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Kostenloser Nahverkehr zur Vermeidung von Dieselfahrverboten?

Ergebnisse einer techniksoziologischen Simulationsstudie

Wissenschaftlicher Verein für Verkehrswesen
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- Socio technical Change
- Progression Person Transport (DE)
- Simulator SimCo
- Base Scenario
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Technology Studies Group

- established in 2002
 - 15 team members
- research projects
 - human-machine interaction
 - risk management in organizations
 - governance of socio-technical systems
 - modeling and simulation
- cooperation with
 - mechanical engineering, computer sciences,
electrical engineering ...



Digitalisierung von Arbeit

Das Projekt **TraDiLog** analysiert die Konsequenzen der Digitalisierung von Arbeit am Beispiel der Logistikbranche.

Auswirkungen der Digitalisierung

- Höhere Komplexität der Arbeitsaufgaben
- Zunehmende Überwachung durch Technik
- Gestiegener Kommunikations- und Interaktionsbedarf
- Zeitliche Flexibilisierung und Entgrenzung von Arbeit

Neue Anforderungen an Mensch, Technik und Organisation

- Veränderte Kompetenz- und Qualifikationsanforderungen
- Förderung von Kreativität und Innovationskultur
- Partizipatives Transformationsmanagement

Digitale Transformation gestalten

Auf Basis unserer Forschung verfolgen wir ein Gestaltungskonzept für die digitale Transformation, das die Perspektiven der regionalen Akteure verknüpft und gewinnbringend nutzt.



Das Innovations- und Digitalisierungspotenzial wird durch eine Verknüpfung der **Akteurperspektiven** ausgeschöpft:

- Die **Politik** fördert den Wissenstransfer und regionale Innovations- und Unternehmens-Kulturen.
- Nutzerorientierte Mensch-Technik-Interaktion ist Voraussetzung für den Innovationserfolg von **Unternehmen**.
- Die Partizipation von **Mitarbeitern** und **Bürgern** fördert Transformationserfolg und Akzeptanz von Digitalisierung.



Mobilität der Zukunft

Das Projekt **MoFFa** untersucht das Zusammenspiel von Mensch und Technik am Beispiel des automatisierten Fahrzeugs.

Anforderungen an Technikgestaltung

- Koordination von Mensch und Technik
- Nutzergerechtes Design
- Kompetenzentwicklung und Qualifizierung

Simulationsexperimente mit dem Simulator **SimCo** sowie Befragungen liefern Ergebnisse zur nachhaltigen Gestaltung von Verkehrssystemen und zu Alternativoptionen (z.B. Car-Sharing).

Datengesellschaft

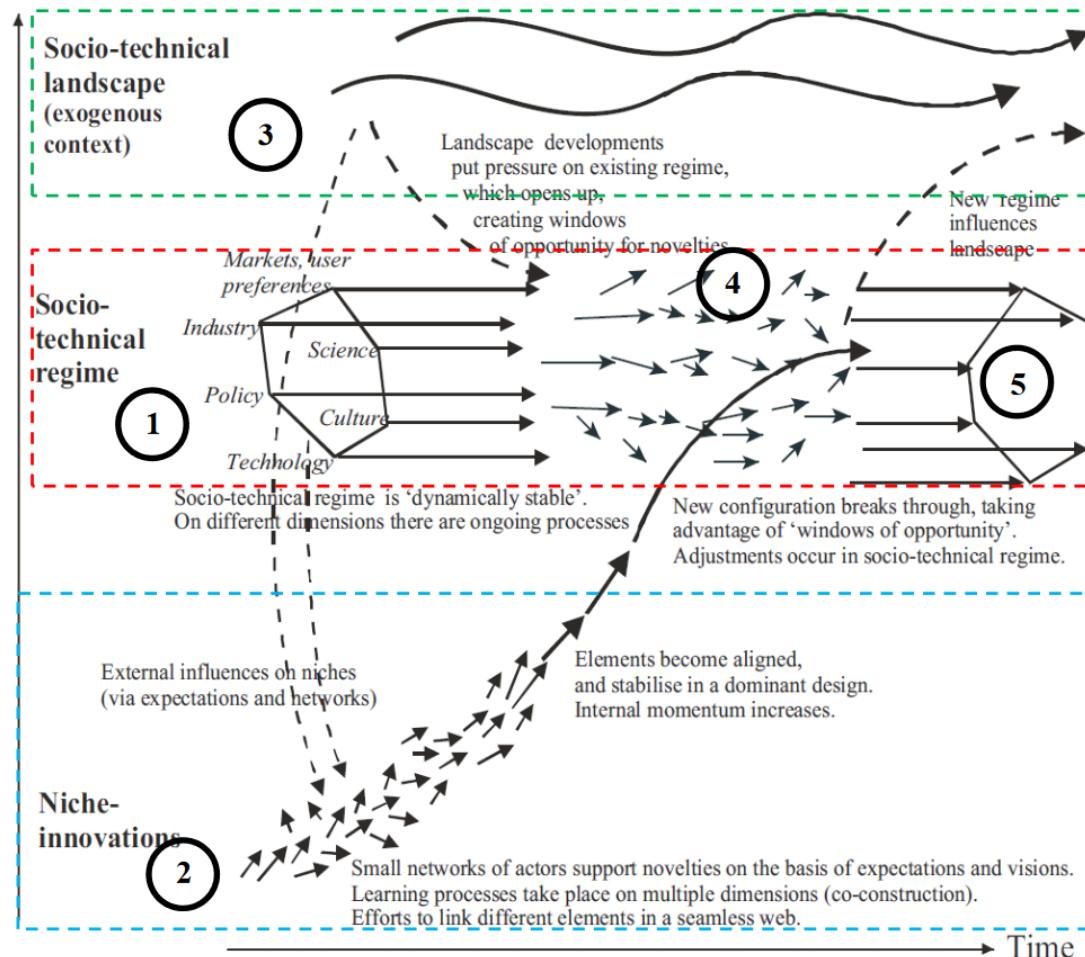
Die Projekte **ABIDA** und **KoRiSim** erforschen Chancen und Risiken einer datenbasierten Steuerung komplexer Systeme.

