Preferred citation style

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Engineering growing networks: Some ideas

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- Boris Jäggi
- Alejandro Marmolejo
- Basil Vitins
- Claude Weis

Engineering is

=		Analysis
	+	Design
	+	Optimisation
	+	Talk to convince
	+	Implementation
	+	Operation

Engineering is

= Analysis

e.g. **Understanding traffic growth**

\+ Design

e.g. **Developing better guidelines**

\+ Optimisation

e.g. **Making better informed choices**

\+ Talk to convince

\+ Implementation

\+ Operation

A brief detour: IVT

A brief detour: IVT about 45 researchers

Travel and spatial behaviour
Demand modelling,
Cost-benefit analysis

Public transport

Network design
Supply planning

Production planning
Infrastructure operations

Operations/Safety

Individual transport

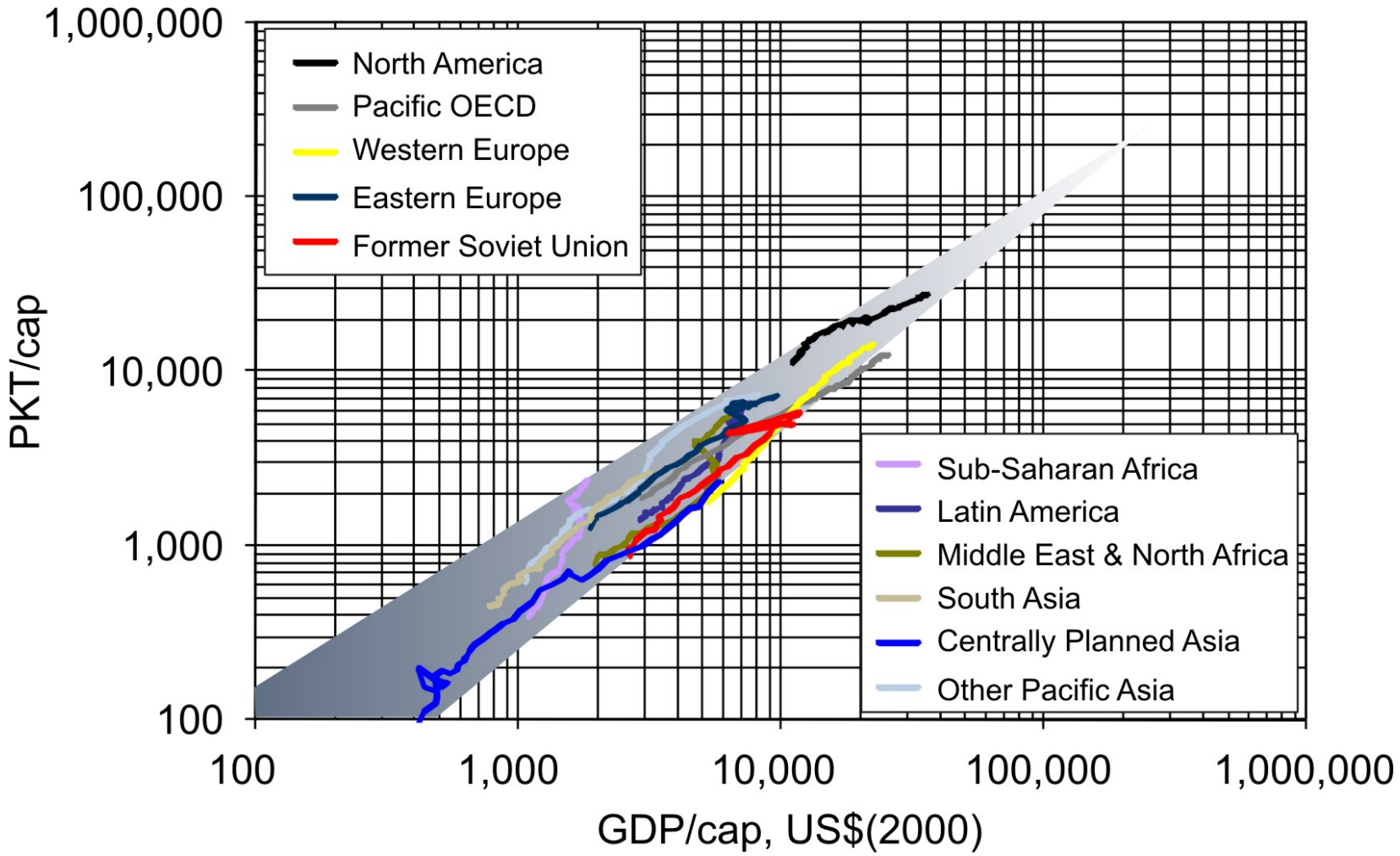
Network design
Infrastructure operations

Traffic engineering
Traffic safety

Physical design, project management, **maintenenace**

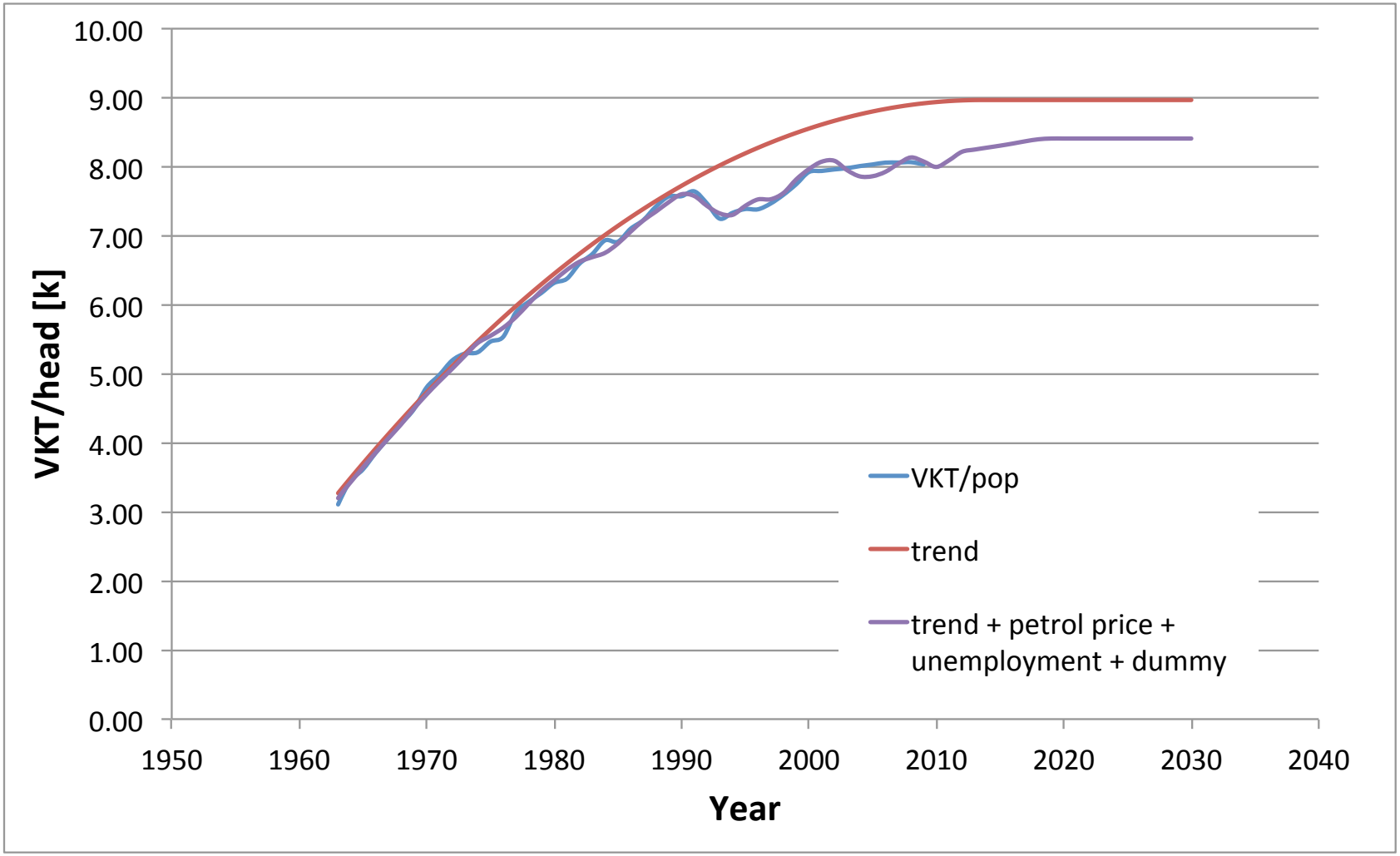
Understanding traffic growth

Travel demand: km/Head (1950 – 2005)



Quelle: Schäfer, Jacoby, Heywood und Waitz (2009) S. 479

CH: Drivers of traffic growth: BITRE, Report 128



Drivers of traffic growth

VKT = AVKT/Capita * Pop

= AVKT/Car * Cars/Capita * Pop

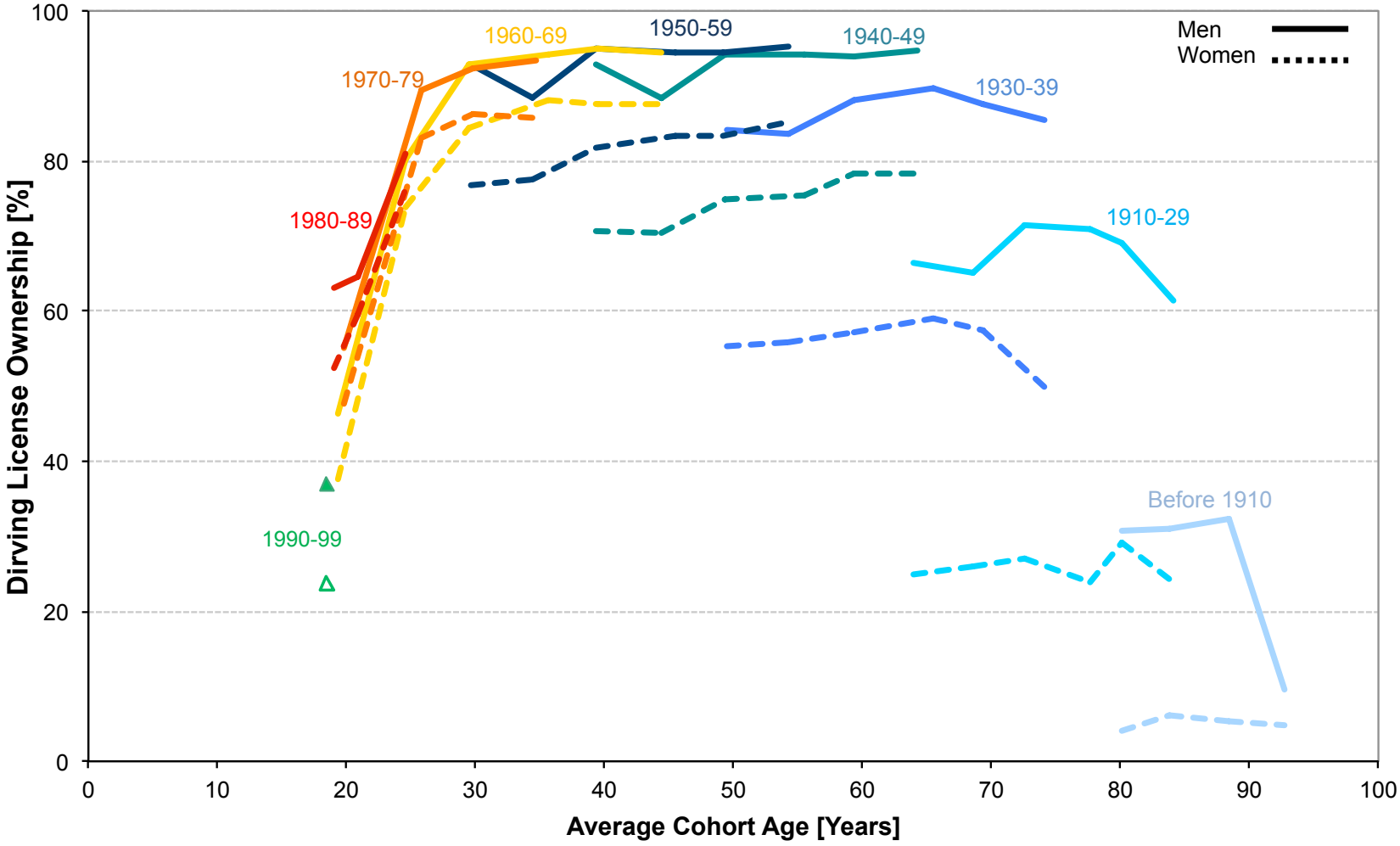
= AVKT/Car * Cars/Lic * Lic/Capita * Pop

