MOMENTUM

Modelling Emerging Transport
Solutions for Urban Mobility

Modelling shared mobility services

Regensburg, 30th November 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815069

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The Intermediate modelling approach

Narayanan, S., Salanova Grau, J. M., Frederix, R., Tympakianaki, A., & Antoniou, C. (2021). Modelling of shared mobility services - An approach in between traditional strategic models and agent-based models. In 24th Euro Working Group on Transportation (EWGT) Meeting, 8 Sep. 2021.

Multi-method framework for car-sharing service in Regensburg

Narayanan, S., & Antoniou, C. (2021). Expansion of a car-sharing service to reduce car-ownership and improve transport equity. Under review.

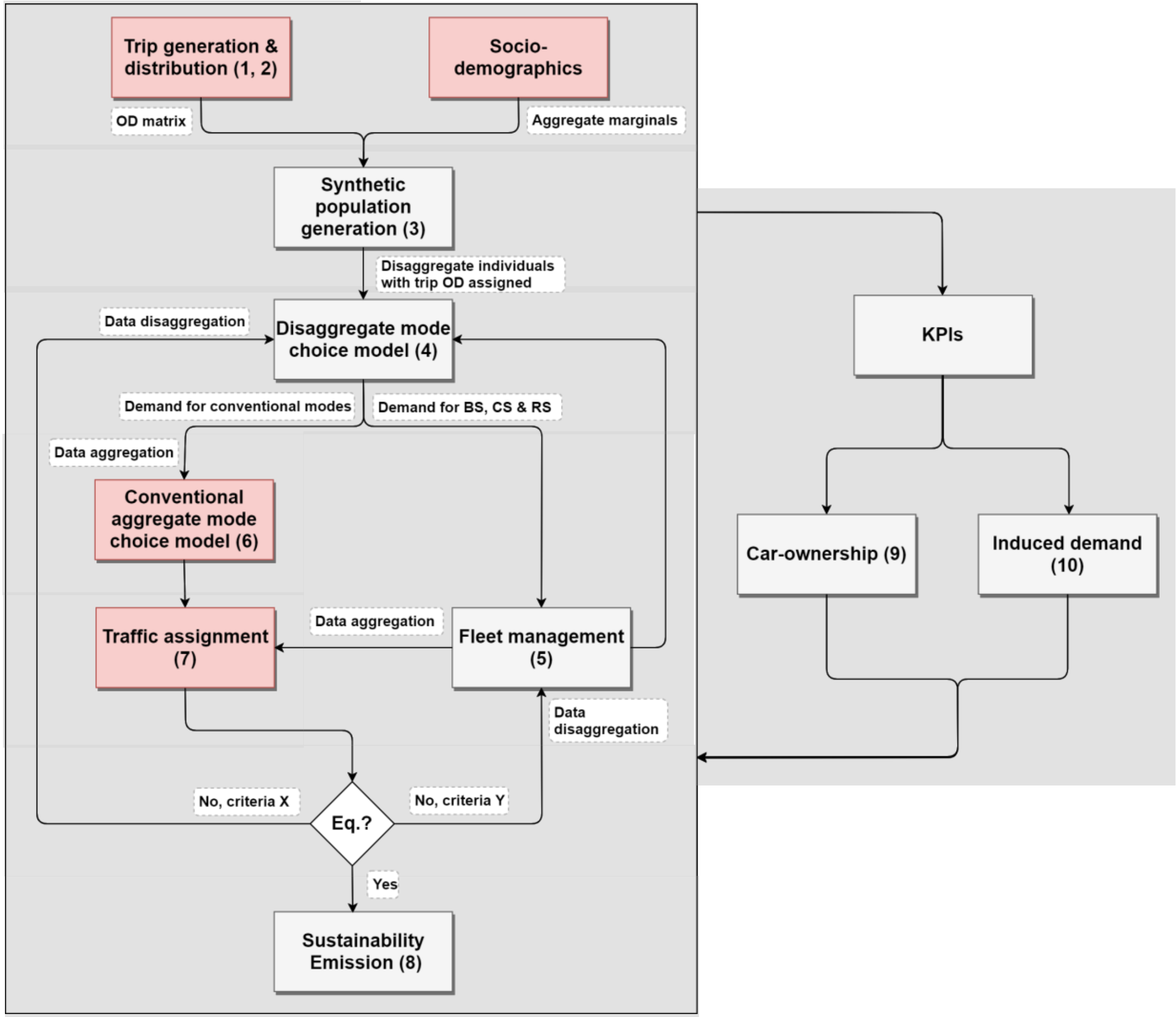
The intermediate modelling approach
Needs & objectives