- Analyse von Nutzervertrauen in Technik und App-basierte Handlungsempfehlungen
- Steuerung und Umsteuerung des Verkehrs- und des Energiesystems

Soziologie

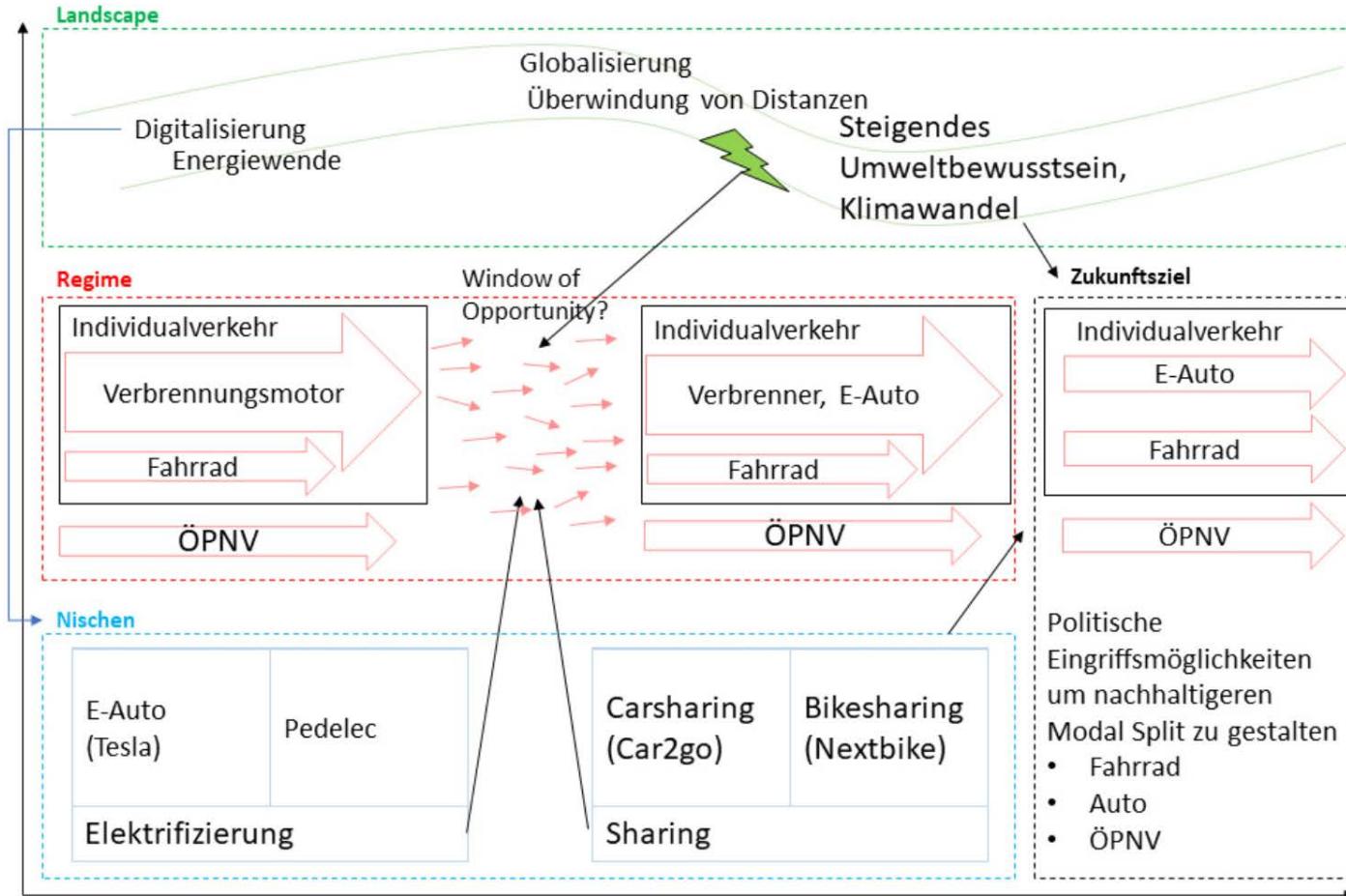
Im Mittelpunkt unserer **soziologischen** Forschungen stehen der Faktor „Mensch“, die Nutzerakzeptanz sowie die Optionen einer nachhaltigen (Um-)Gestaltung komplexer Systeme.

Socio technical change



Multi-Level
Perspective in
Anlehnung an
Geels 2011: 28

Progression person transport (DE)



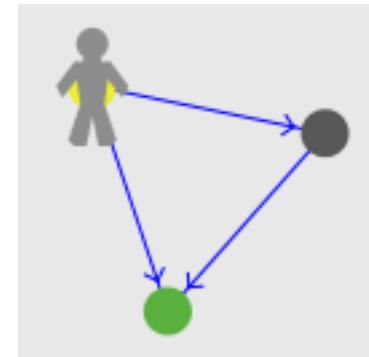
Simulator „SimCo“

- simulation framework
 - *sociological* model of a socio-technical system
 - actions and interactions
 - agents (micro) and system (macro)
 - *spatial* dimension of infrastructure systems
 - boundary conditions
 - means for (intentionally) controlling the system

→ investigate the governability of complex infrastructure systems by means of ABMS

Concept formalization: Agents' decision making

- agents move through network
 - fulfill tasks
 - select nodes with high utility
 - use technologies
 - constrained by state of network
- sociological theory of action
 - macro-micro-macro model
 - bounded rationality
 - individual preferences and goals
 - multiple evaluation criteria → subjective expected utility

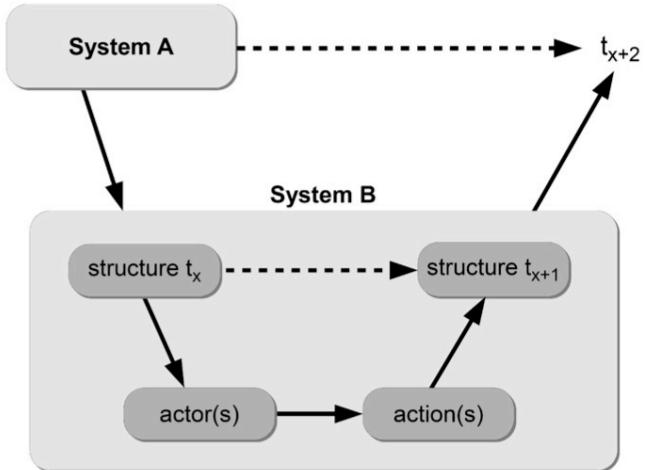


$$SEU_i = \sum_{j=1}^n p_{i,j} \cdot u_j$$

Software implementation

ABMS

- agents
- rules
- landscape



NetLogo (<https://ccl.northwestern.edu/netlogo>)