= 365 * Act/Day * Trip/Act * KT/Act * Car%
* Cars/Lic * Lic/Capita * Pop

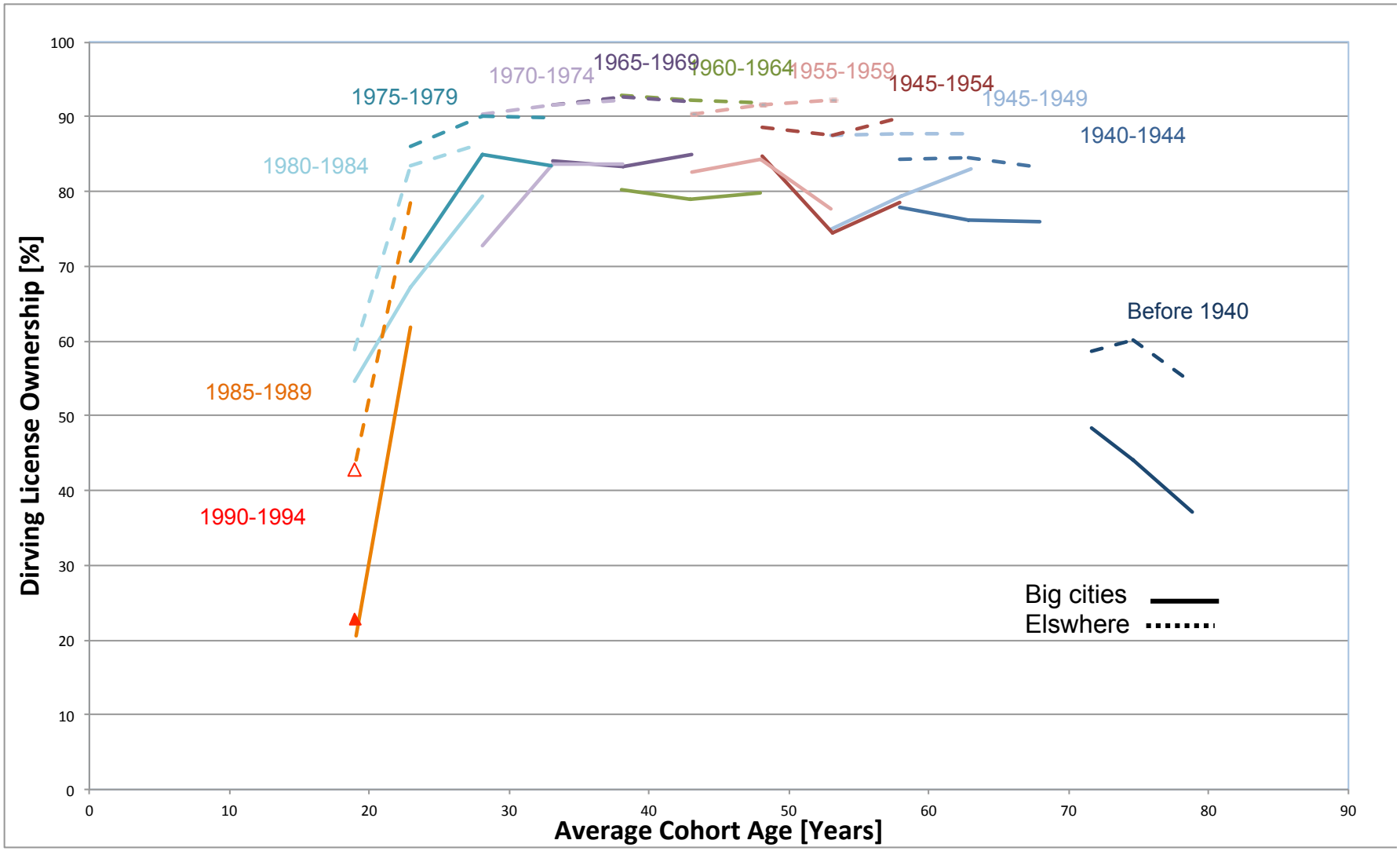
= 365 * Act(X)/Day *Trip/Act * KT(Car, X, I) * Car%(Car, X, I)
* Cars(X) / Lic * Lic(X, I) / Capita * Pop(I, Y)

Driving licences

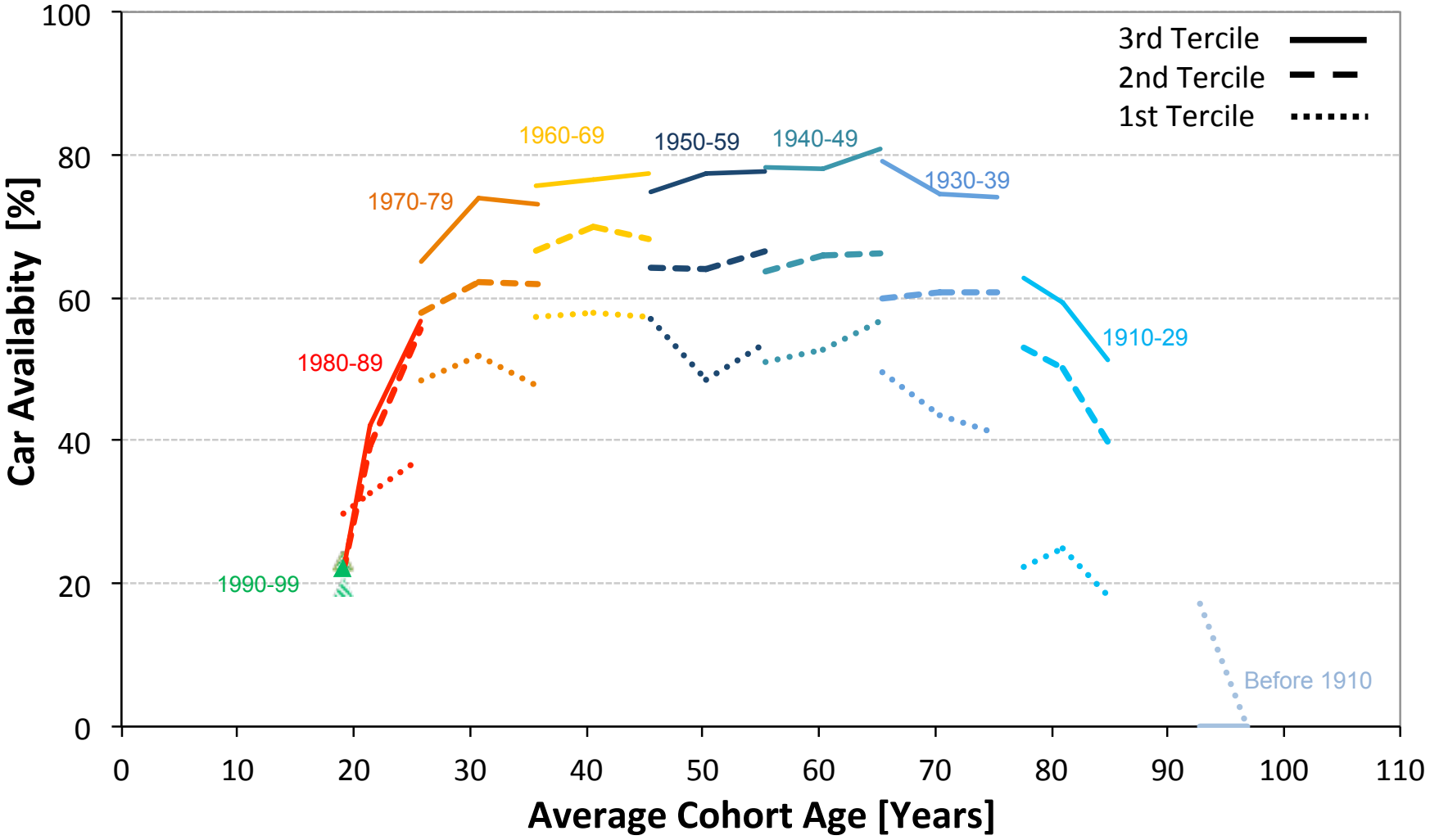
CH: Driving licence holding by gender



CH: Driving licence holding by location (5 year cohorts)