- Shared mobility services are penetrating the European cities
- Introduction of such services in cities calls for proper evaluation of them, to avoid inefficiency & ineffectiveness
- Modelling of shared mobility requires agent based approaches (based on existing pertinent literature)
- However, many cities, especially small & medium sized cities, continue to use the traditional strategic four-step modelling approach
- Need for an intermediate modelling approach, which can be integrated to the existing models of the cities

The intermediate modelling approach
Modelling schema – High penetration

Red colour shaded boxes indicate the existing components in the traditional four-step transport modelling approach

BS: Bike-Sharing
CS: Car-Sharing
RS: Ride-Sharing



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The intermediate modelling approach
Modelling schema – Low penetration

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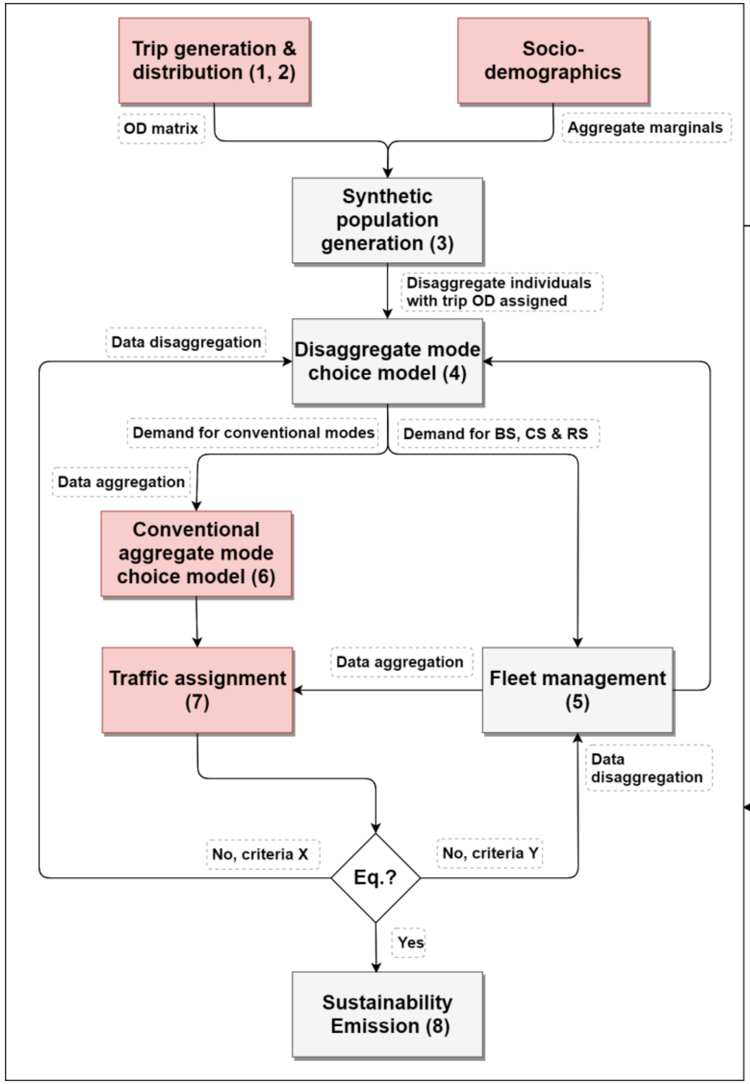