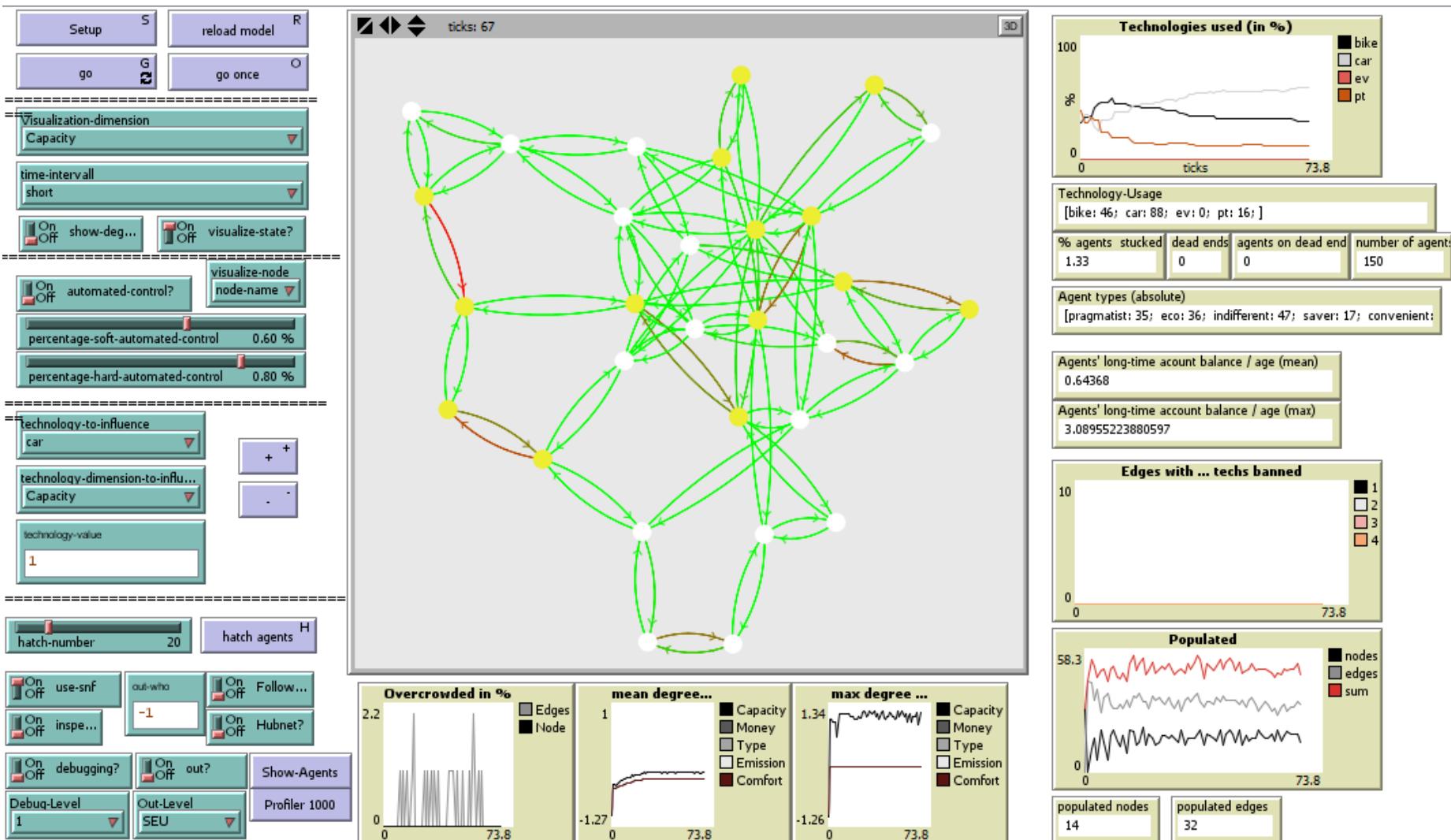
- widespread in social sciences

Scenario generator

Output organization

- GUI (→) – interface for human probands
- stats extension → CSV → SPSS

GUI SimCo



Realistic* base scenario

| | Type | Number |
|--------|---------------|--------|
| Nodes | Home | 204 |
| | Task | 236 |
| | Standard | 160 |
| | Total | 600 |
| Edges | Shared-small | 984 |
| | Shared-big | 110 |
| | Car-only | 104 |
| | Bike-only | 3 |
| | PT-only | 110 |
| | Total | 1312 |
| Agents | Pragmatic | 1000 |
| | Eco | 600 |
| | Indifferent | 1.800 |
| | Penny Pincher | 600 |
| | Convenient | 2.000 |
| | Total | 6000 |

- * three options
- survey-based
(too optimistic)
 - equally distributed
 - realistic

Agent types

| Agent types | Cheap | Fast | Eco-friendly | Comfortable | N=506 |
|-------------|------------|------------|--------------|-------------|-------|
| Pragmatist | 3.7 | 6.8 | 2.4 | 1.2 | 119 |
| Eco | 4.4 | 2.0 | 7.6 | 1.9 | 123 |
| Indifferent | 4.0 | 4.6 | 2.8 | 4.2 | 157 |
| Saver | 9.0 | 4.7 | 3.7 | 0.7 | 58 |
| Convenient | 0.6 | 6.4 | 0.2 | 6.8 | 49 |

- Clusters based on mean rated goals (ranging from 1-10)
- Survey data (conducted 2014/15)
- adjustment of biases
 - additional “hidden goals” (mental frames)

Suitability of technologies

| Technology | Fast | Cheap | Eco-friendly | Comfortable |
|----------------------|-------------|-------------|--------------|-------------|
| Public transport | 3.15 | 4.85 | 6.28 | 3.67 |
| Bike | 4.06 | 8.94 | 9.32 | 3.30 |
| Car (fossil-fuelled) | 6.08 | 3.00 | 1.96 | 6.72 |
| Electric vehicle | 7.80 | 6.08 | 7.64 | 7.78 |

- Assessment regarding the achievement of goals (ranging from 1-10)
- Survey data (conducted 2014/15)