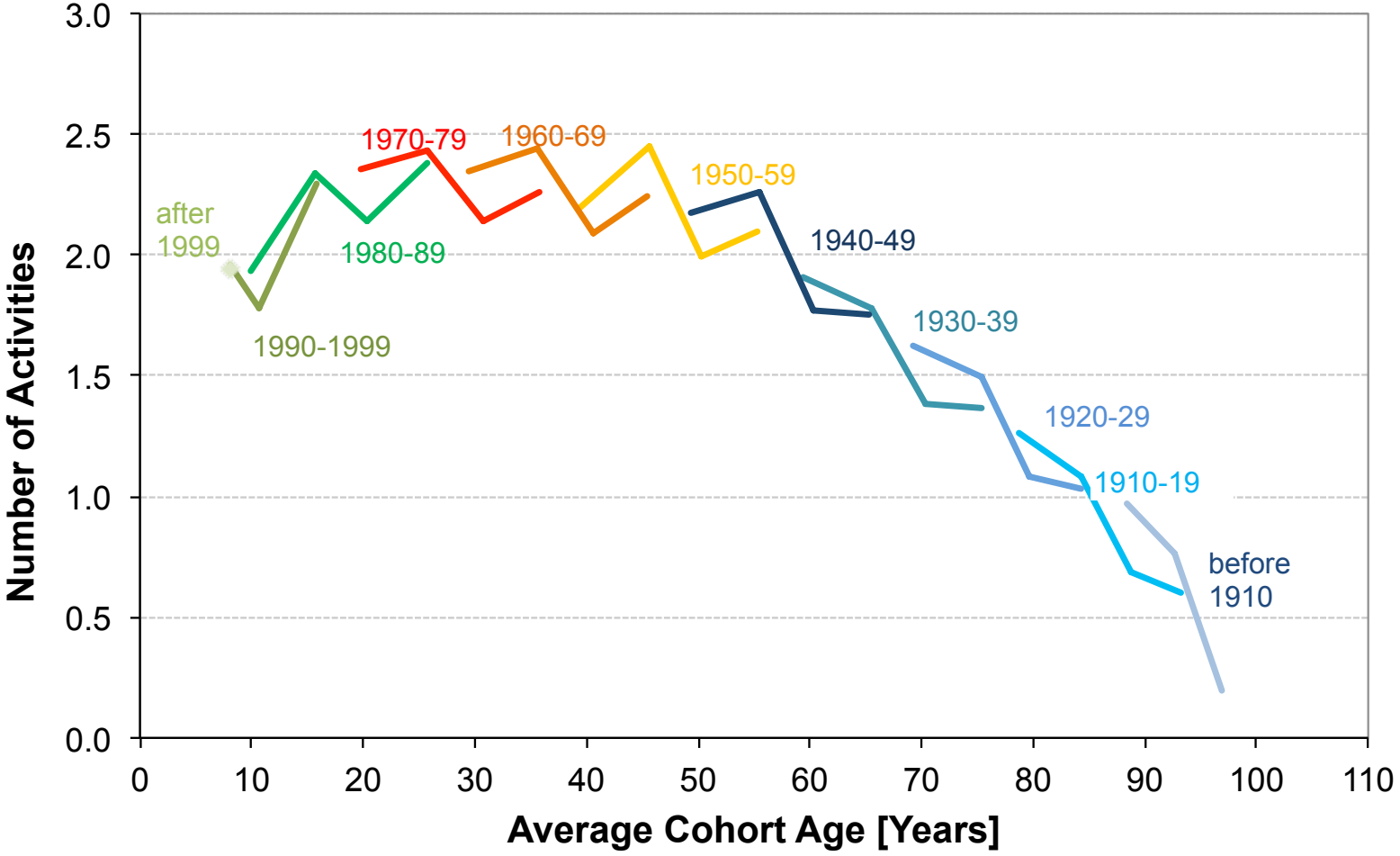


CH: Car always available by income tercile

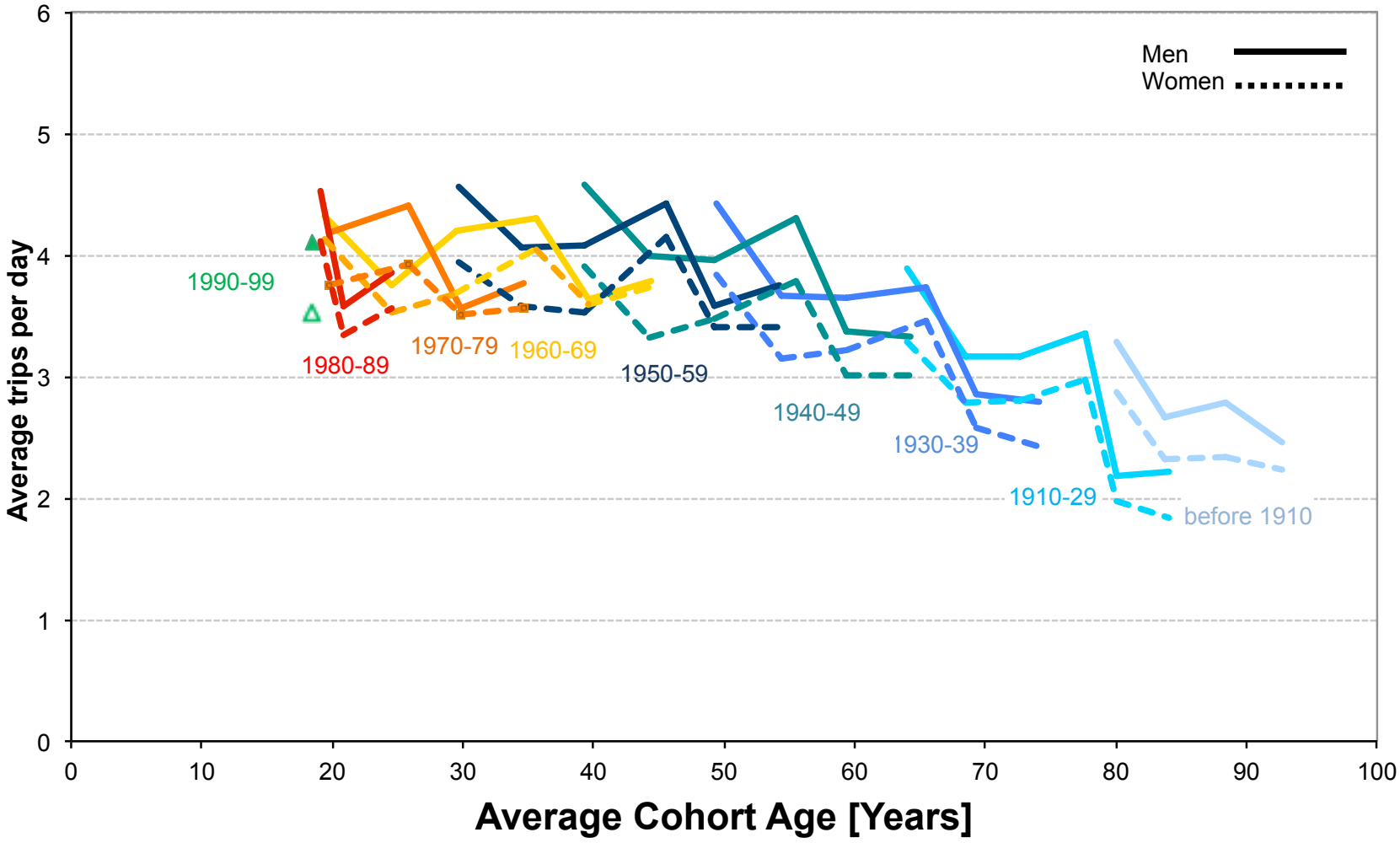


Daily number of activities

CH: Number of activities: All purposes

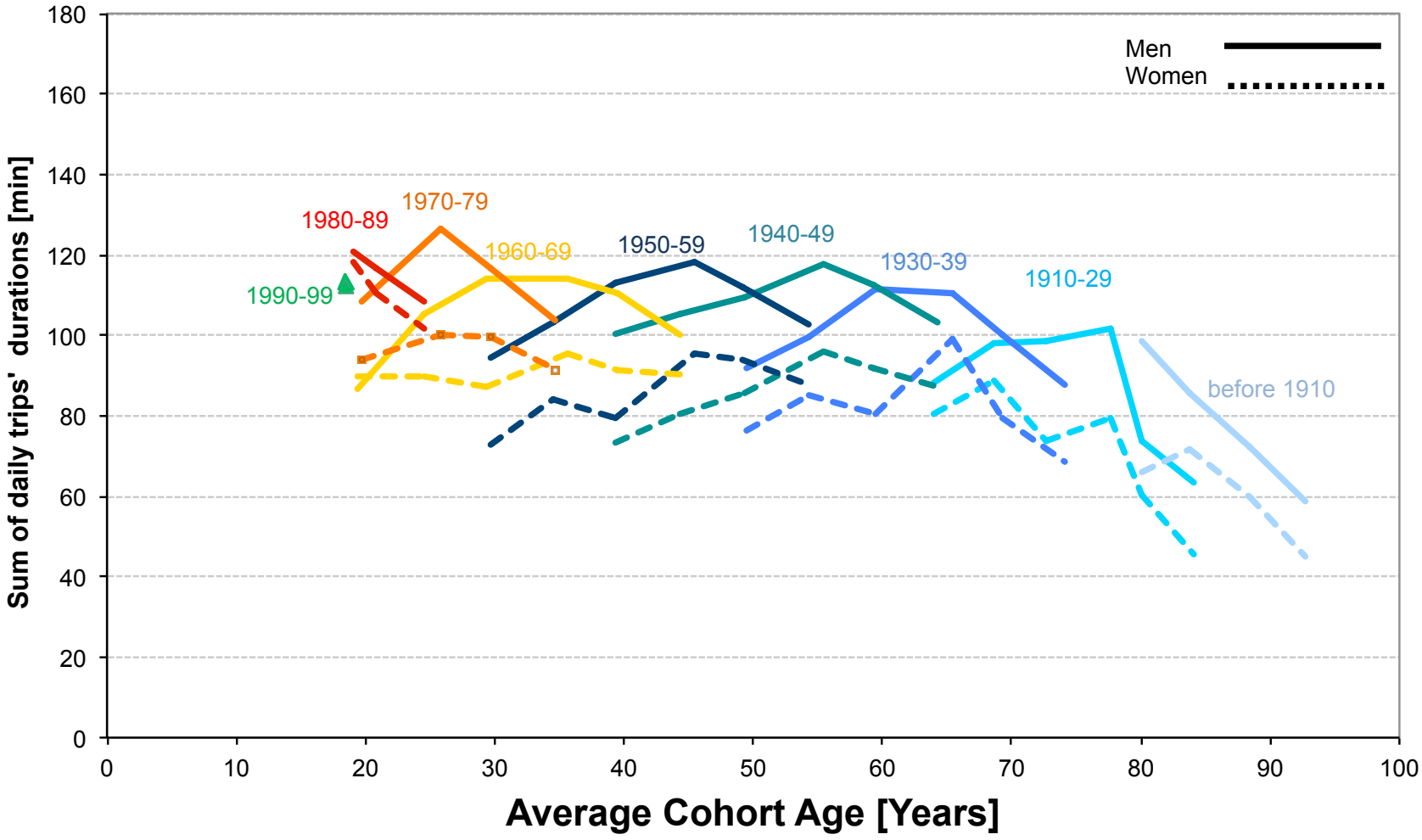


CH: Daily number of trips

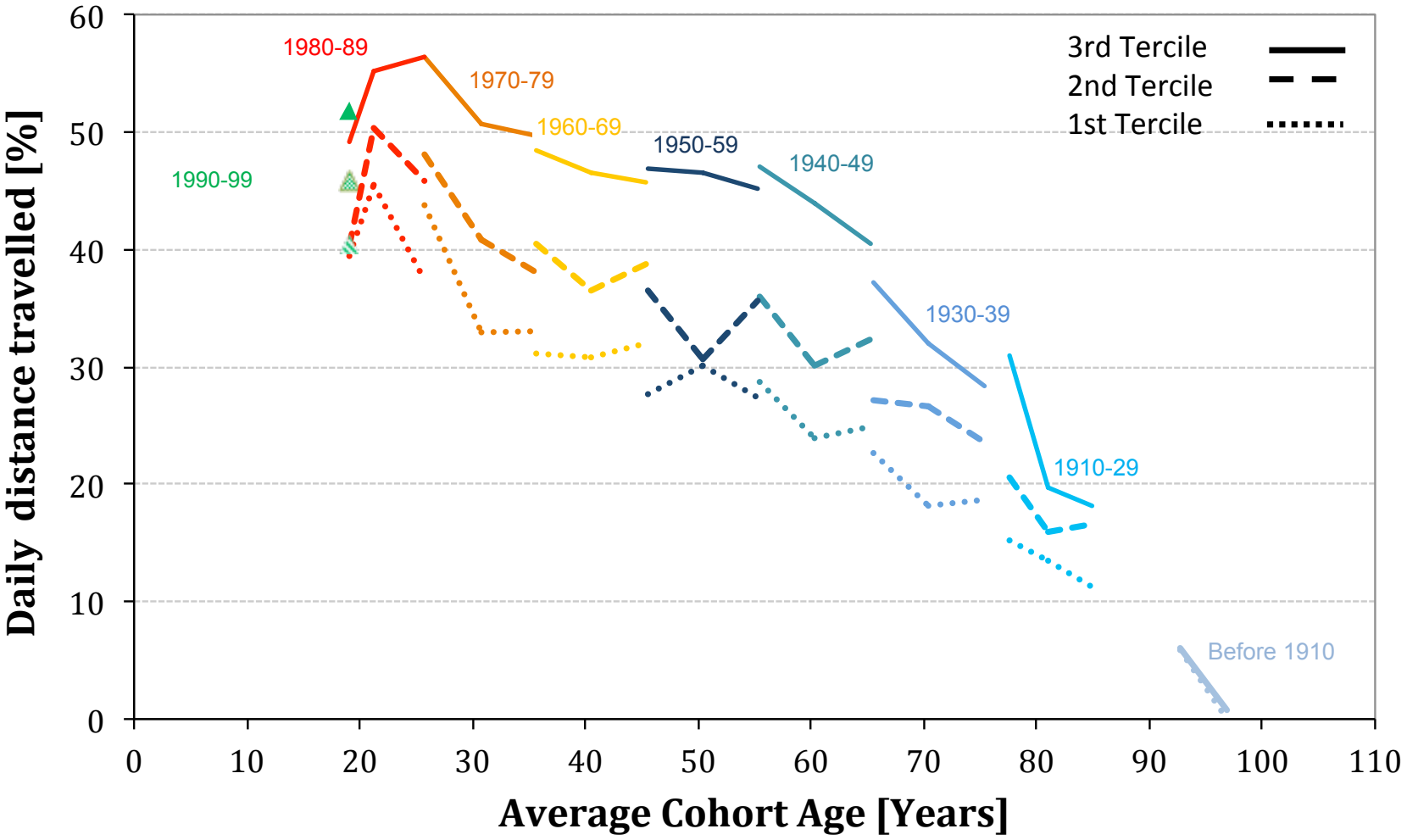


Durations and distances travelled

CH: Daily duration travelled

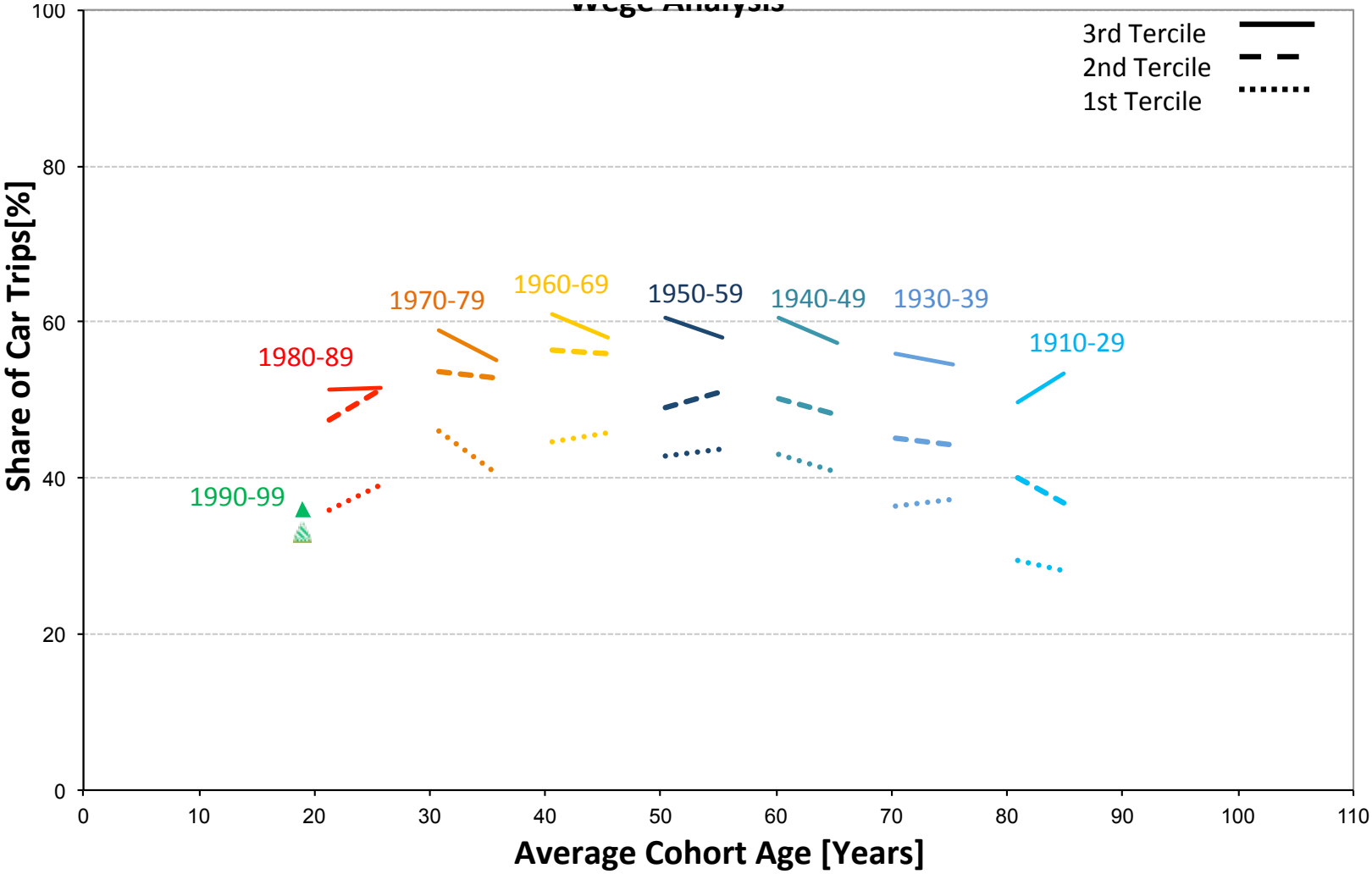


CH: Daily distance travelled (10 year cohorts)