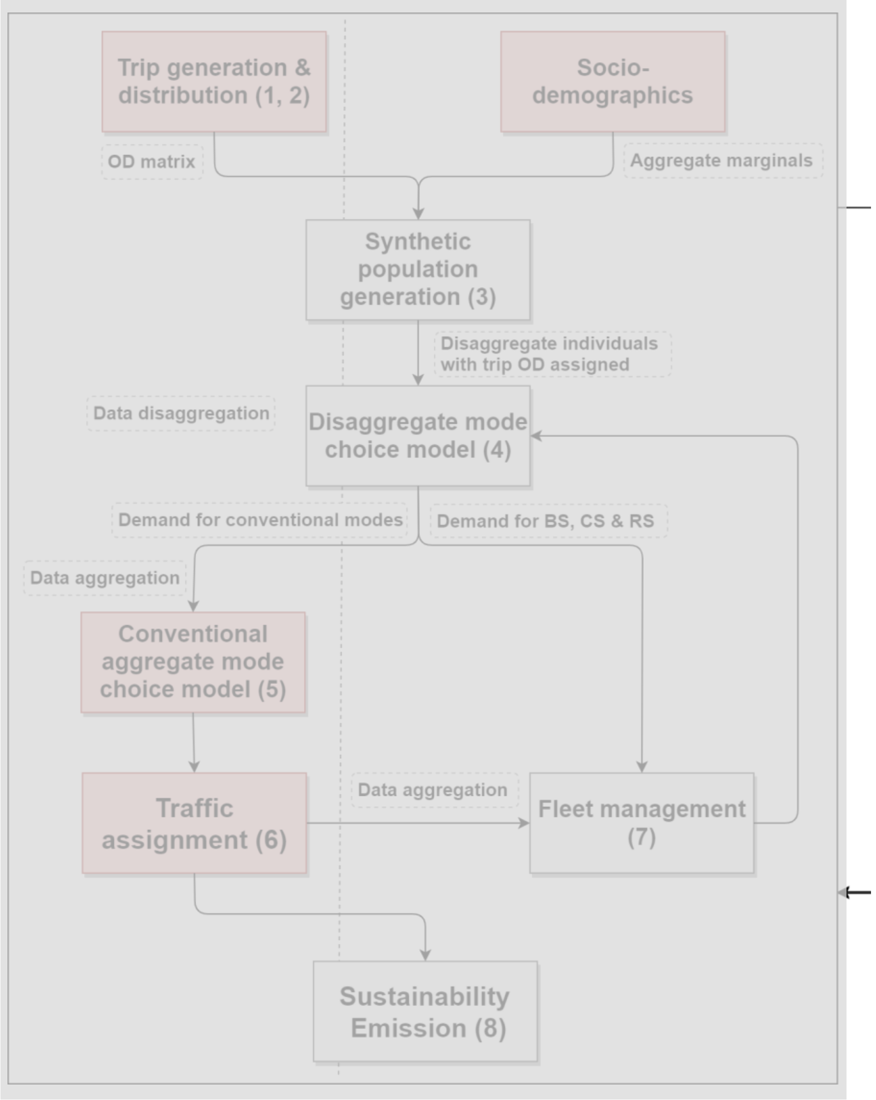

BS: Bike-Sharing
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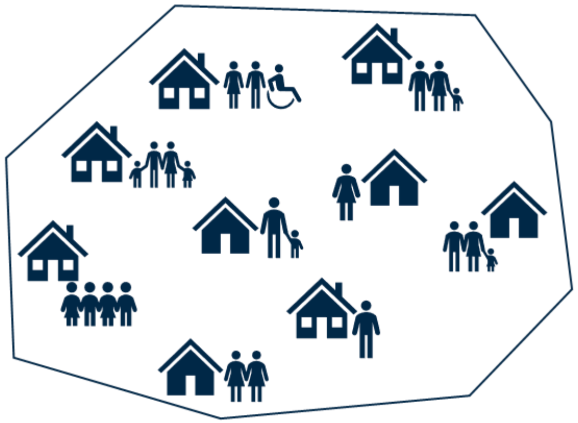
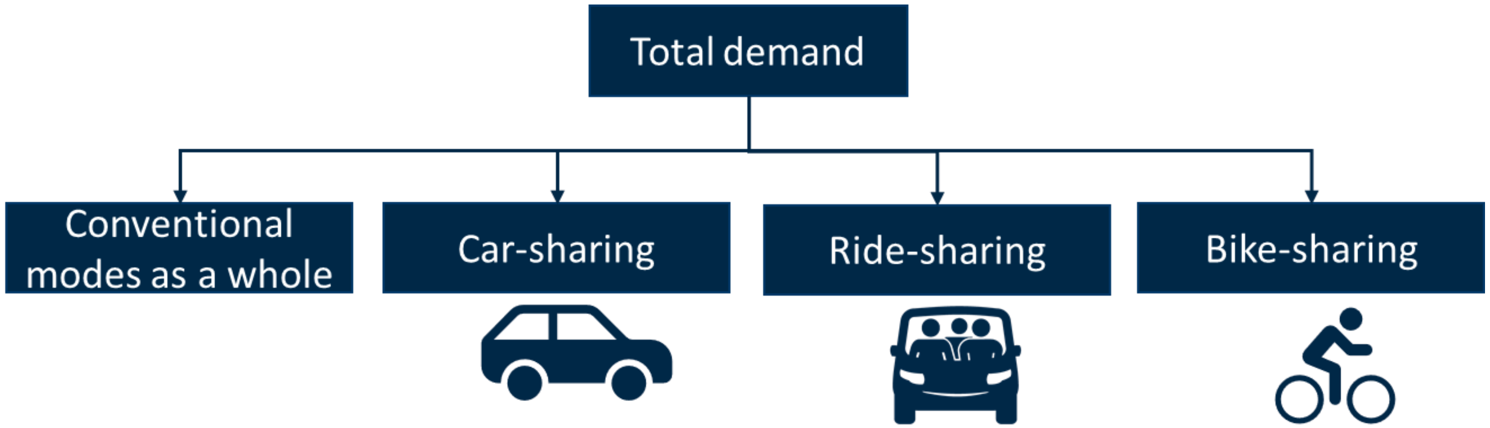
Red colour shaded boxes indicate the existing components in the traditional four-step transport modelling approach

- Generate a simplified disaggregate representation of the actual population based on socio-demographic and other information to capture the preference in selecting a new mobility service
- Open source tool PopGen (MARG, 2016) - Iterative Proportional Updating (IPU) algorithm
- Sampling techniques and statistical matching procedures (D'Orazio et al., 2006) to enrich the synthetic population with attributes that are not simultaneously available in both census and travel survey data



1. Trip generation
2. Trip distribution
3. Synthetic population generation
4. Disaggregate mode choice
5. Fleet management
6. Conventional agg. mode choice
7. Traffic assignment
8. Emission calculation
9. Car-ownership
10. Induced demand estimation

- Development of a generalised multinomial logit model based on smoted household survey data
- Consideration for non-availability of a sharing vehicle and inability to use car-sharing without license type B