Regime change in road transportation



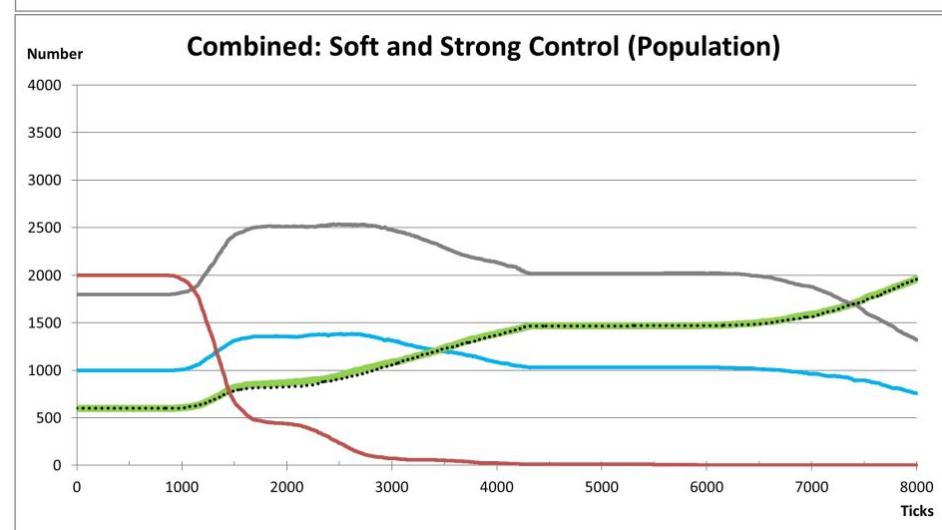
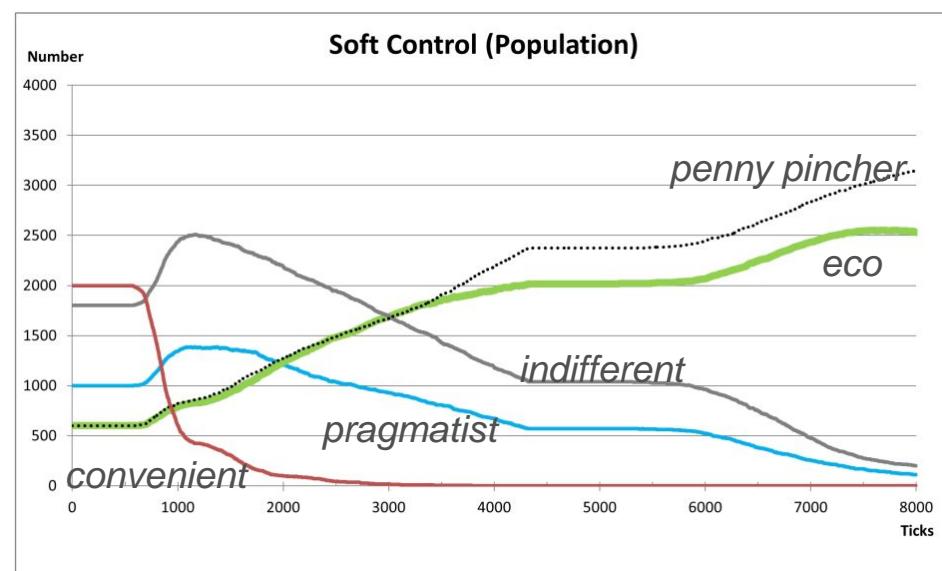
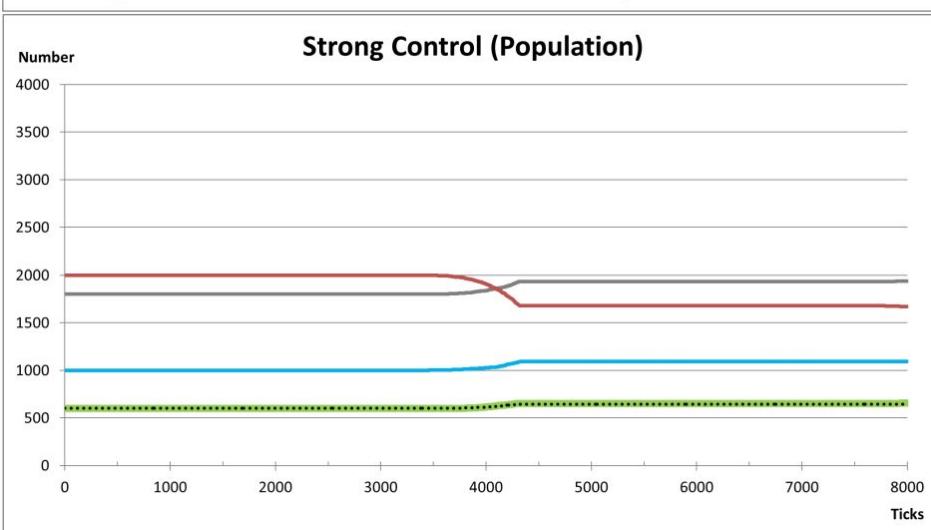
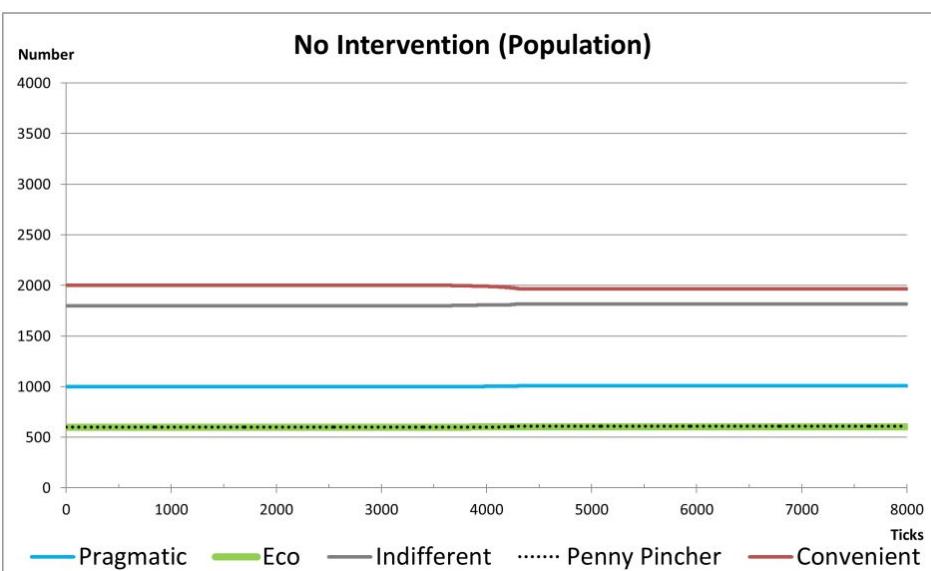
modes of governance

1. no intervention (= base scenario)
2. soft control: road pricing
 - congestion charging, emission pricing, cordon schemes
 - raising and lowering again
3. strong control: ban of the car
 - temporal, spatial
 - re-allowing after short-time („day“)
4. combination of soft and strong control
 - 60% of limit: soft measures
 - 80% of limit: (additional) strong measures

