Chair of Transportation Systems Engineering
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Modelling the impact of mobility pricing on mode choices

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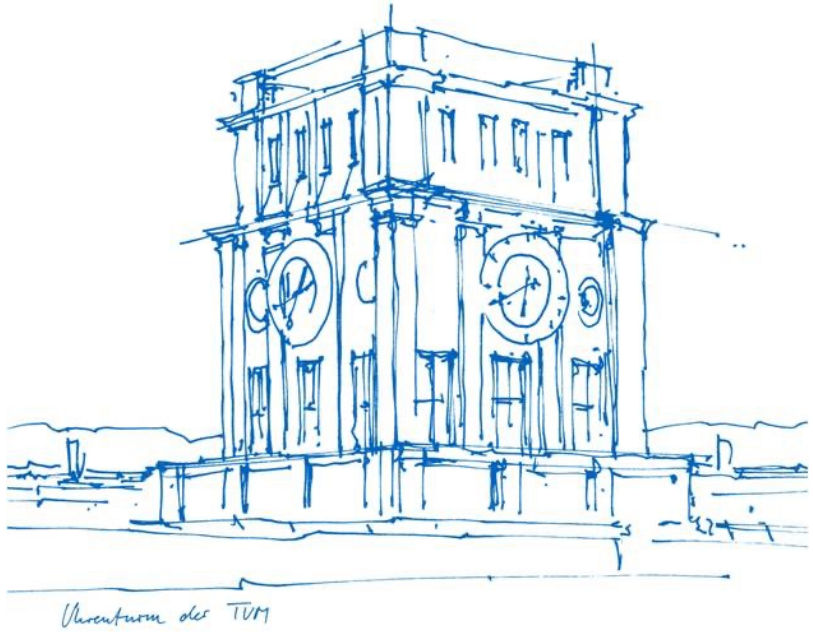

MCube
Münchner Cluster für die Zukunft der Mobilität in Metropolregionen

Overview of the presentation

- Motivation and objective
- Workflow
- The stated preference survey
- Mode choice model
- Simulation
- Improvements and ToDos

Motivation and objective

The transportation of people and goods causes external effects (also called externalities or external costs):

- Air and noise pollution
- Time losses due to congestion
- Accidents with injuries and deaths
- Damage to infrastructure

Those costs are not reflected directly in the price of mobility and, therefore, may not influence travellers' decisions.

This work investigates if the internalisation of external costs can generate a modal shift from private cars to modes with lower external costs.

Workflow

1. Stated preference survey design
2. Data collection
3. Mode choice modelling
4. Simulation
5. Adjustment of utility constants
6. Simulations (base case to full external costs)
7. Evaluation of the output
8. Policy implications

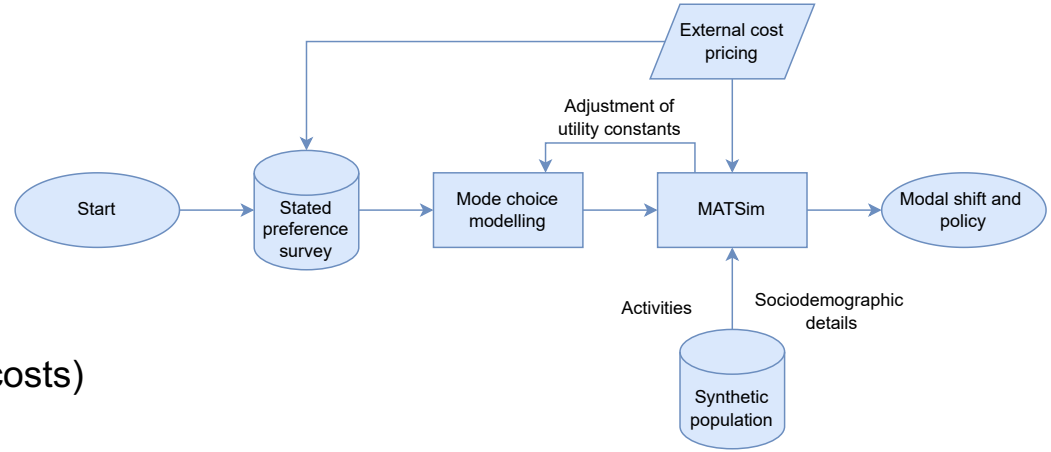

Figure 1: Methodological framework.