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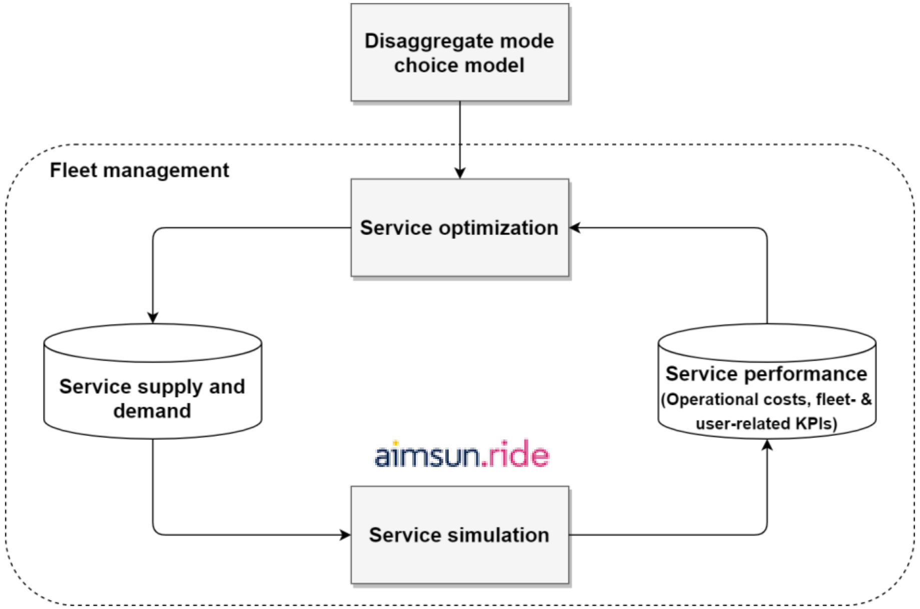
Step 5 - Fleet management

- Service optimization objective: Generate the supply side of the different shared mobility services (methods from operational research)
- Service simulation objective: Assess the service performance and calculate the necessary KPIs
- Iteration between the two steps until convergence



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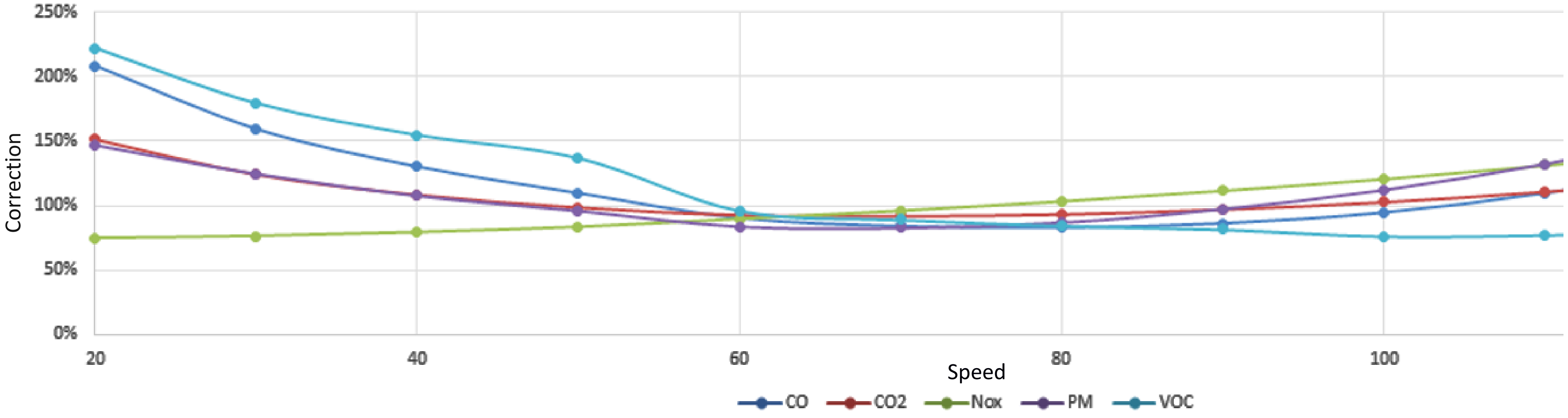
Step 8 - Static emission model