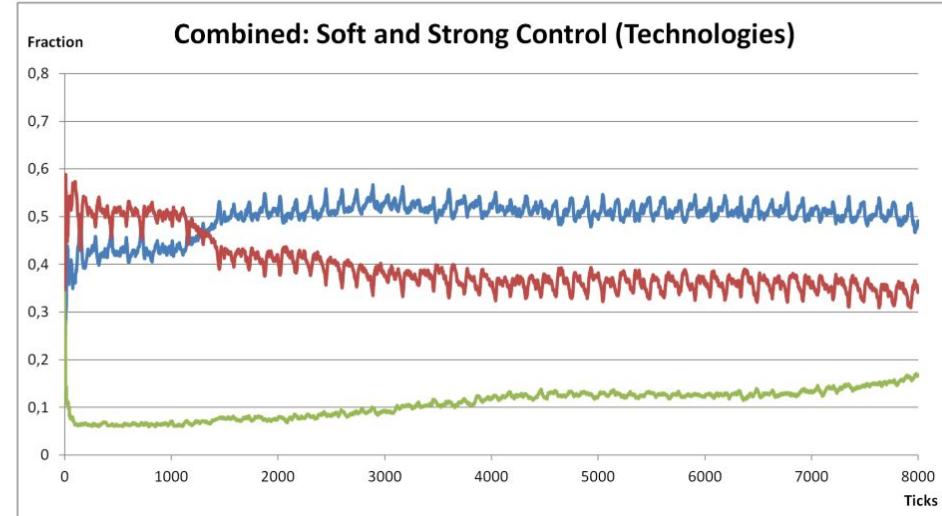
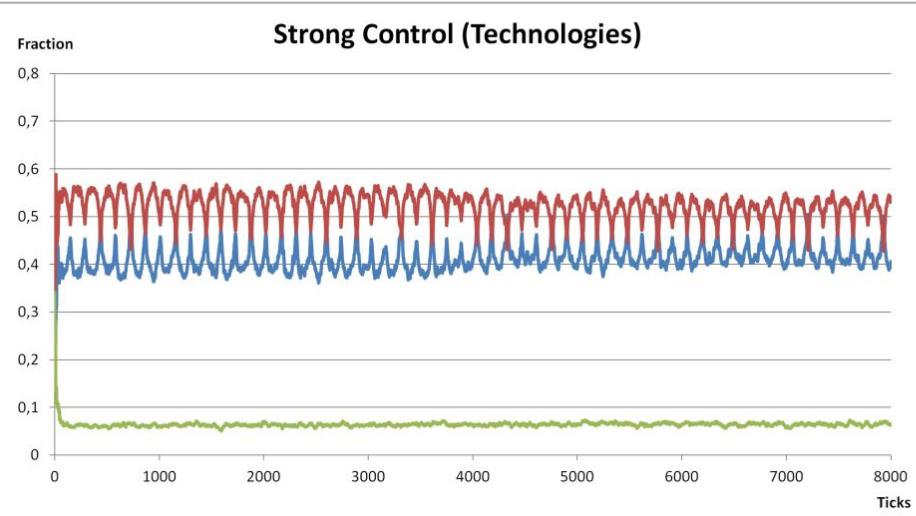
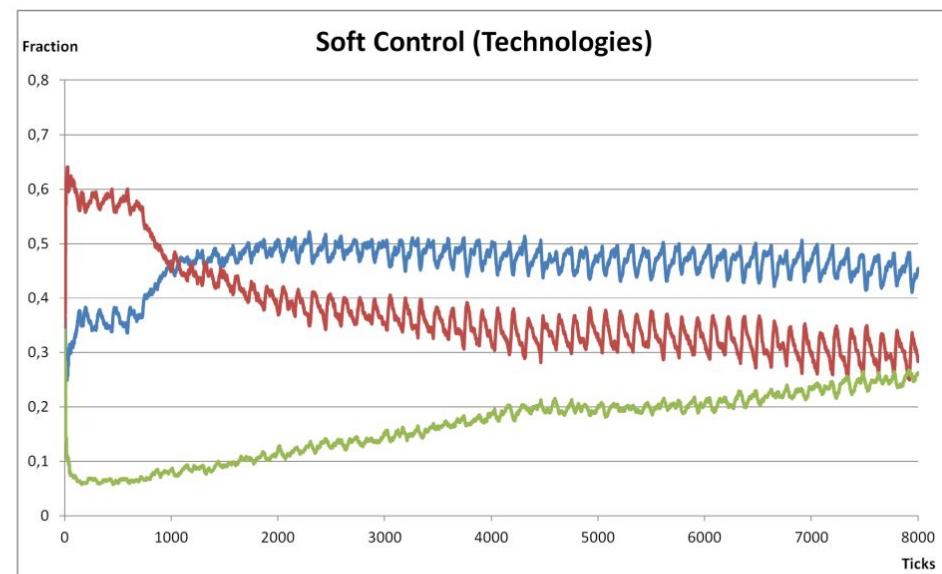
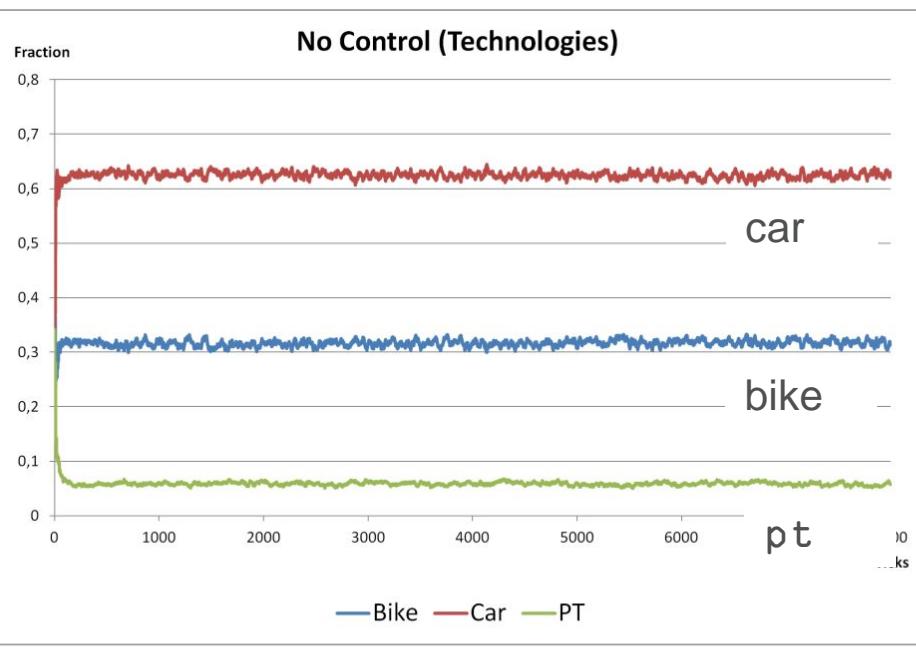
Basic governance experiments → transformation

| | Mean capacity utilization of edges | Mean pollution on edges (short) | Mean pollution on edges (long) | Usage of Bikes | Usage of Cars | Usage of Public transport |
|----------------|------------------------------------|---------------------------------|--------------------------------|----------------|---------------|---------------------------|
| No control | 21,4% | 18,0% | 33,3% | 31,6% | 62,5% | 5,9% |
| Soft control | 15,8% | 12,8% | 24,7% | 46,0% | 37,5% | 16,5% |
| Strong control | 19,1% | 15,6% | 28,9% | 41,4% | 52,1% | 6,5% |
| Combined | 16,4% | 12,9% | 24,7% | 49,9% | 39,0% | 11,1% |

Agent population



Technology usage



Basic governance experiments → risk management *static interventions (mean values)*

| Intervention | Capacity utilization | Emissions (short time) | Emissions (long time) |
|--------------------------|----------------------|------------------------|-----------------------|
| Base scenario | 21,6% | 18,0% | 33,4% |
| Comfort bike | 17,3% | 13,2% | 24,6% |
| Comfort public transport | 19,1% | 16,5% | 30,5% |
| Costs car | 16,7% | 13,3% | 25,4% |

Basic governance experiments

situational interventions (**mean** values)

| Mode of governance | Capacity utilization | Emissions (short time) | Emissions (long time) |
|-------------------------------|----------------------|------------------------|-----------------------|
| No control (base scenario) | 21,6% | 18,0% | 33,4% |
| Soft control | 18,2% | 14,5% | 27,7% |
| Strong control | 19,5% | 15,7% | 29,2% |
| Combined | 18,0% | 14,1% | 26,9% |

Basic governance experiments

situational interventions (max network values)

| Mode of governance | Capacity utilization | Emissions (short time) | Emissions (long time) |
|-------------------------------|----------------------|------------------------|-----------------------|
| No control (base scenario) | 25,7% | 36,1% | 71,1% |
| Soft control | 25,7% | 34,8% | 60,4% |
| Strong control | 22,0% | 31,8% | 63,1% |
| Combined | 22,0% | 31,5% | 58,6% |