The stated preference survey

Aimed to capture the effect of external cost pricing.

Part 1 – Mobility instruments

- Driving license
- Access to private car (owned, leased or company car)
- Other, non-relevant (with this topic) questions.

Part 2 - Mode choice experiments

- Integrating external costs as one of the attributes (values from Schröder et al., 2023).

Part 3 - Sociodemographic details

- Gender, age, disability
- Education, occupation, income
- Nationality

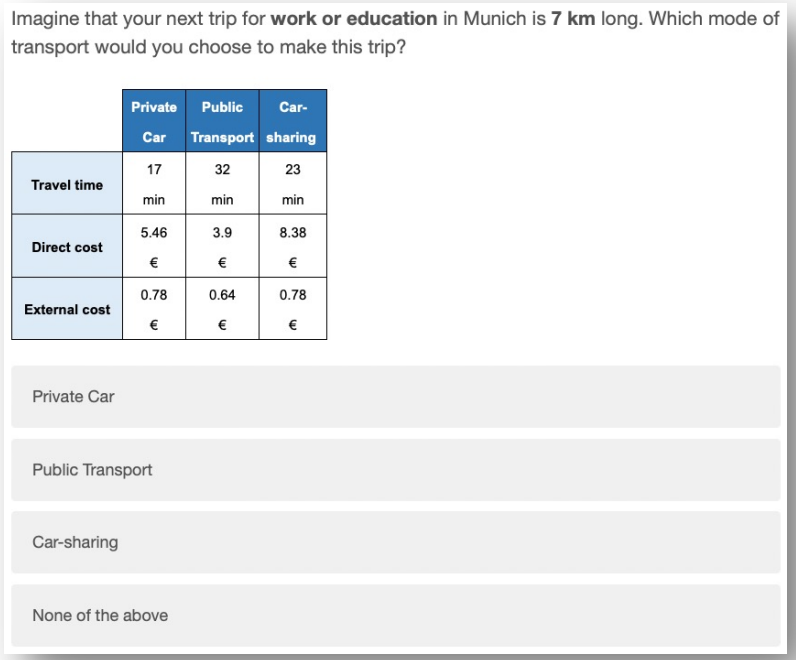

Figure 2: Example question from the stated preference survey.
*Shared modes excluded from the current analysis.

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Imagi… **Mobility pricing vs. road pricing.** …ode of transp…

Mode	External cost €/km
Walking	0.01
Private car	0.16
Private bike	0.07
Public transport	0.07

Public Transport

Car-sharing

None of the above

Figure 2: Example question from the stated preference survey.
*Shared modes excluded from the current analysis.

Mode choice model

Online data collection:

- 600 respondents from Munich, Germany.
- Key characteristics of the population were represented, but percentages were not exact.
- Removed responses with underrepresented sociodemographics or failed attention check.
- Responses ‘None / I would choose something else’ and shared modes were omitted in this model.

Table 1: Multinomial logit (MNL) mode choice model.