- Light-weight post-processing step to estimate emissions at link level and by aggregation on the entire network
- Country- and year-specific (2016 to 2050) , speed-corrected aggregated emission factors per pollutant (CO, CO_2, NOx, PM, VOC) (Rodrigues et al., 2020)
- Network, traffic speeds and vehicle-kilometers extracted on a per-link basis from the traffic model



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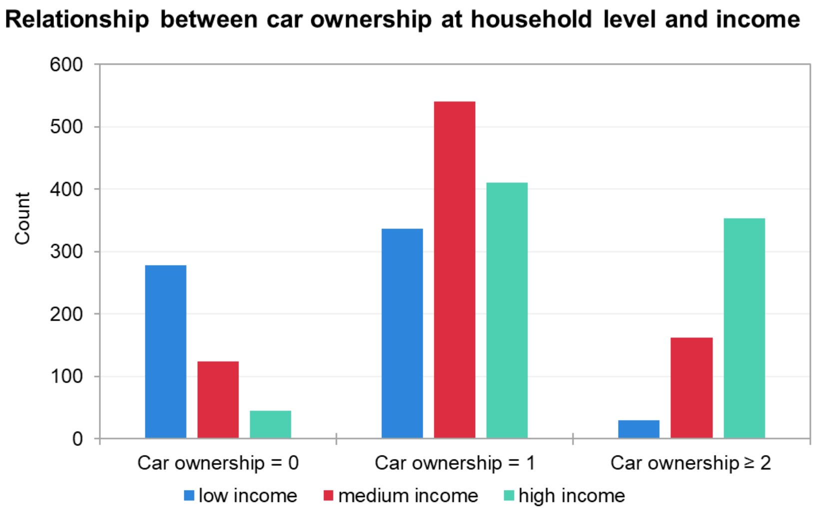
Step 9 - Disaggregate car ownership model

- Growing concern for private car ownership, and the ability of car-sharing services to reduce car-ownership
- Need for a car-ownership model, especially with the consideration of the supply of car-sharing system
- Variables: Age, household size, income, cargo bike ownership, PT pass availability, car-sharing subscription , car-sharing supply (number of vehicles per district) and commute speed



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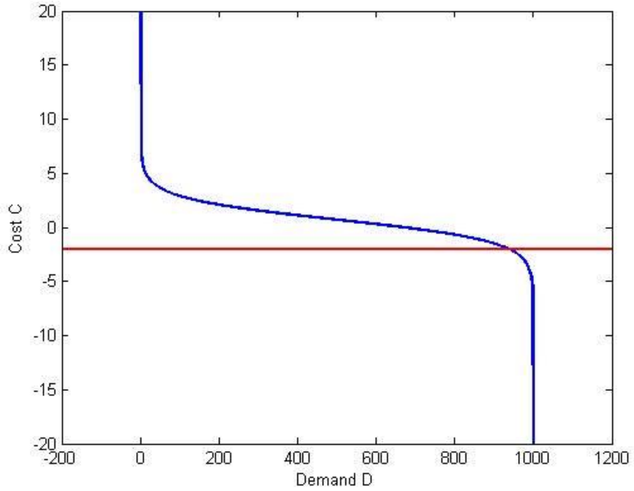
Step 10 - Induced demand (demand elasticity)

- New modes of transport induce changes in demand (OD matrix)
- A nested logit model, with choices to travel or not at upper level and the different modes at lower level of the choice to travel
- Sum of the utilities of each mode (i.e., the total utility of the available modes) is considered as the utility to travel
- Direct quantification of the utility of the choice "not-to-travel" is not possible. Calibration based on case-specific survey or demand elasticity from the literature is feasible



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Multi-method framework for car-sharing service in Regensburg