Basic governance experiments

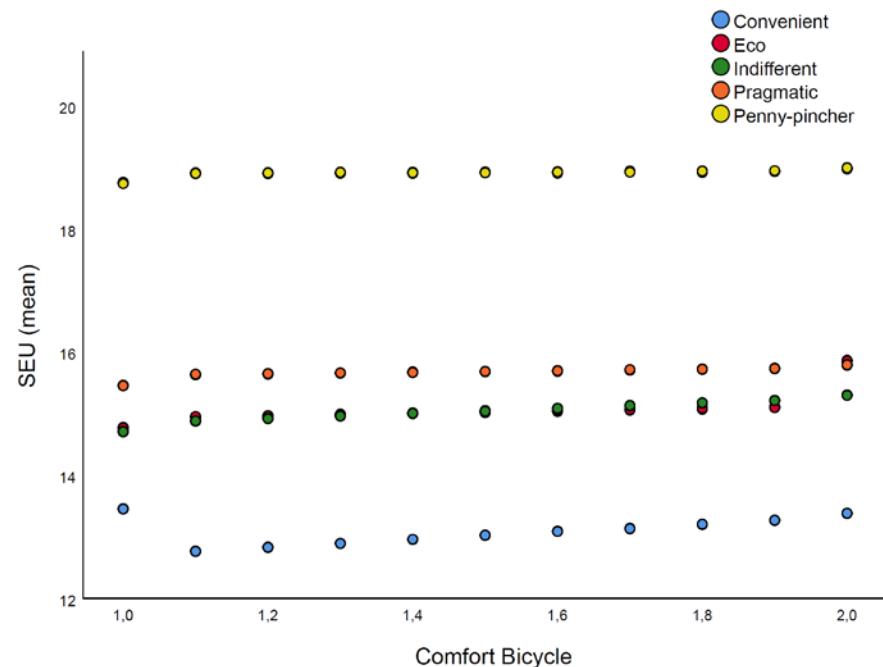
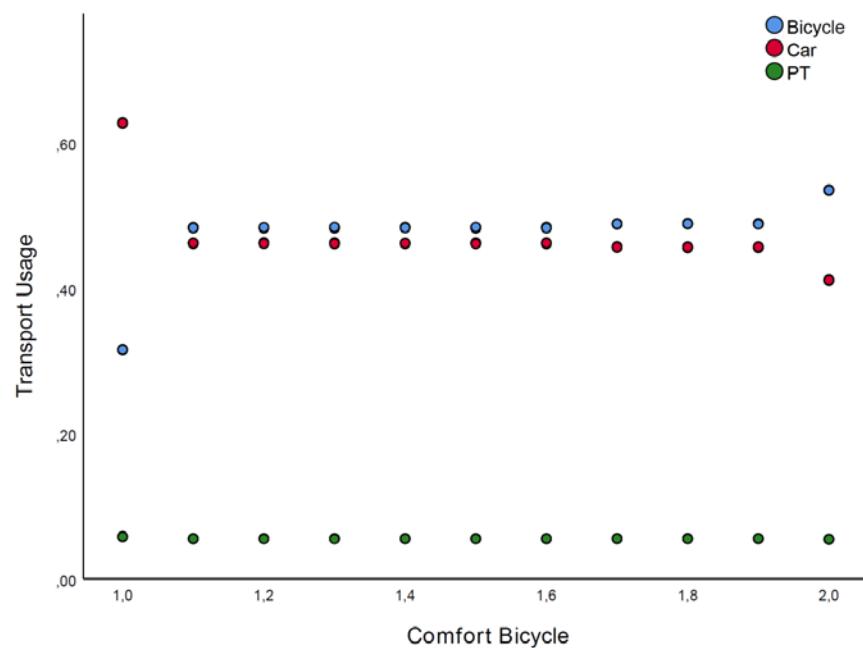
situational interventions (**max edge** values)

| Mode of governance | Capacity utilization | Emissions (short time) | Emissions (long time) |
|-------------------------------|----------------------|------------------------|-----------------------|
| No control (base scenario) | 120,5% | 251,8% | 471,9% |
| Soft control | 133,8% | 244,8% | 444,6% |
| Strong control | 128,4% | 108,0% | 202,1% |
| Combined | 132,6% | 111,5% | 204,9% |

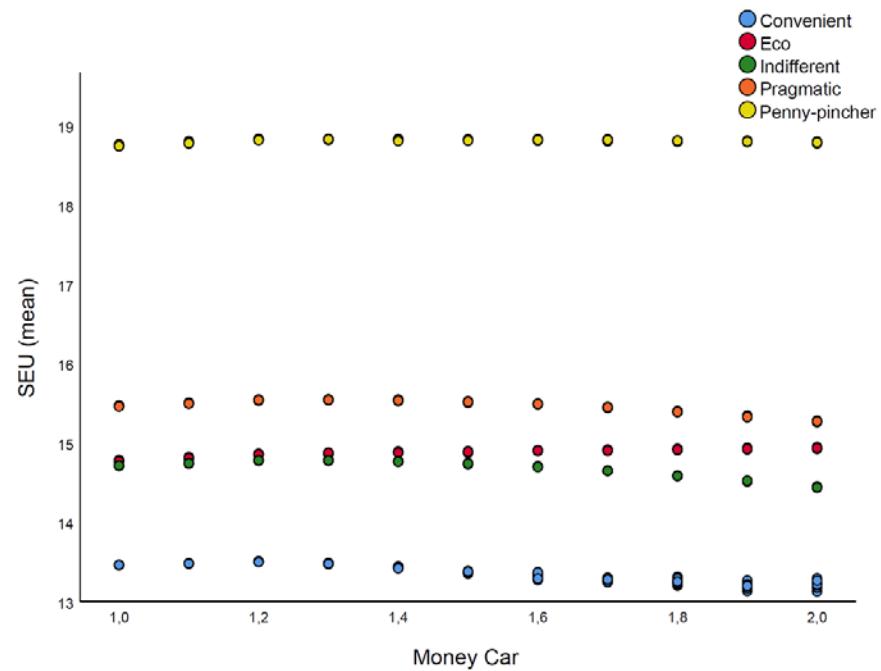
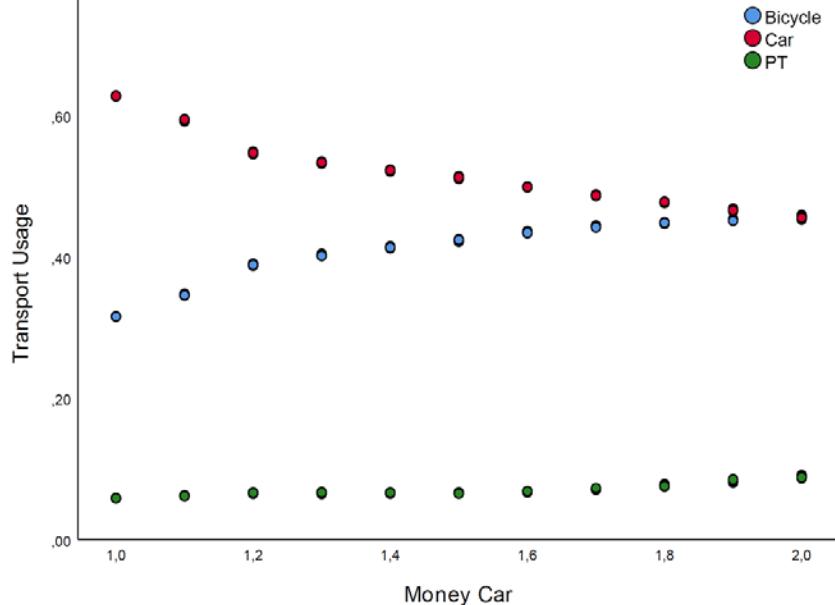
Policy Options towards fostering a sustainable person transport