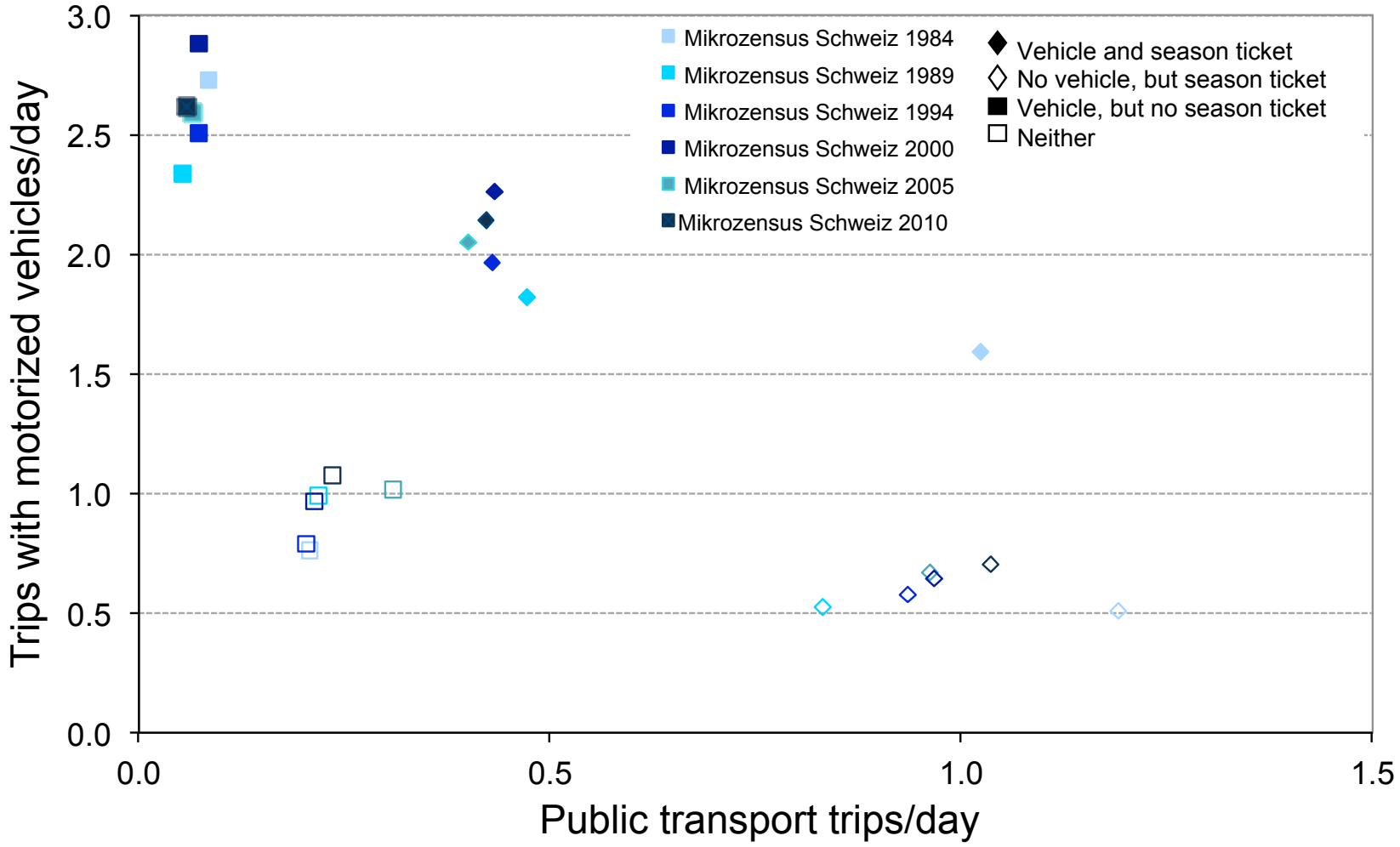


Mode share

CH: Trip main mode share: Car

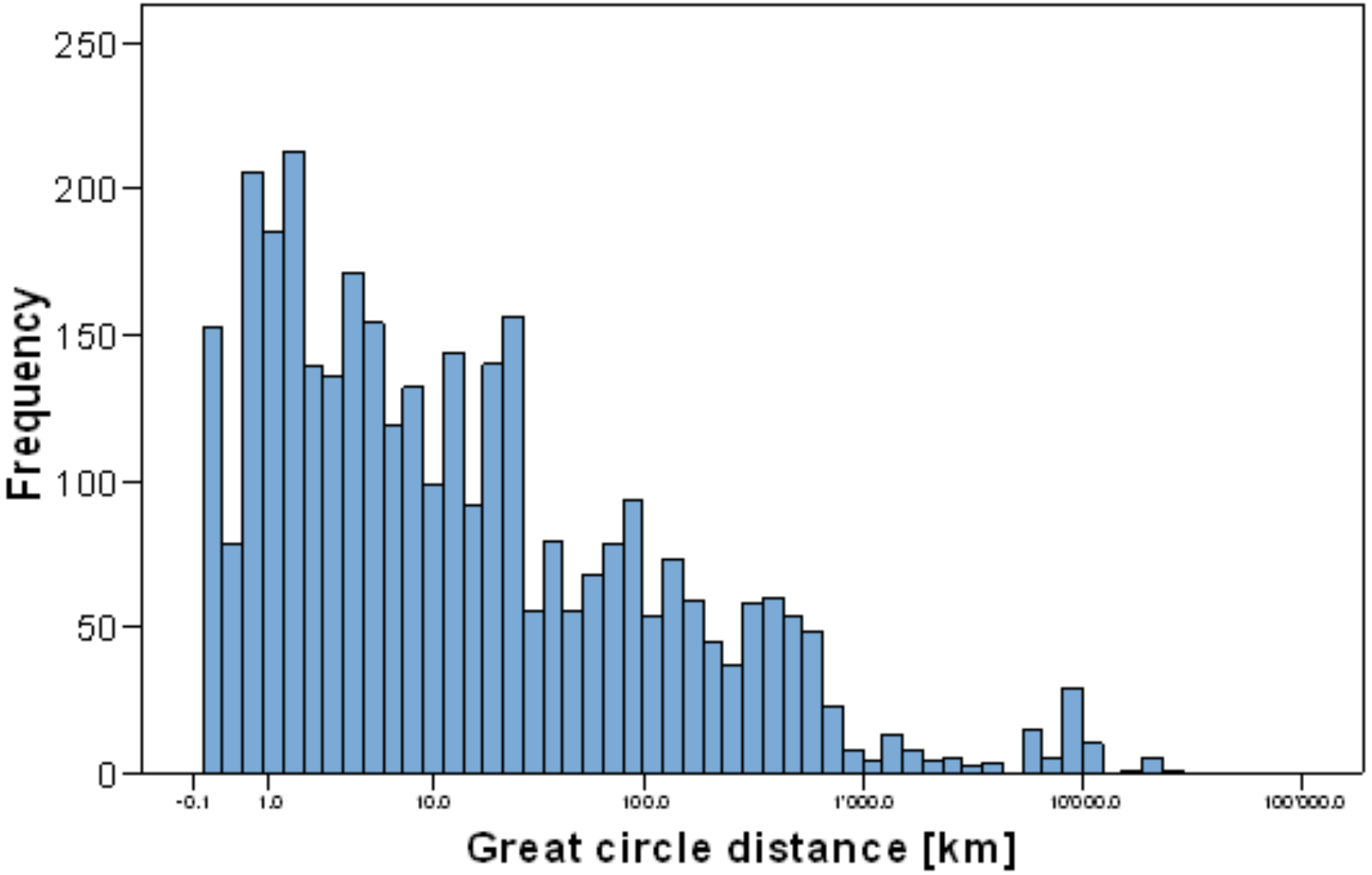


CH: Daily number of car and public transport trips



But look at long distance travel

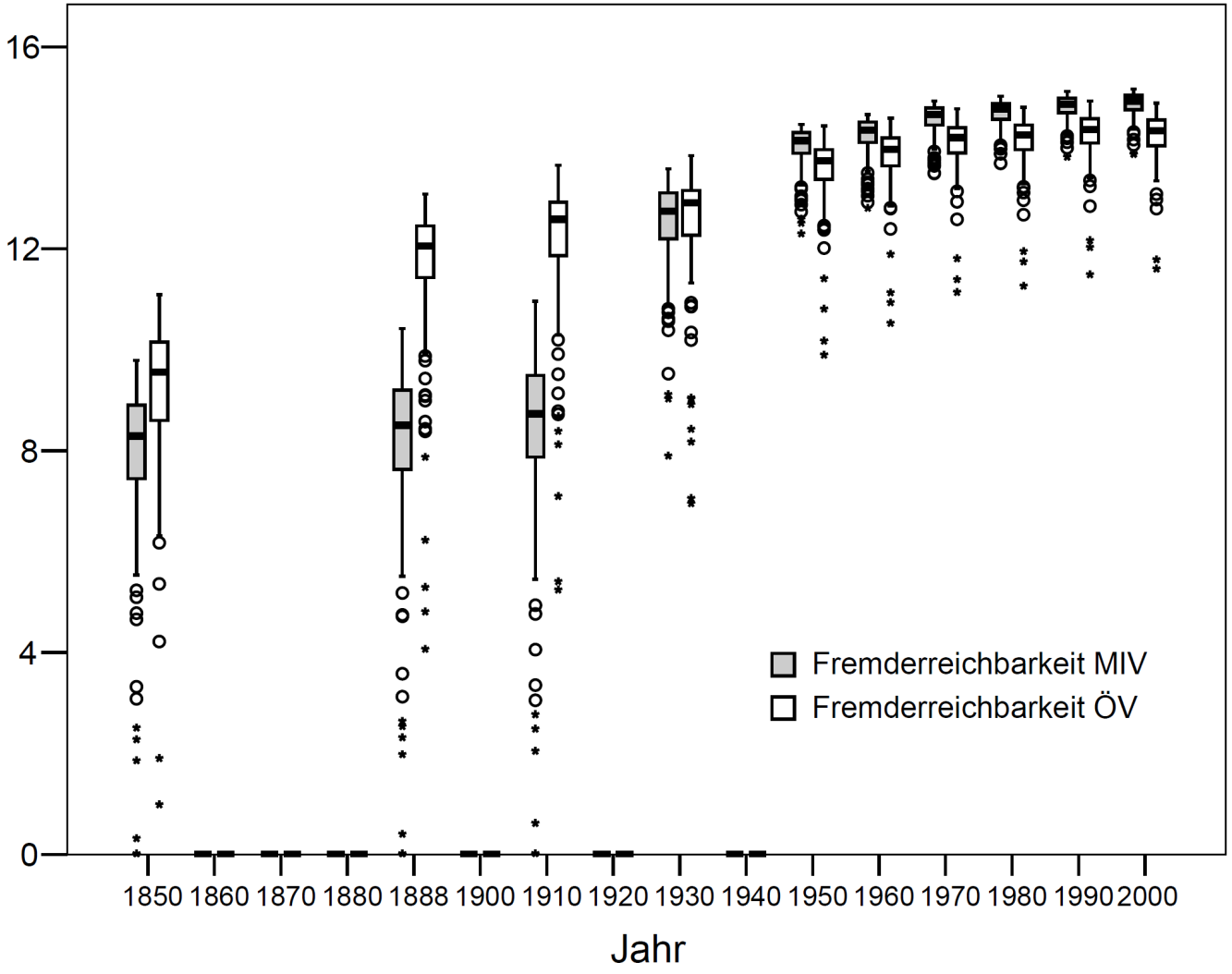
Distances between home locations of friends



Frei and Axhausen, 2007

Accessibility and induced demand

Stable (ln) accessibilities, e.g. Switzerland 1850 – 2000



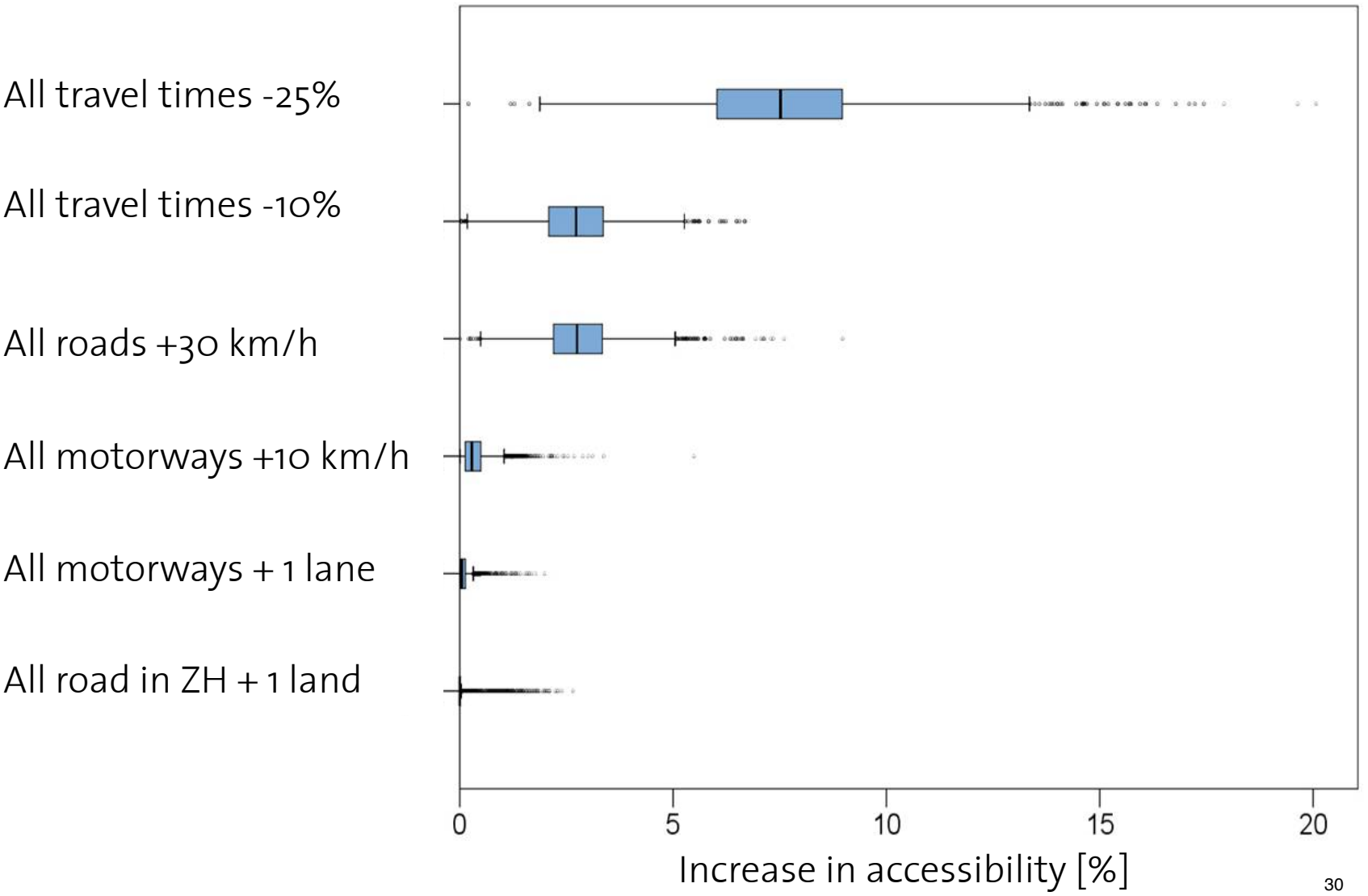
Source: Axhausen, Fröhlich and Tschopp (2006) S.10

Mean elasticities (1970-2000) with respect to

Accessibility	Share out-of-home	0.61
	Number of trips	0.44
	Number of trips per journey	0.24
	Time out-of-home	0.10
	Distance travelled	1.14
Price index for travel	Share out-of-home	-0.06
	Number of trips	-0.19
	Number of trips per journey	-1.66
	Time out-of-home	-1.95
	Distance travelled	-0.84

Source: Weis and Axhausen (2011)

CH: Municipal accessibility change for



Developing better guidelines

Traditional motorway cross-section design

Desired LOS >

Expected LOS = Function of

Chosen cross-section
Expected flow in an arbitrarily chosen n^{th} hours of an assumed annual flow profile

Developing better guidelines, e.g. Switzerland

Guideline	Considers			
	Long term dynamics	Short term flow variance	Short term fapacity variance	Generalised costs
Crosssection	No	No	No	No
Signals	Yes, hour	Yes	No	IVT only
Round abouts	No	No	Yes	IVT only
Intersection w/o signals	No	No	Yes	IVT only
CBA	(Yes)	No	No	Yes

Proposal of Bernard and Axhausen (2008)

Generalised costs (travel time, SDE, SDL) [CHF]

