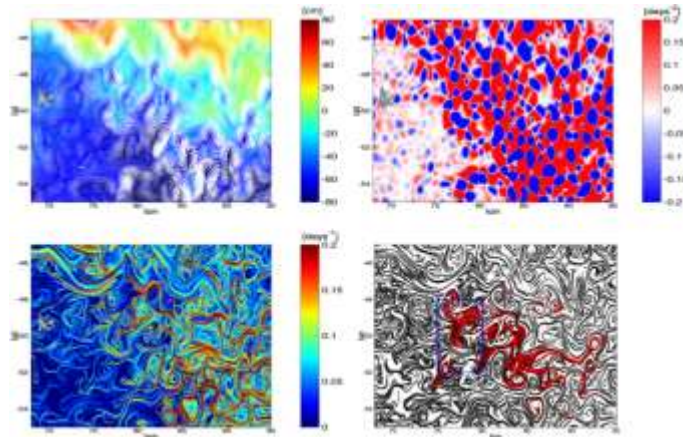
Documentation on messengers

Tradesmen journals

Letters and notes of scholars, clergymen, artists



From an accessibility landscape to impact models



Synthesis

Outlook

Bringing together bits and parts of historical transport networks

Estimating global models transport -> state evolvement

Estimating agglomeration economies et al. for certain regions

European integration

Separatism & nationalism

Investment in future transport systems

Urban sprawl vs. compact productive cities

Networks follow networks

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