| Bicycle | Car | PT |
|--|--|--|
| 1)Raises in comfort <ul style="list-style-type: none">• Bicycle Infrastructure• Pedelecs | 3) Internalizing external effect on the environment <ul style="list-style-type: none">• Traffic toll• Higher fuel taxes | 5) Free public transport <ul style="list-style-type: none">• Scientific discourse since 1972• Recently present in political debates• No definite scientific result |
| 2) Expansion of bicycle network <ul style="list-style-type: none">• Bicycle highway• Transforming car streets in to bicycle streets | 4) Speedlimits <ul style="list-style-type: none">• On highways• In town | |

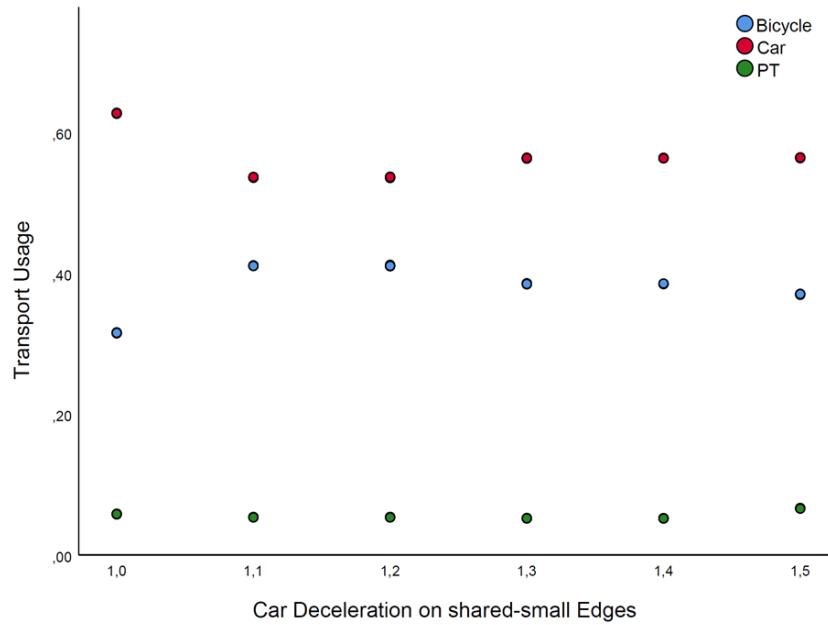
1) Raise bicycle comfort



3) Increase costs of car usage

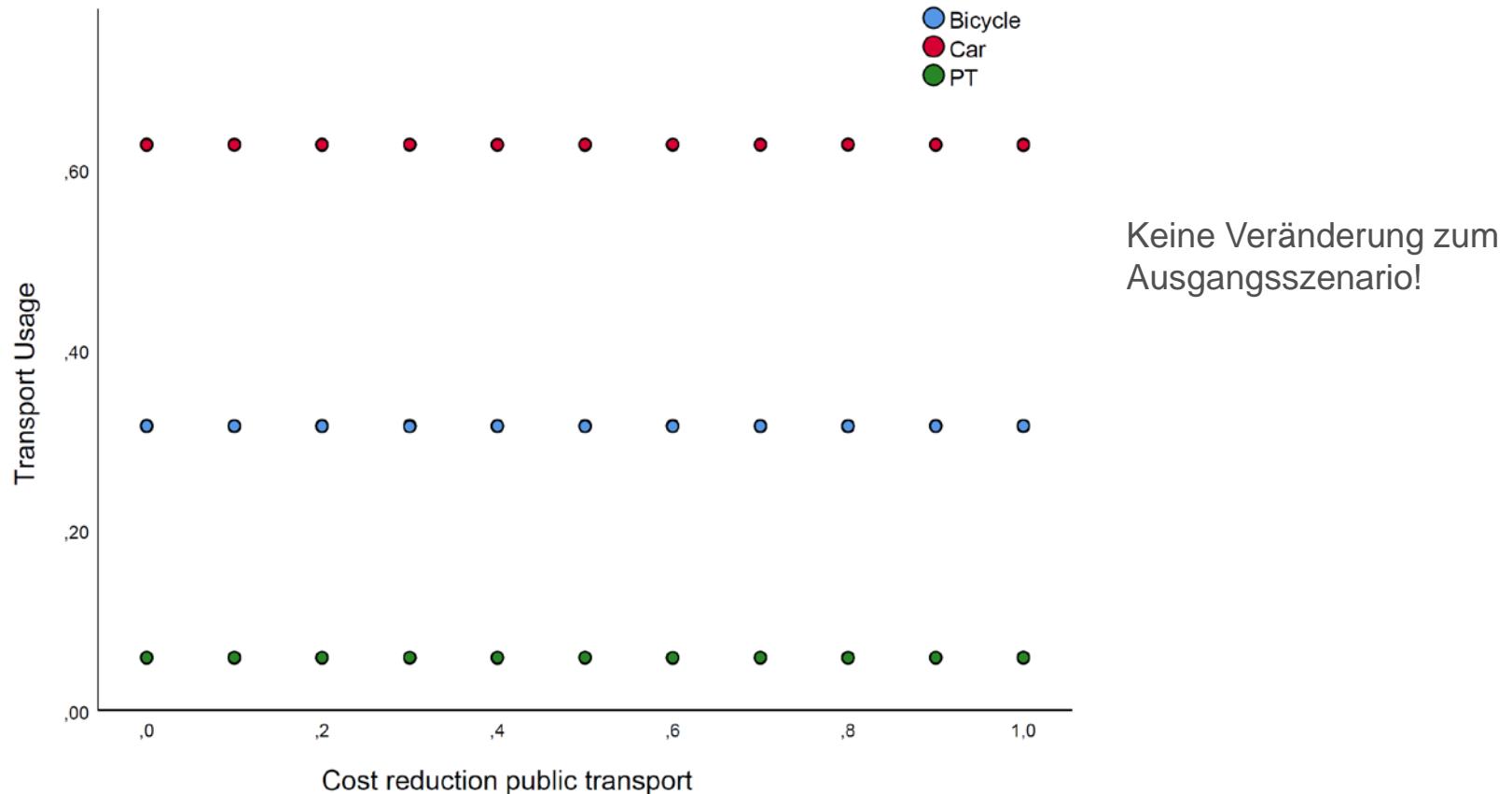


4) Inner-city speed limits

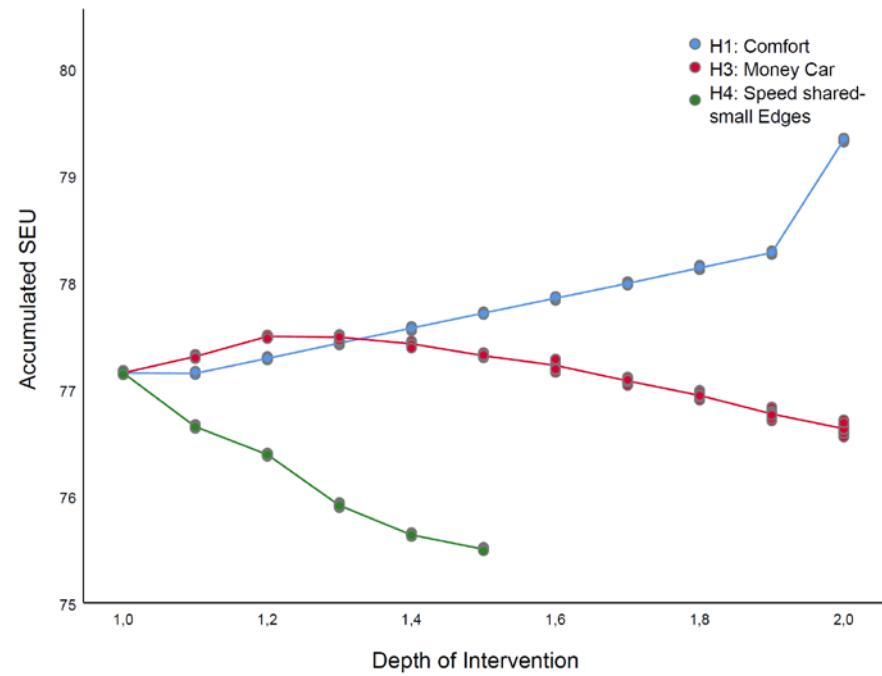
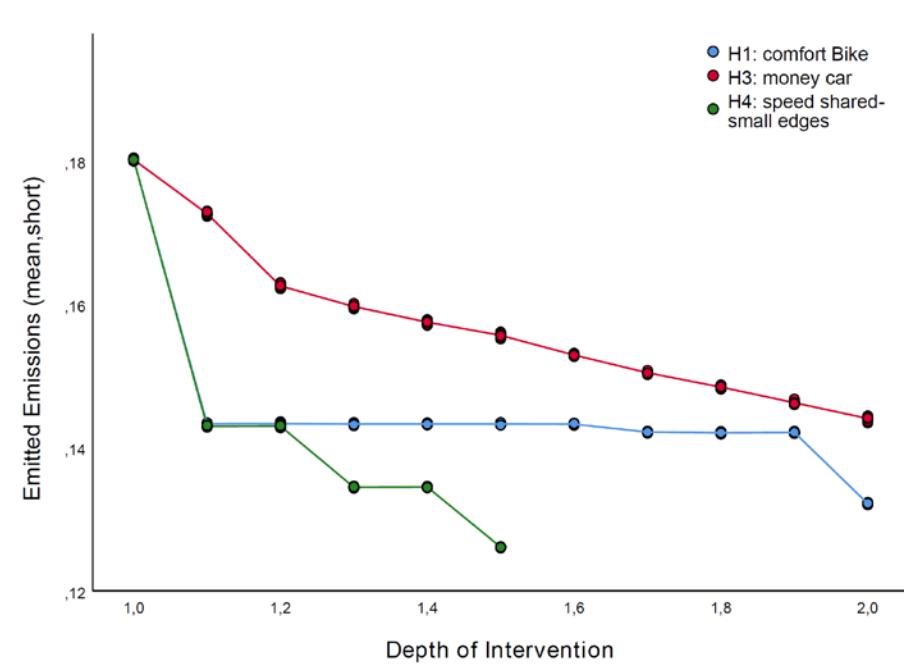


| | Deceleration of car's speed on small-shared edges | | |
|---------------|---|-------|---------|
| | 1 | 1,1 | 1,5 |
| SEU | | | |
| Pragmatist | 15,46 | 15.50 | ▲ 15,13 |
| Eco | 14,78 | 14,80 | ▲ 14,59 |
| Indifferent | 14,71 | 14,76 | ▲ 14,52 |
| Penny-pincher | 18,75 | 18,77 | ▲ 18,95 |
| Convenient | 13,46 | 12,82 | ▼ 12,31 |
| Added SEU | 80,16 | 76,65 | 75,50 |

5) Cost Reduction Public Transport



8. Comparison: Emissions and SEU



8. Policy Options towards fostering a sustainable person transport

| Bicycle | Car | PT |
|---|---|--|
| 1)Raises in comfort <ul style="list-style-type: none"> • Bicycle Infrastructure • Pedelecs | 3) Internalizing external effect on the environment <ul style="list-style-type: none"> • Traffic toll • Higher fuel taxes | 5) Free public transport <ul style="list-style-type: none"> • Scientific discourse since 1972 • Redress present in politics • No definite scientific result |
| 2) Expansion of bicycle network <ul style="list-style-type: none"> • Bicycle highway • Transforming car streets in to bicycle streets | 4) Speedlimits <ul style="list-style-type: none"> • On highways • In town | |