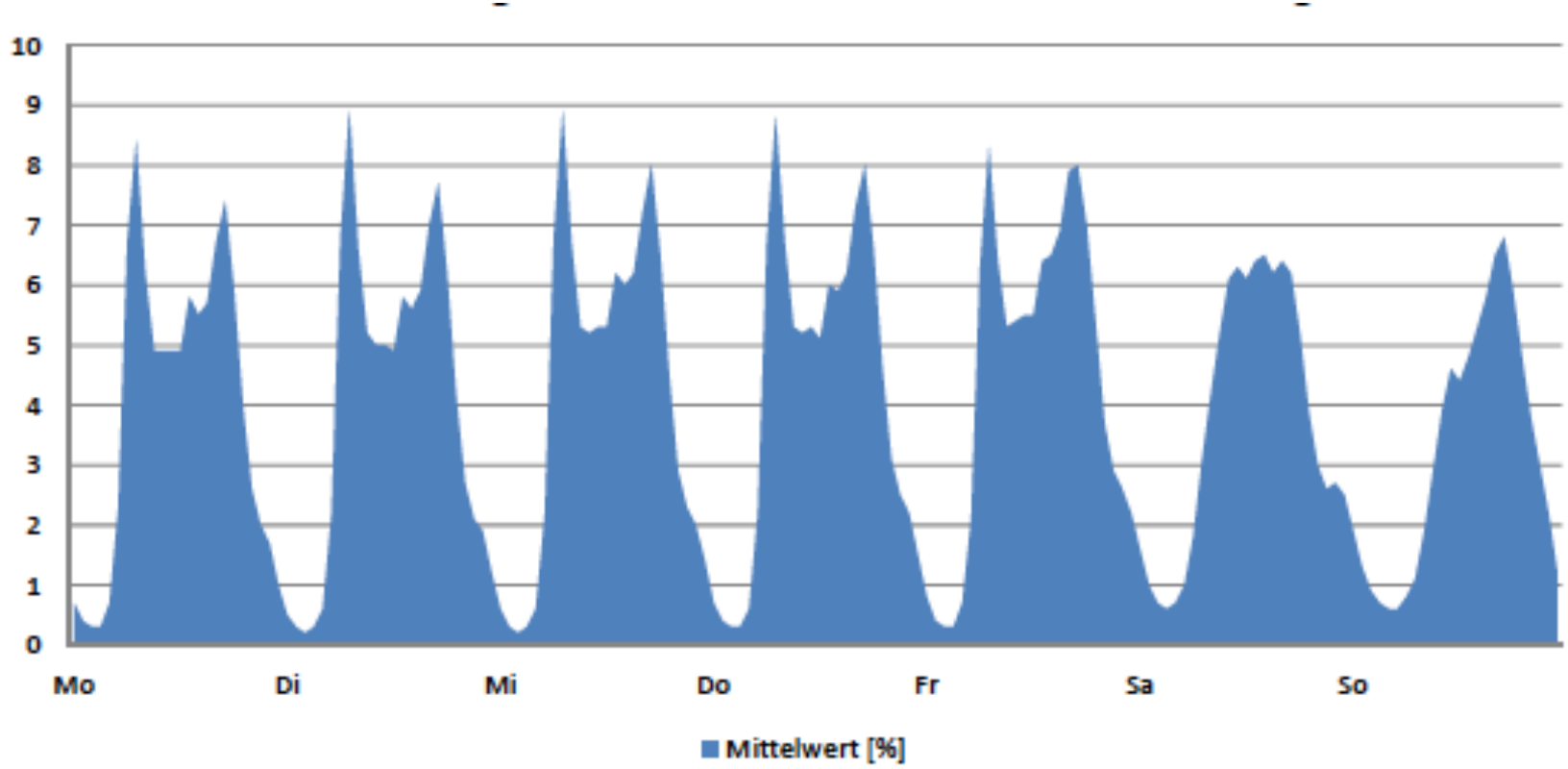
Breakdown costs = Function of

breakdown probability = function of
(5min - variance of flow,
5min variance of capacity)
breakdown depth (speed loss)
breakdown duration (flow)

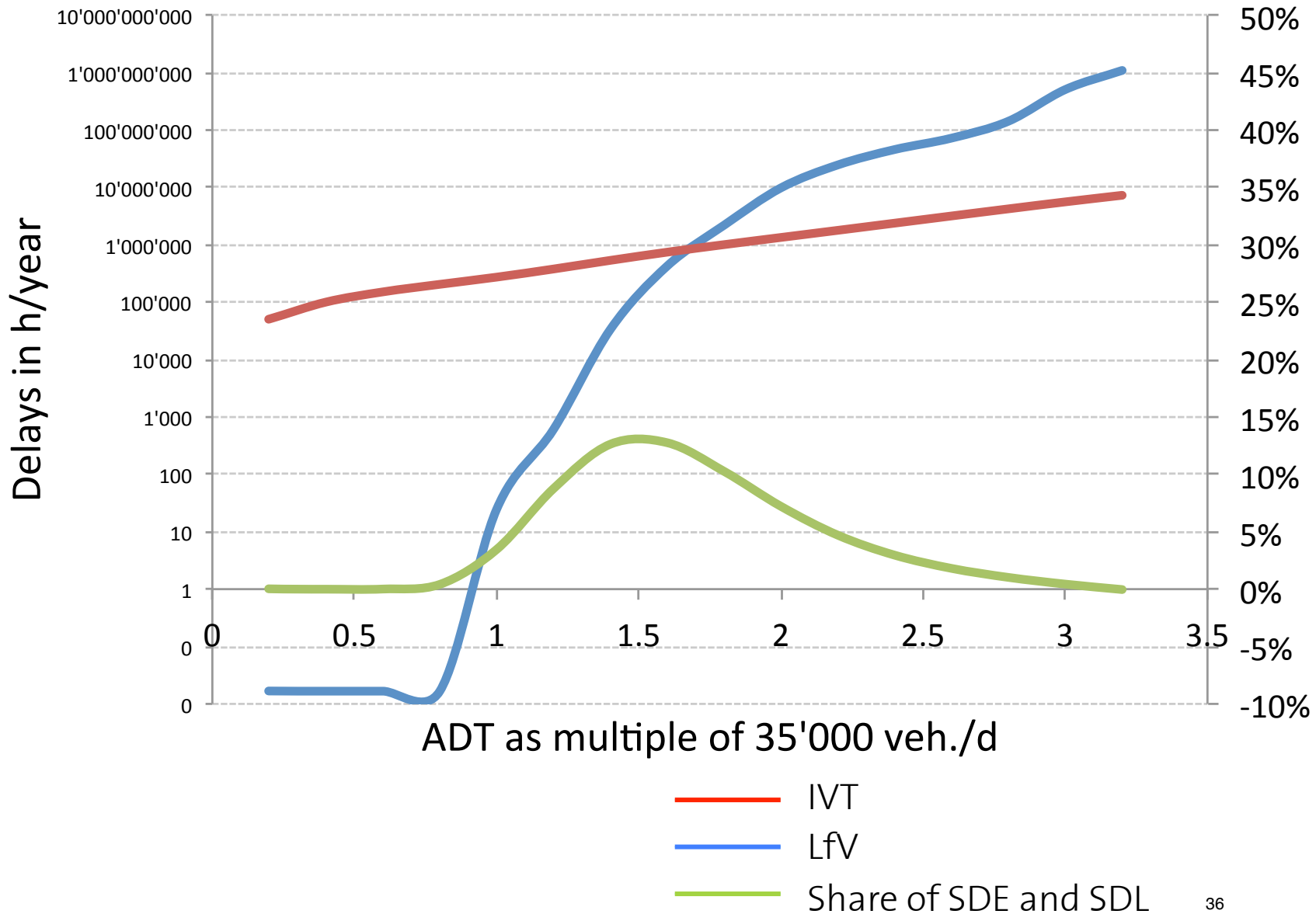
across all hours of an assumed annual flow profile

Bernard, M. and K.W. Axhausen (2008) Grundlagen für eine differenzierte Bemessung von Verkehrsanlagen, final report for SVI 2000/339, Schriftenreihe, 1283, Bundesamt für Strassen, UVEK, Bern.

Weekly demand profile (4, A1) used for the comparison



2 lanes: Comparison with Brilon et al.‘s simulation



In which ways better guidelines ?

Guideline	Considers			
	Long term dynamics	Short term flow variance	Short term capacity variance	Generalised costs
Crosssection	Yes	Yes	Yes	(Yes)
Signals	Yes	Yes	Yes	(Yes)
Round abouts	Yes	Yes	Yes	(Yes)
Intersection w/o signals	Yes	Yes	Yes	(Yes)
CBA	Yes	(Yes)	(Yes)	Yes

Making better informed (design) choices

Words of power

.....

The world will little note nor long remember what we say here but it can never forget what they did here. It is for us the living rather to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us, that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion, that we here highly resolve that these dead shall not have died in vain, that this nation under god shall have a new birth of freedom and that government of the people by the people for the people shall not perish from the earth.

Words of power

.....

The world will little note nor long remember what we say here but it can never forget what they did here. It is for us the living rather to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us, that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion, that we here highly resolve that these dead shall not have died in vain, that this nation under god shall have a new birth of freedom and that **government of the people by the people for the people** shall not perish from the earth

Words of power

We hold these truths to be self-evident...

...government of the people by the people for the people shall not perish from the earth.

Liberte, fraternite, equalite

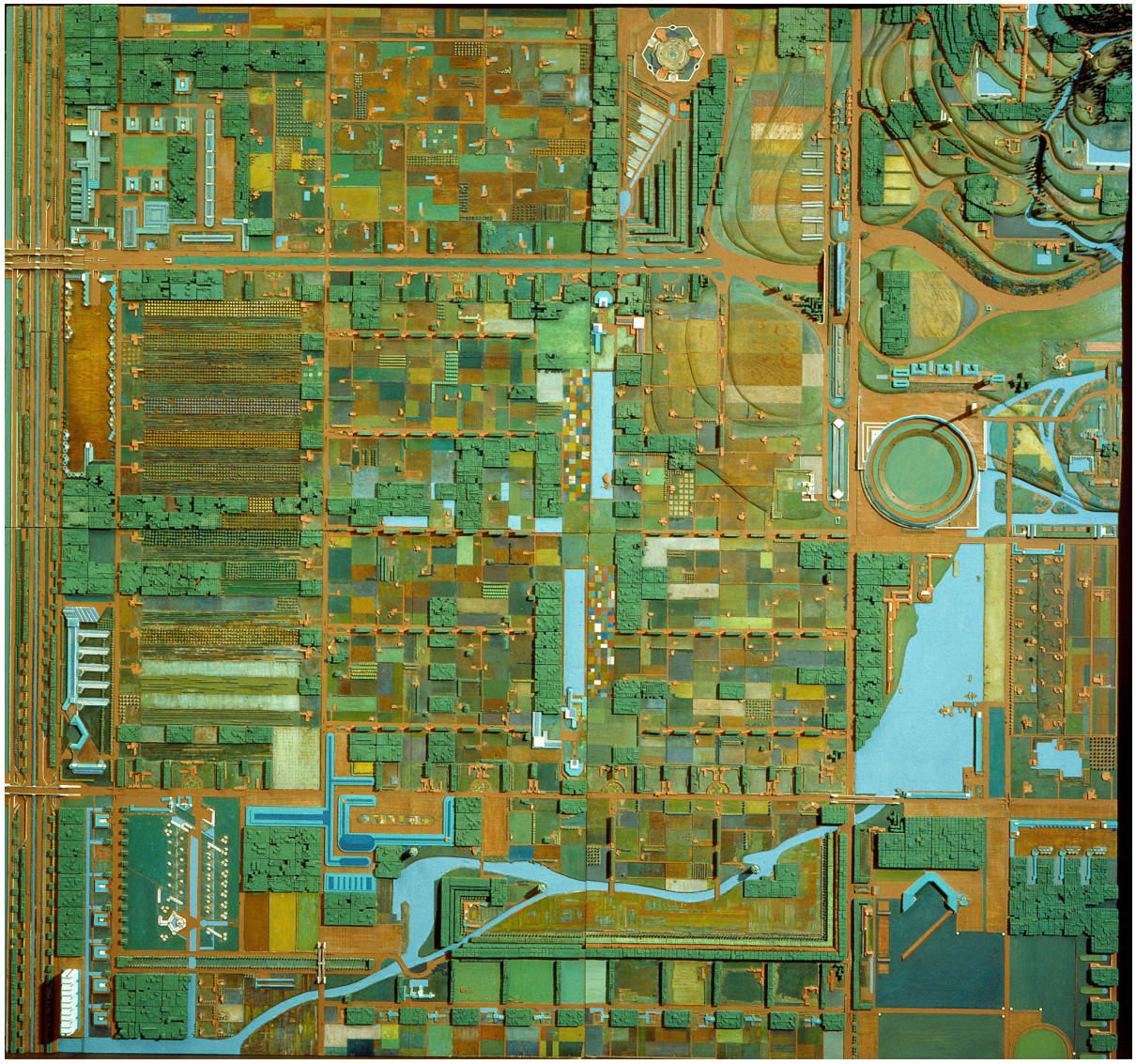
Allons enfants de la patrie ...

Die Würde des Menschen ist unantastbar.

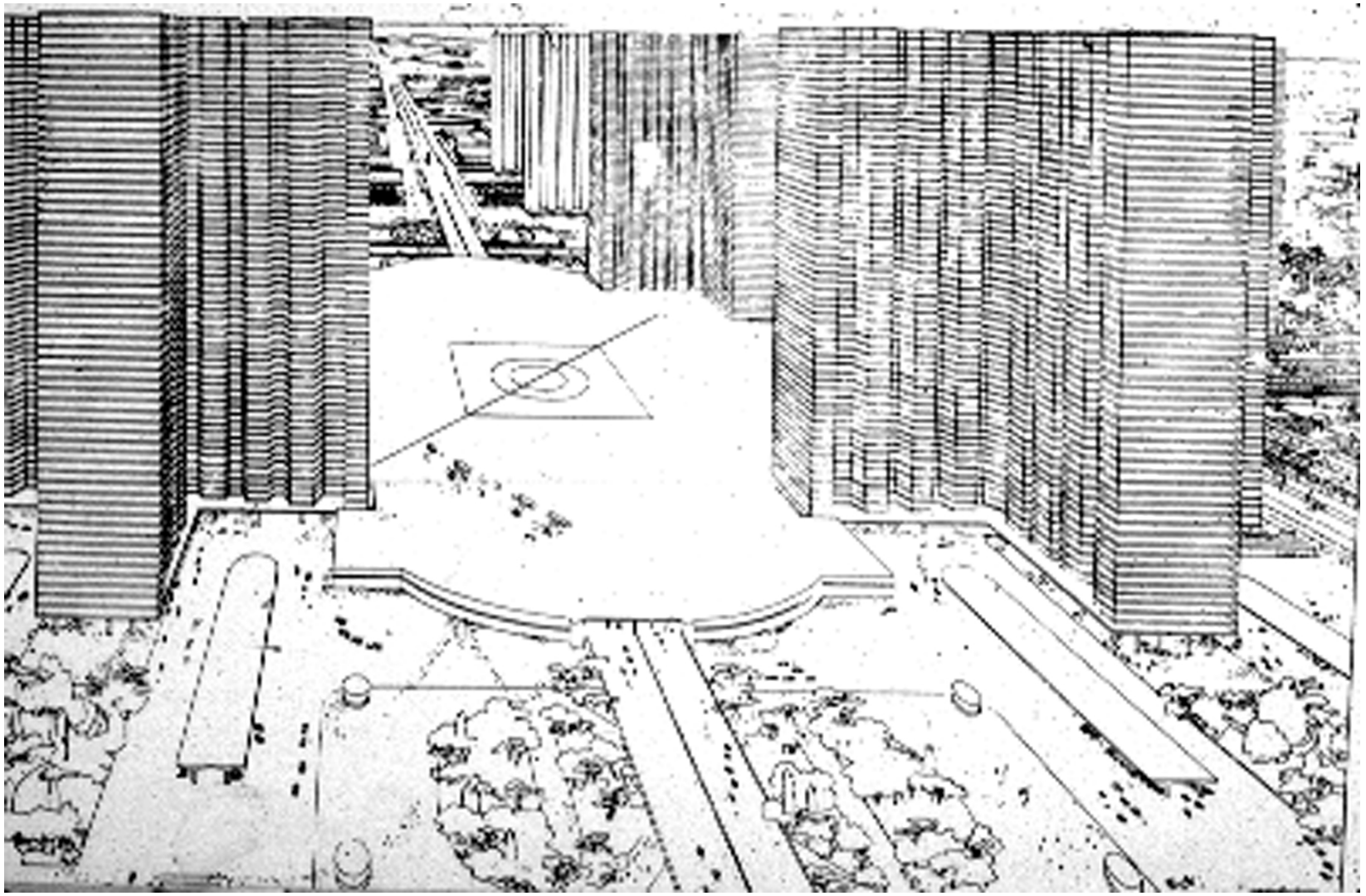
Völker hört die Signale, auf zum letzten Gefecht ...