Modes	**Walking**		**Private Car**		**Public Transport**		**Private Bike**	
Parameters (β_i)	Value	Rob. *t-stat*	Value	Rob. *t-stat*	Value	Rob. *t-stat*	Value	Rob. *t-stat*
ASC	2.010	5.86***	-	-	2.470	11.70***	1.690	4.74***
Travel time (min.)	-0.031	-3.79***	-0.027	-4.00***	-0.033	-5.91***	-0.041	-1.49
Direct cost (€)	-0.166	-5.25***	-0.166	-5.25***	-0.166	-5.25***	-0.166	-5.25***
External cost (€)	-0.302	-2.34**	-0.302	-2.34**	-0.302	-2.34**	-0.302	-2.34**
Driving license	-1.280	-5.54***	-	-	-1.860	-11.20***	-1.32	-6.11***
Car access$_{=0}$	1.680	9.48***	-	-	1.730	13.70***	1.650	10.00***
Car access$_{\geq 2}$	-0.694	-3.80***	-	-	-0.480	-4.58***	-0.806	-5.63***
Gender$_{\text{Female}}$	-0.483	-3.88***	-	-	-0.375	-4.60***	-0.251	-2.30**
Age$_{\leq 39}$	-	-	-	-	-0.253	-2.60	-0.456	-4.17***
Age$_{50\text{-}69}$					-0.278	-3.13***		
Nationality$_{\text{German}}$	-	-	-	-	-	-	0.637	4.26***
Disability	-0.608	-3.30***	-	-	-	-	-0.671	-4.41***
Household size$_{=1}$	0.315	2.27**	-	-	0.294	3.06***	-0.528	-4.09***
Household size$_{\geq 3}$	-	-	-	-	-0.193	-1.82*	-	-
Personal income$_{\geq 3750}$	-0.348	-2.53**	-	-	-0.154	-1.71*	-	-
Education$_{\text{Low}}$	1.180	3.67***	-	-	0.661	2.58***	-	-
Education$_{\text{University}}$	-	-	-	-	0.142	1.75*	0.373	3.66***
Occupation$_{\text{Student}}$	-	-	-	-	0.760	3.98***	1.020	4.31***
Occupation$_{\text{Unemployed}}$	-0.343	-2.27**	-	-	-0.504	-4.92***	-0.518	-3.76***
Summary of statistics								
No. of observations	4541							
LL*(0)*	-4788.9							
LL*(final)*	-4136.7							
Adj. Rho-square	0.11							
AIC	8557.4							

Significance levels (Rob. *p*-value): 0 ‘***’ 0.01 ‘**’ 0.05 ‘*’ 0.1

Simulation

1. Why use agent-based simulation?

- Consider the preferences of individuals during mode choice in simulation and
- Facilitate a fine analysis of the simulation output based on disaggregated sociodemographic data.

2. What data background is needed?

A synthetic population (5%) – agents and plans, plus the sociodemographic variables of our sample.

In Munich, available from Moeckel et al. (2020).

3. How to perform MNL mode choice in MATSim?

Discrete mode choice extension (Hörl et al. 2019, 2018). Only mode choice as a strategy, considering the sociodemographic details of the agents and their households.

Results

Decrease in the choice probability of car, increase in public transport and cycling:

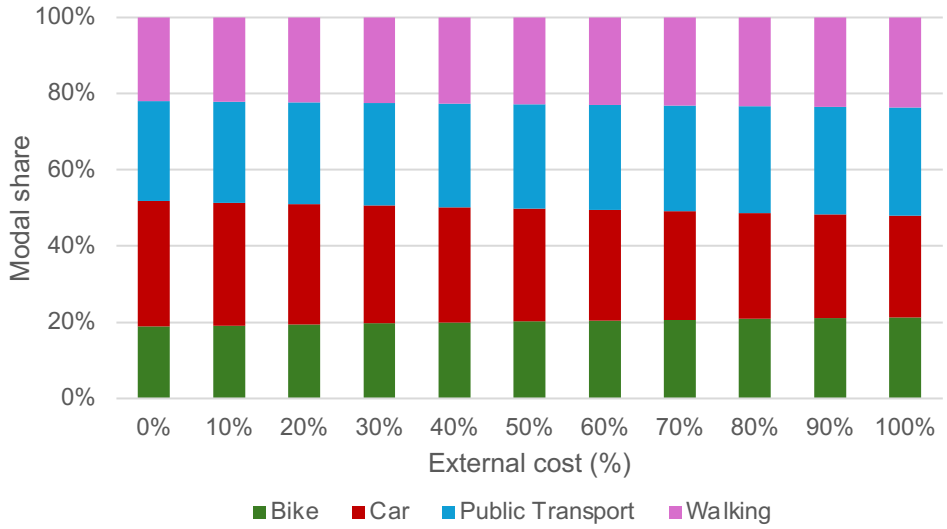

Figure 3: Sensitivity analysis of the external costs.