Discussion:

Political consequences

- Raising the car's cost and slowing the car down are both viable options to reduce emissions.
 - tests should start with only minor interventions
 - minor costs of implementation and easy to do
 - might raise public displeasure
- Raising bicycle comfort
 - investments are necessary
 - Uncertainty: which actions really effect bicycle comfort?

Discussion:

Scientific consequences

- Experiments offered an overview on static interventions
 - comfort
 - cost
 - network
- Possible further research
 - Transport technology based
 - Attribute specific
 - Combination / synergies
 - Real-time steering

Conclusion

- Combination
 - governance, infrastructure systems, ABMS
- Sociological theory of action
- SimCo framework
 - free of semantics
 - different scenarios
 - basic scenario
 - stable and reliable (parameter variation)

Conclusion (cont.)

- Objectives of investigation
 - risk management and/or system transformation
 - governance modes
 - what-if-question
 - experiments that cannot be performed in the real world
- governability of complex socio-technical systems
 - unresolved debates in political sciences (cf. Grande 2012)

Limitations and further perspectives

- limitations
 - ...
- further experiments
 - disturbances: stability (and recovery)
 - alternatives: (e.g. via CarSharing)
 - experiments with human probands
 - additional modules
 - e.g. creation of technological alternatives
 - implementation of different theories of action

Thanks for your attention!

Fabian Adelt, Weyer, Johannes, Sebastian Hoffmann,
Andreas Ihrig, 2018:

Simulation of the of complex systems (SimCo). Basic
concepts and and experiments on urban transportation,
in: Journal of Artificial Societies and Social Simulation 21 (2),
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www.simco.wiwi.tu-dortmund.de