Images of power

Images of power: Llyod Wright‘s Broad acre city



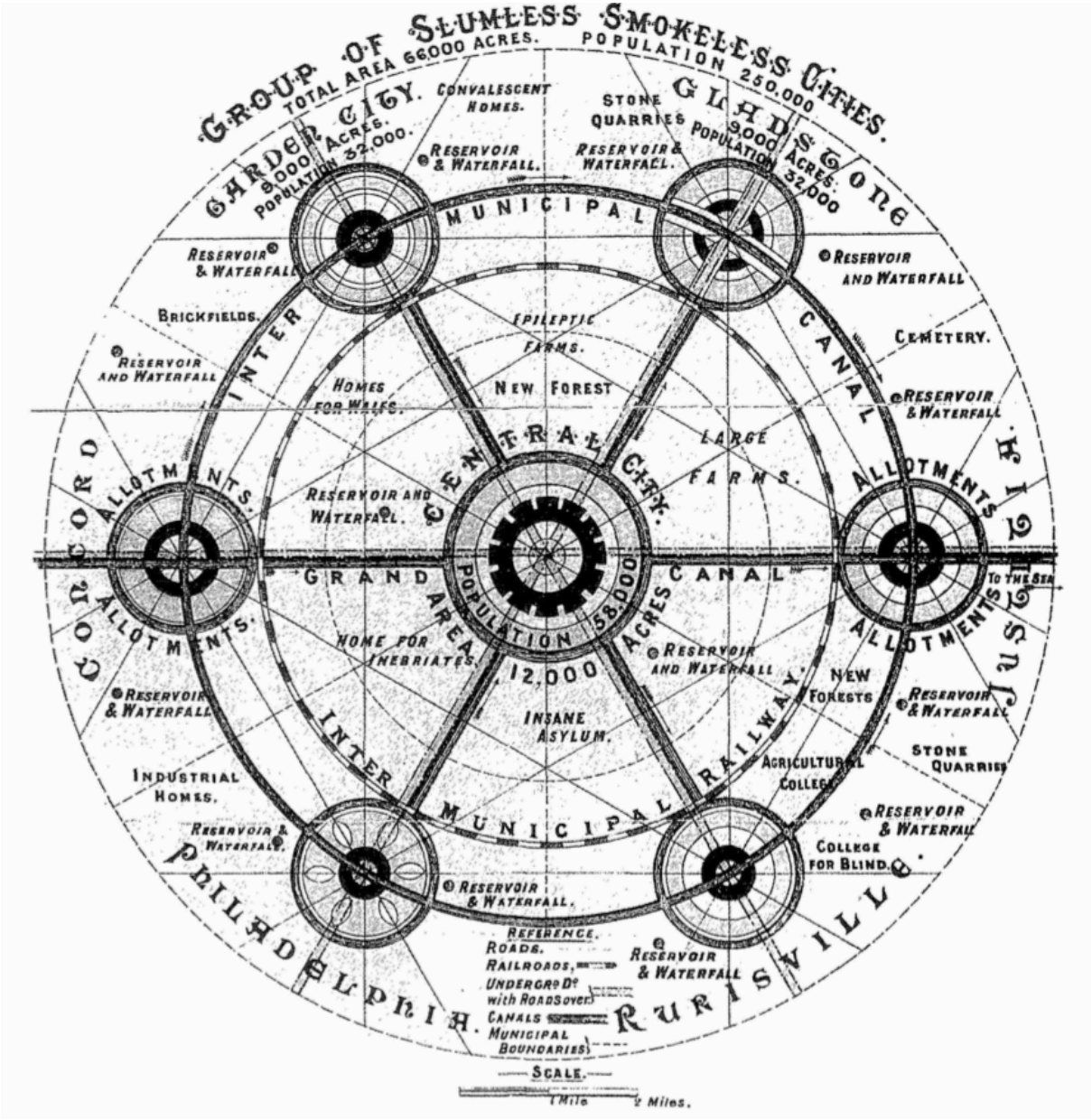
Images of power: Le Corbusier‘s city of the future



Images of power: Friedrich's Greifswald, 1821

home.t-online.de/home/k-j.lebus/cdf-hgw.htm

Images of power: Howard's garden city, 1899



Are our (incremental) guidelines any better ?

How to demonstrate the quality of our guidelines ?

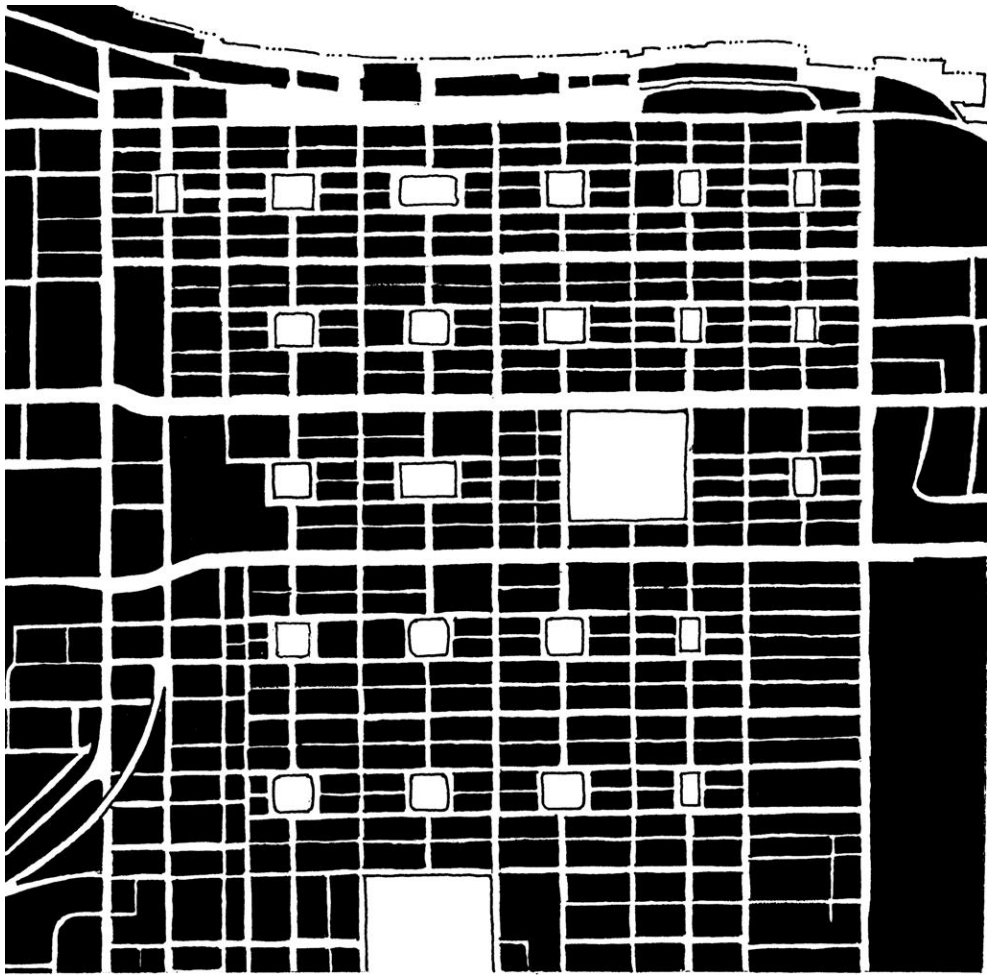
Incremental decisions:

- Short run social benefits larger then their full costs
- Consistency with urban and social vision

Cumulative effect:

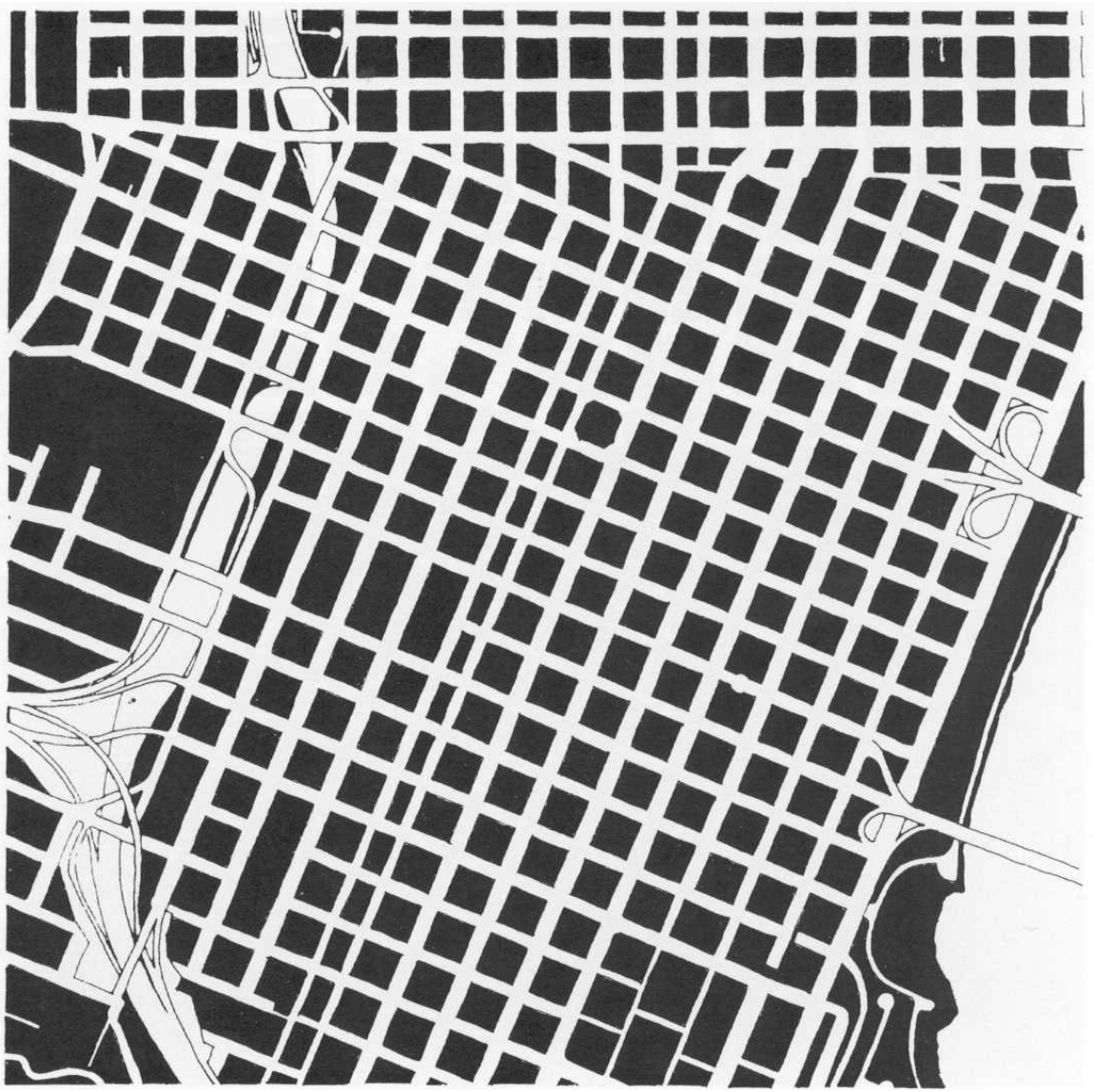
- Consistency with self-image
- Minimize longer term costs