Results

Change in road traffic counts (passenger cars only):

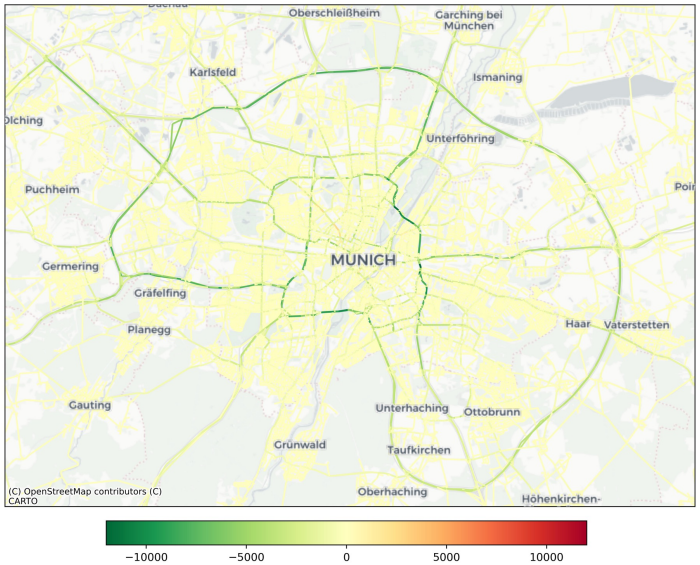

Figure 4: Change in car traffic 0-100% external costs (24 h).

Results

“Disaggregated sociodemographic analysis”:

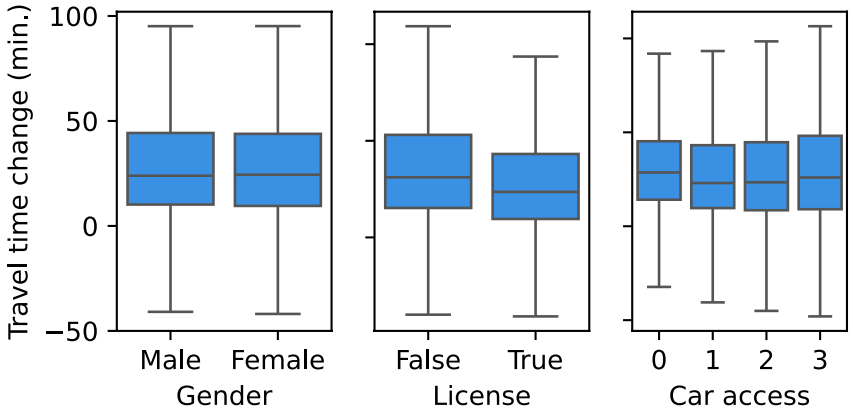

Figure 5: Change in travel time for agents **changing** mode.

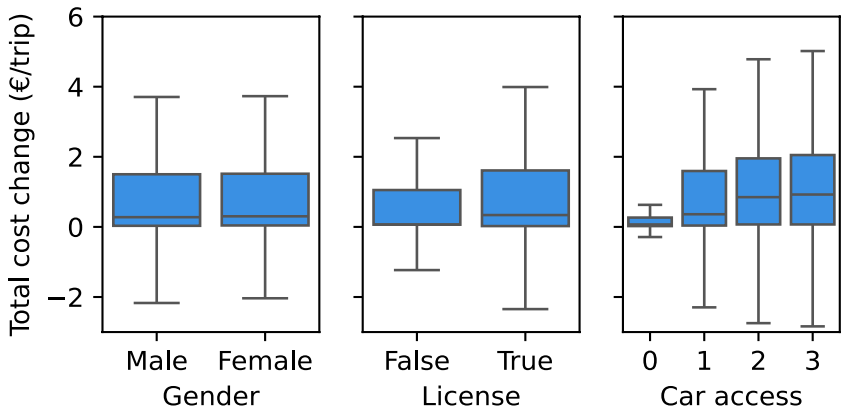

Figure 6: Change in total travel cost for agents **not changing** mode.

Results not final.

Improvements and To-Dos

- Calibrating trip **distance** distribution per mode.
- Implementing bike as a **network** mode.
- Integrating **shared** modes, e.g. car sharing, bike sharing and e-scooter sharing.
- Calculating **emissions** before-after.
- Investigating spatially and temporally **varying pricing policies**:
  - External costs vary temporally and spatially.
  - Complex charging policies in real road pricing schemes.
- Investigating the impact on transportation **equity**.

References

Hörl, S., Balać, M., & Axhausen, K. W. (2018). A first look at bridging discrete choice modeling and agent-based microsimulation in MATSim. *Procedia Computer Science, 130*, 900–907.

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Thank you!

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https://www.mos.ed.tum.de/en/vvs/home/

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