Example grammars: Savannah



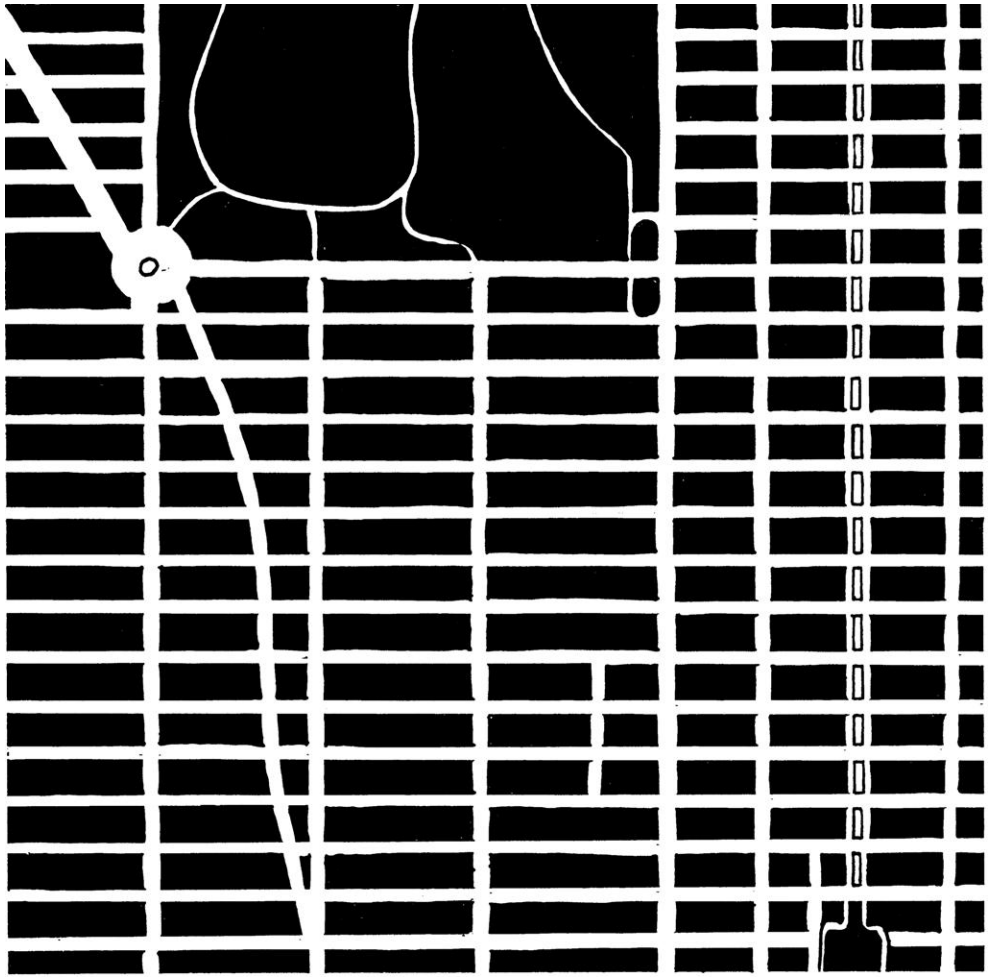
Quelle: Jacobs (1993) S.244

Example grammars: Paris



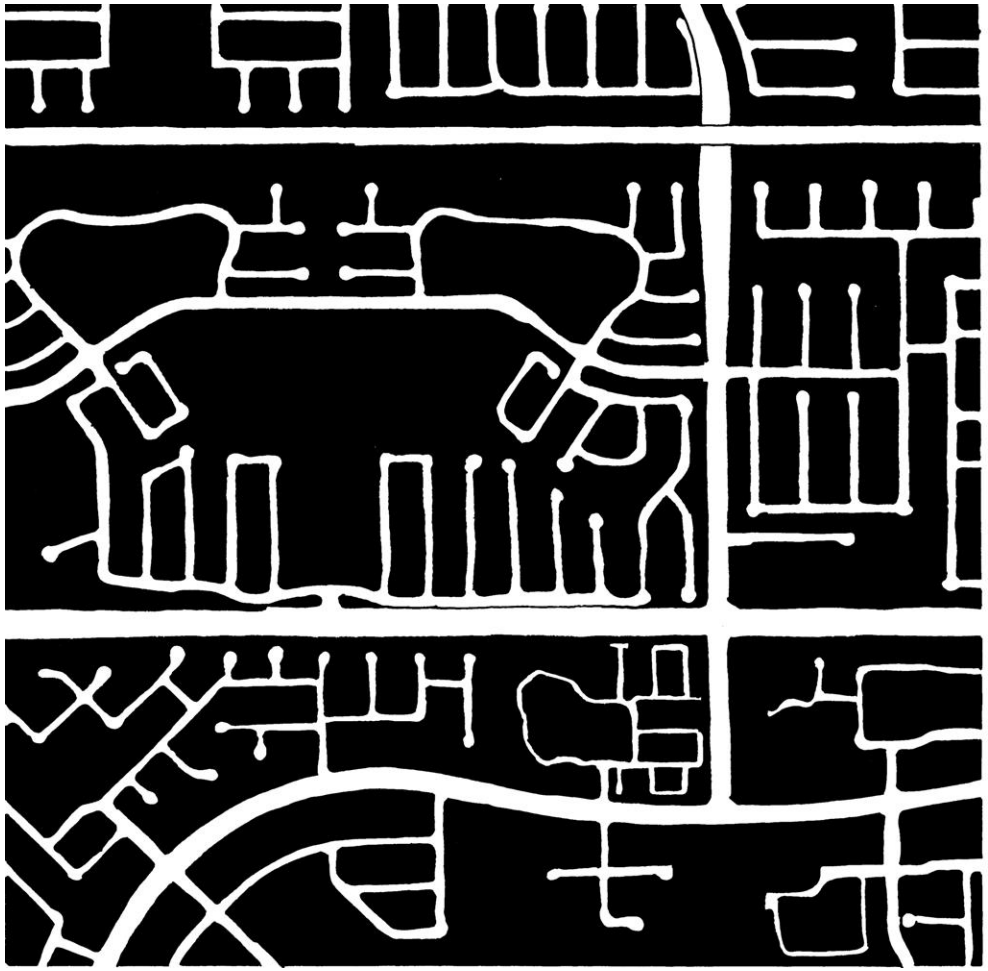
Quelle: Jacobs (1993) S.234

Example grammars: Manhattan



Quelle: Jacobs (1993) S.232

Example grammars: Irvine



Quelle: Jacobs (1993) S.222

Testing design grammars using optimisation

Testing design grammars using optimisation

Define grammars

Test grammar

Vary grammar parameters

Generate optimal networks on the featureless plain

Evaluate

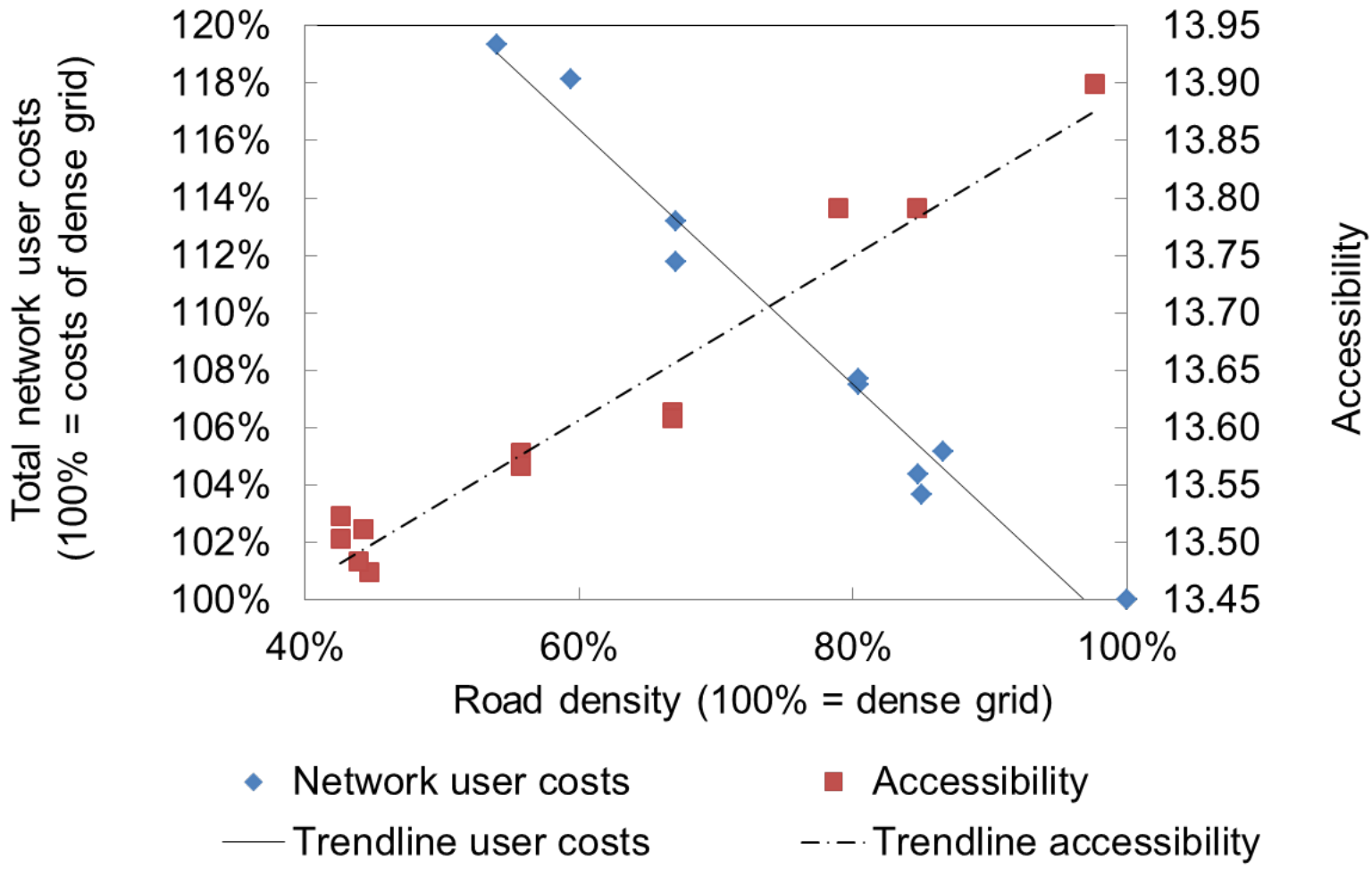
Select grammar

Testing hierarchies

	Average score	Difference
No hierarchical shape grammar	-126'843	-
Hierarchical shape grammar, fixed type share	-135'242	+6.6%
Hierarchical shape grammar, optimized type share	-135'044	+6.5%

Source: Vitins, Schüssler and Axhausen (2011), Vitins and Axhausen (2013)

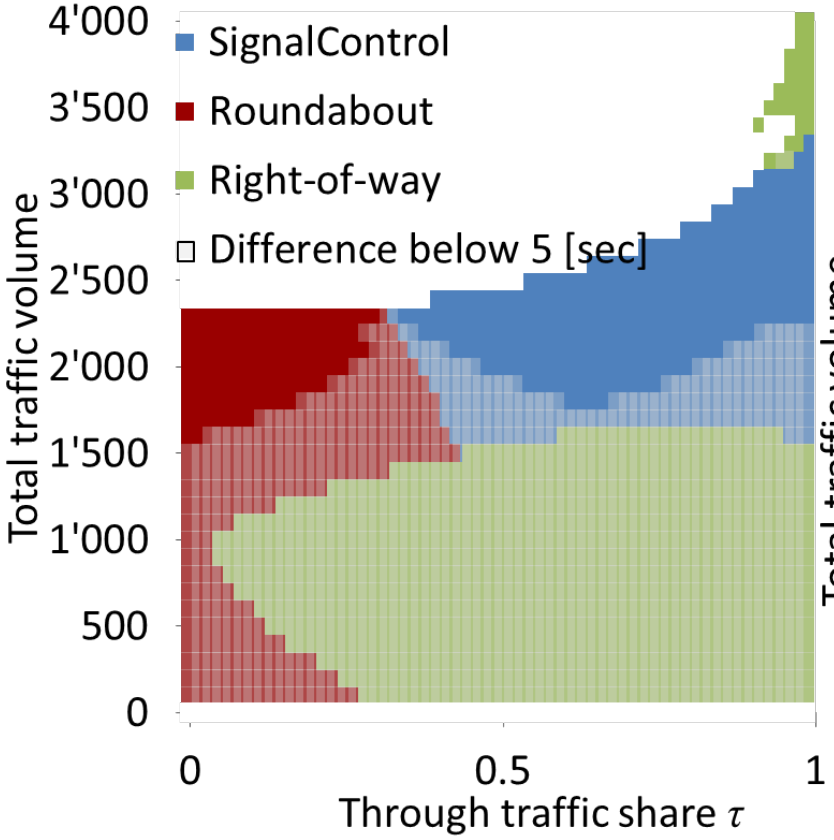
User Costs and Accessibility



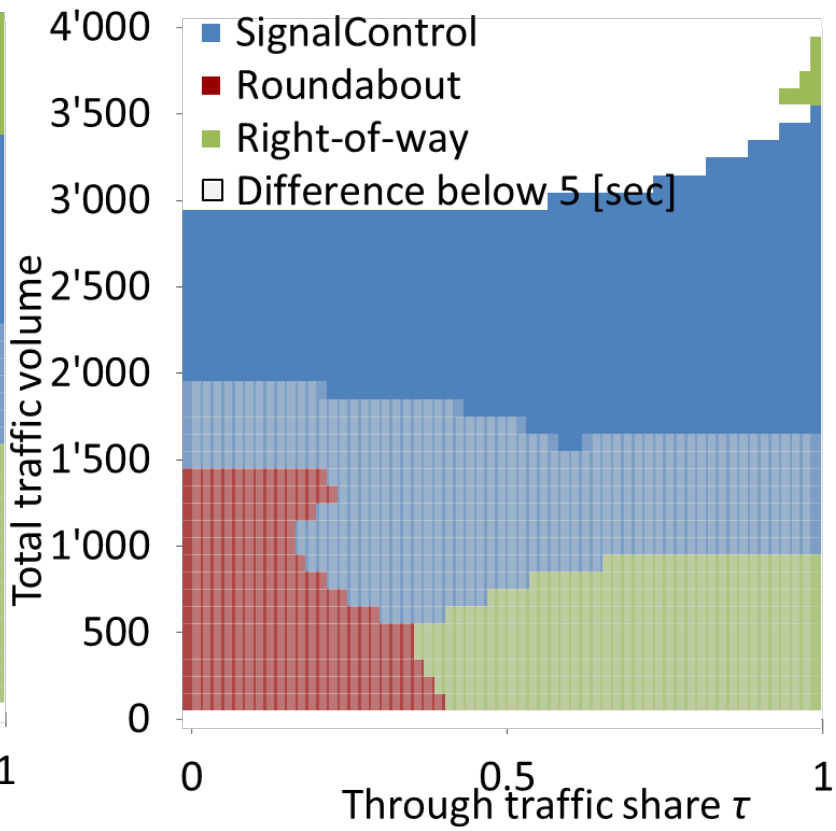
Source: Vitins, Garcia-Dorado, Vanegas, Aliaga and Axhausen (2013)

Intersection types with the lowest total turn delays

3 arm intersections

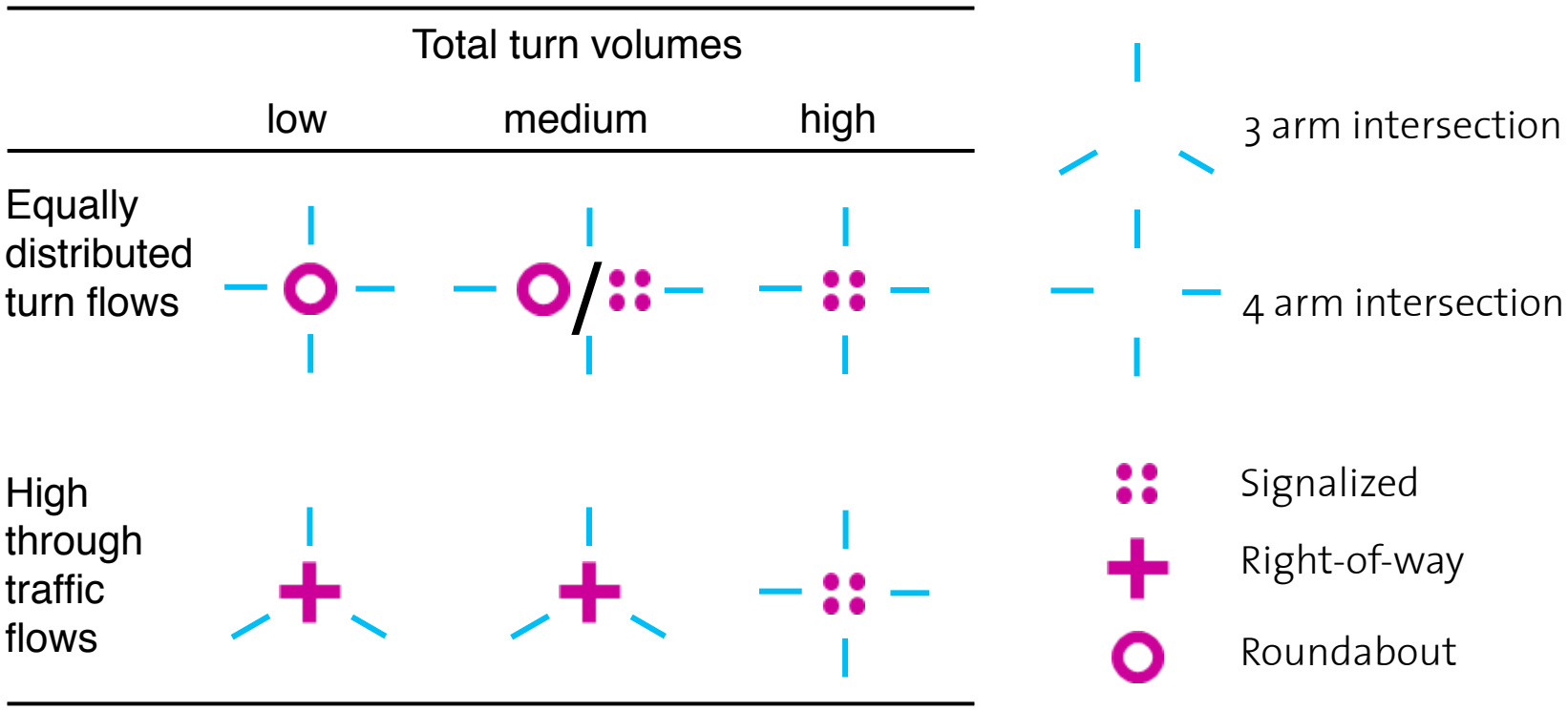


4 arm intersections



Source: Vitins and Axhausen (2013)

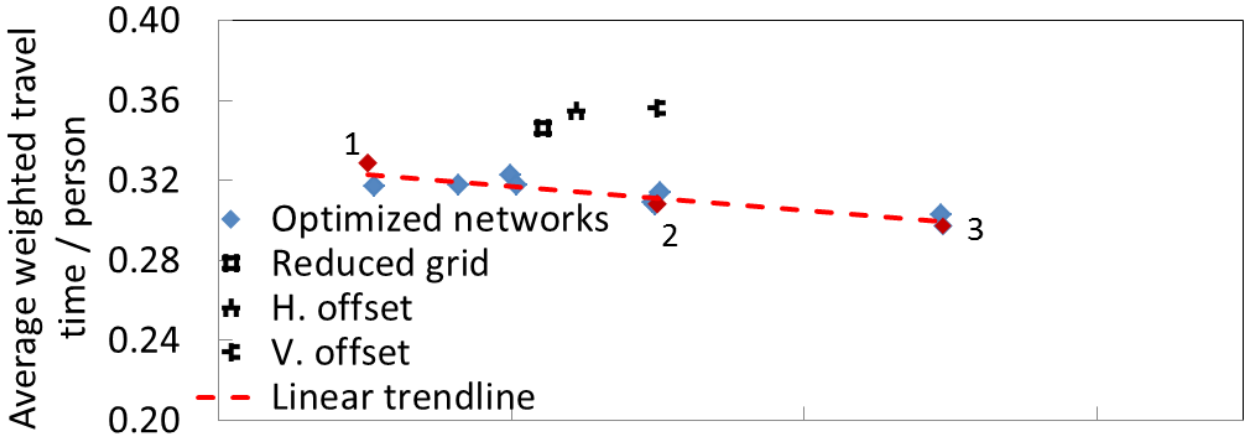
Rules for intersection type choice and network topology



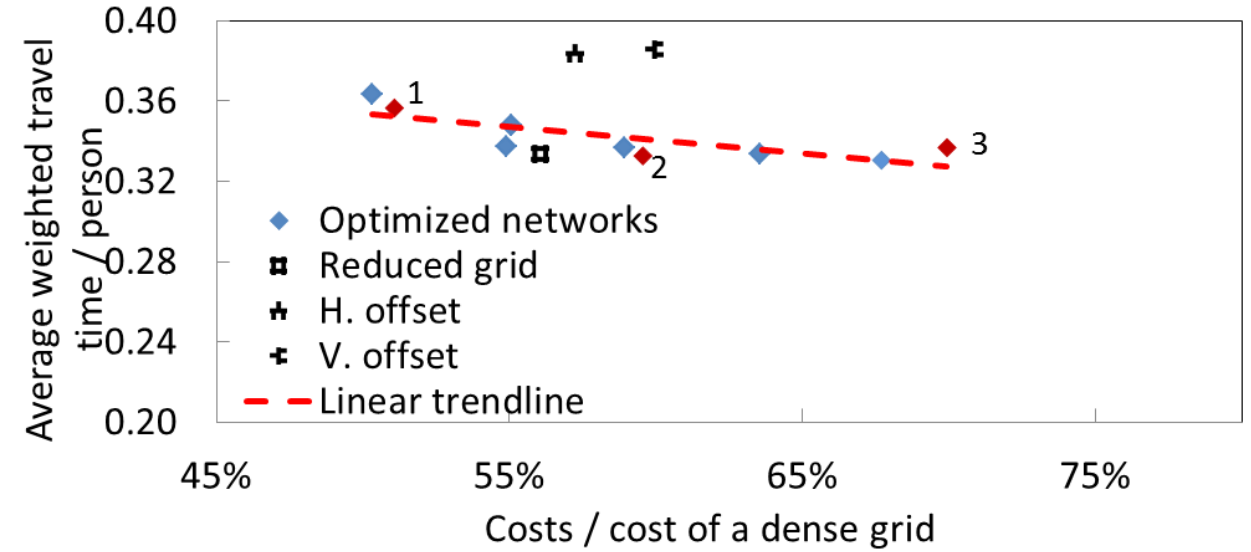
Source: Vitins and Axhausen (2013)

Comparison of optimized and pattern networks

Networks with *right-of-way* intersections

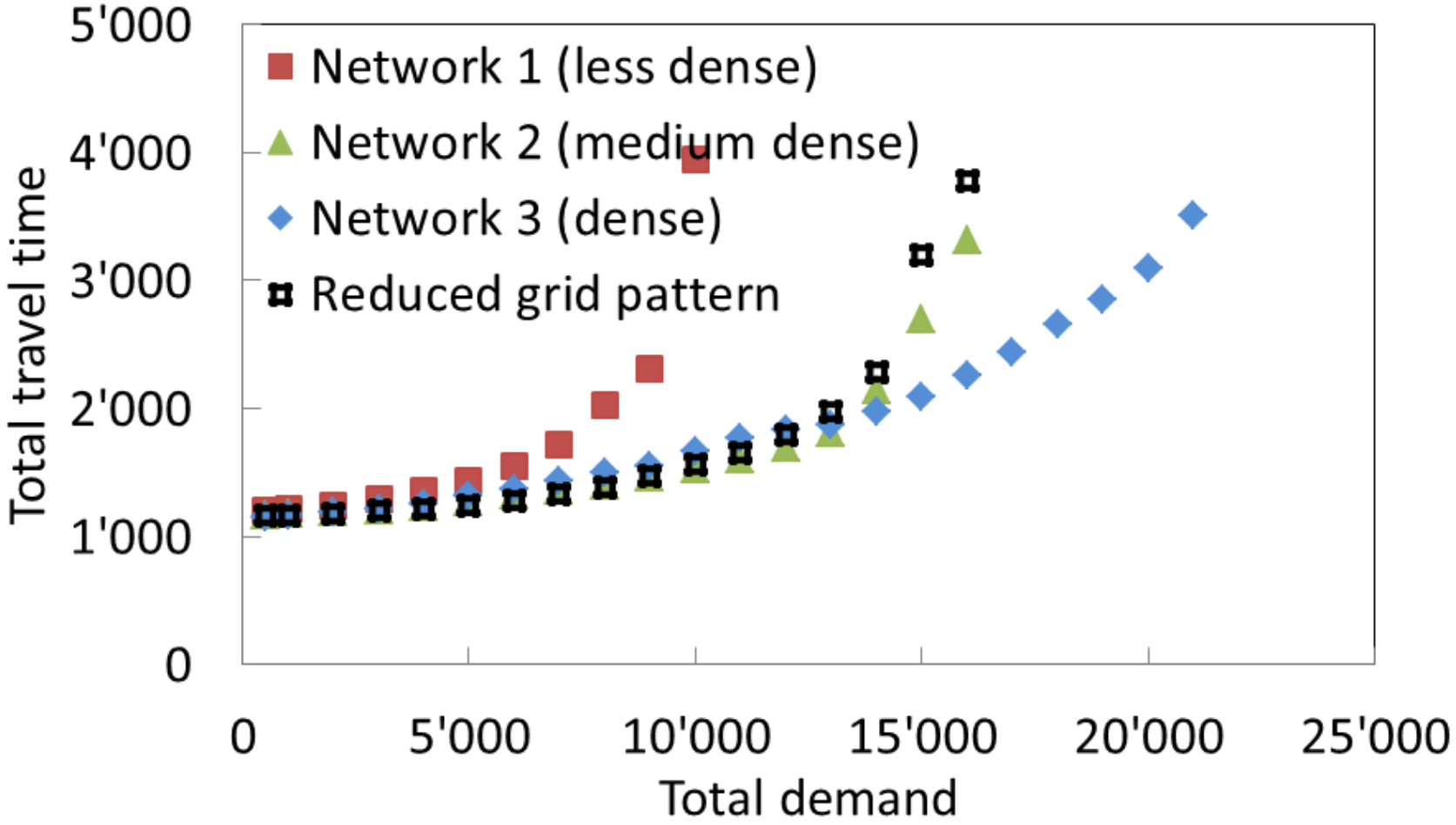


Networks with *signalized* intersections



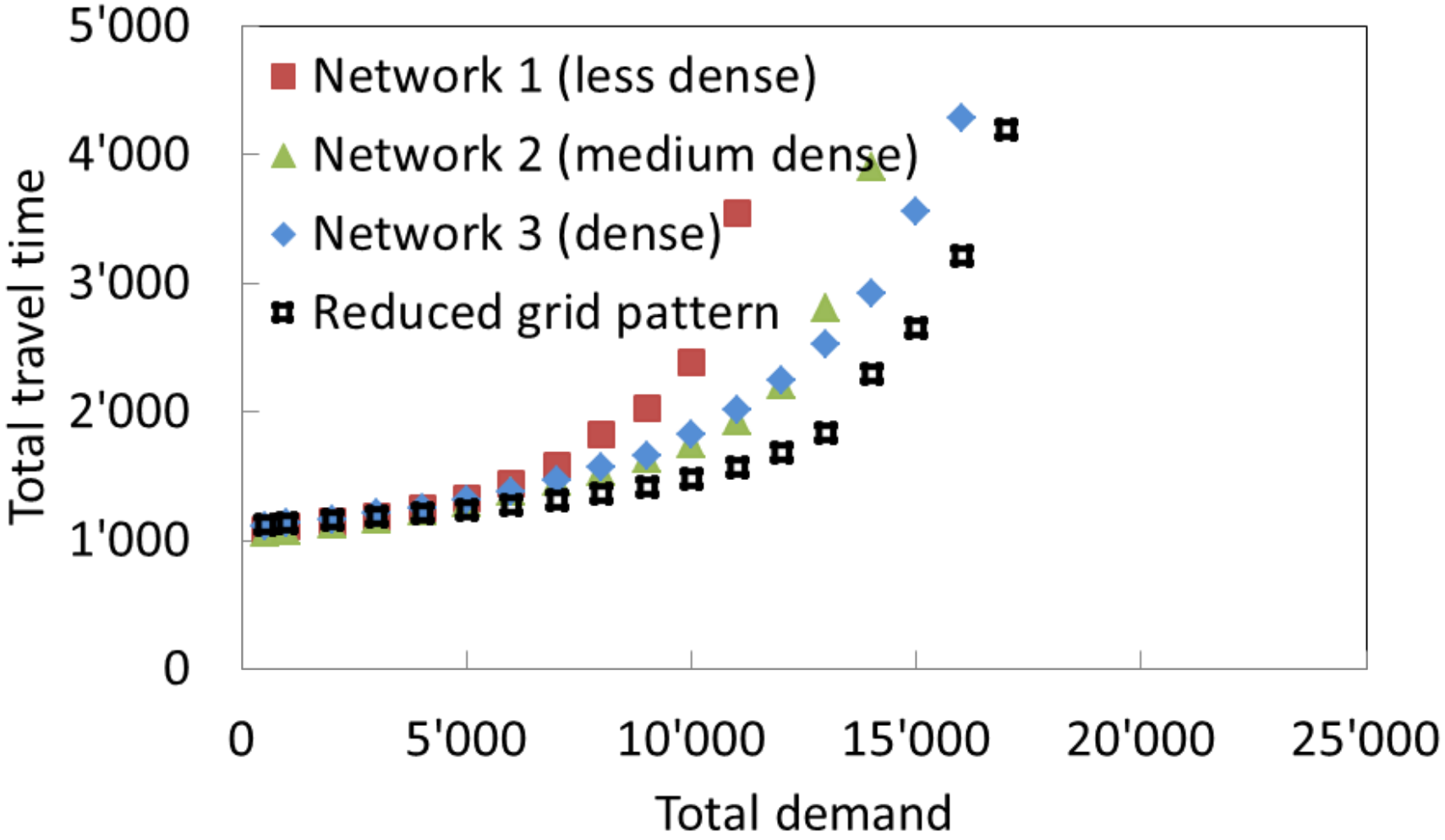
Source: Vitins and Axhausen (2013)

Sensitivity analysis of networks with signal lights



Source: Vitins and Axhausen (2013)

Sensitivity analysis of networks with roundabouts



Source: Vitins and Axhausen (2013)

Summary

Summary

- Build and support the best possible guidelines early
- Improve the rules and methods for incremental choices
- Account for induced demand
- Remember the saturation phase

Questions ?

www.matsim.org

www.ivt.ethz.ch
www.futurecities.ethz.ch

www.senozon.ch

References

Vitins, B. J., I. Garcia-Dorado, C. A. Vanegas, D. G. Aliaga and K. W. Axhausen (2013) Evaluation of shape grammar rules for urban transport network design, paper presented at the *92nd Annual Meeting of the Transportation Research Board*, Washington, D.C.

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Vitins, B.J., N. Schüssler and K.W. Axhausen (2011) Shape Grammars for Hierarchical Transport Network Design, presentation at the *11th Swiss Transport Research Conference*, Ascona, Mai 2011.