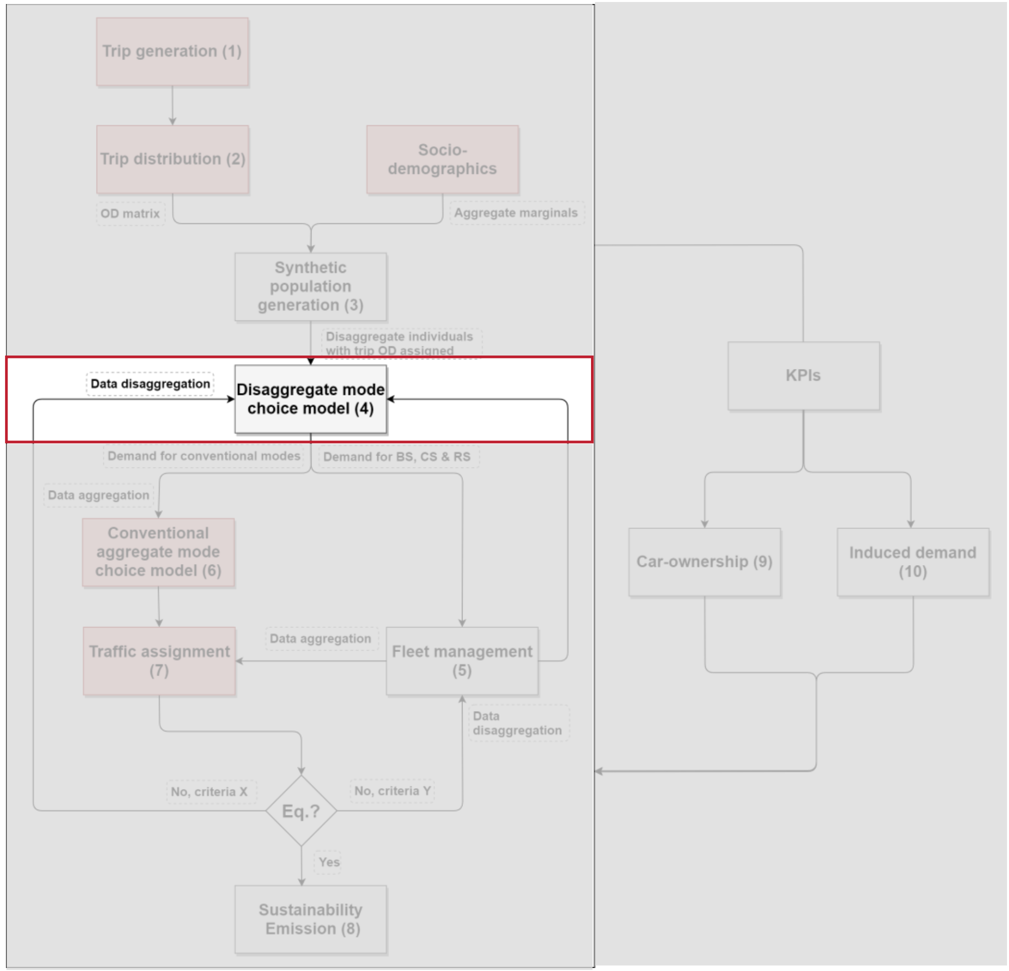
Narayanan, S., & Antoniou, C. (2021). Expansion of a car-sharing service to reduce car-ownership and improve transport equity. Under review.

- The round-trip station-based car-sharing system in Regensburg is specifically designed to focus on serving special trips (e.g., trips to furniture stores)
- PT is meant to cover regular trips like commuting and the car-sharing system is meant to cover special trips (e.g., trips to furniture stores), reducing the necessity for car-ownership.
- The OD matrices from strategic transport models in many cities, usually, do not adequately cover the demand stratum (i.e., special trips) of the aforementioned system.

Multi-method framework for car-sharing service in Regensburg

Needs & objectives

- The car-sharing system is small and the modal split for the service is very less (< 50 trips per day)
- It is not possible to account the demand for the service through the traditional mode choice models and adequately evaluate the service using existing transport modelling approaches.
- An external approach is needed to estimate demand. Besides demand, it is also required to characterize the users of such a system.



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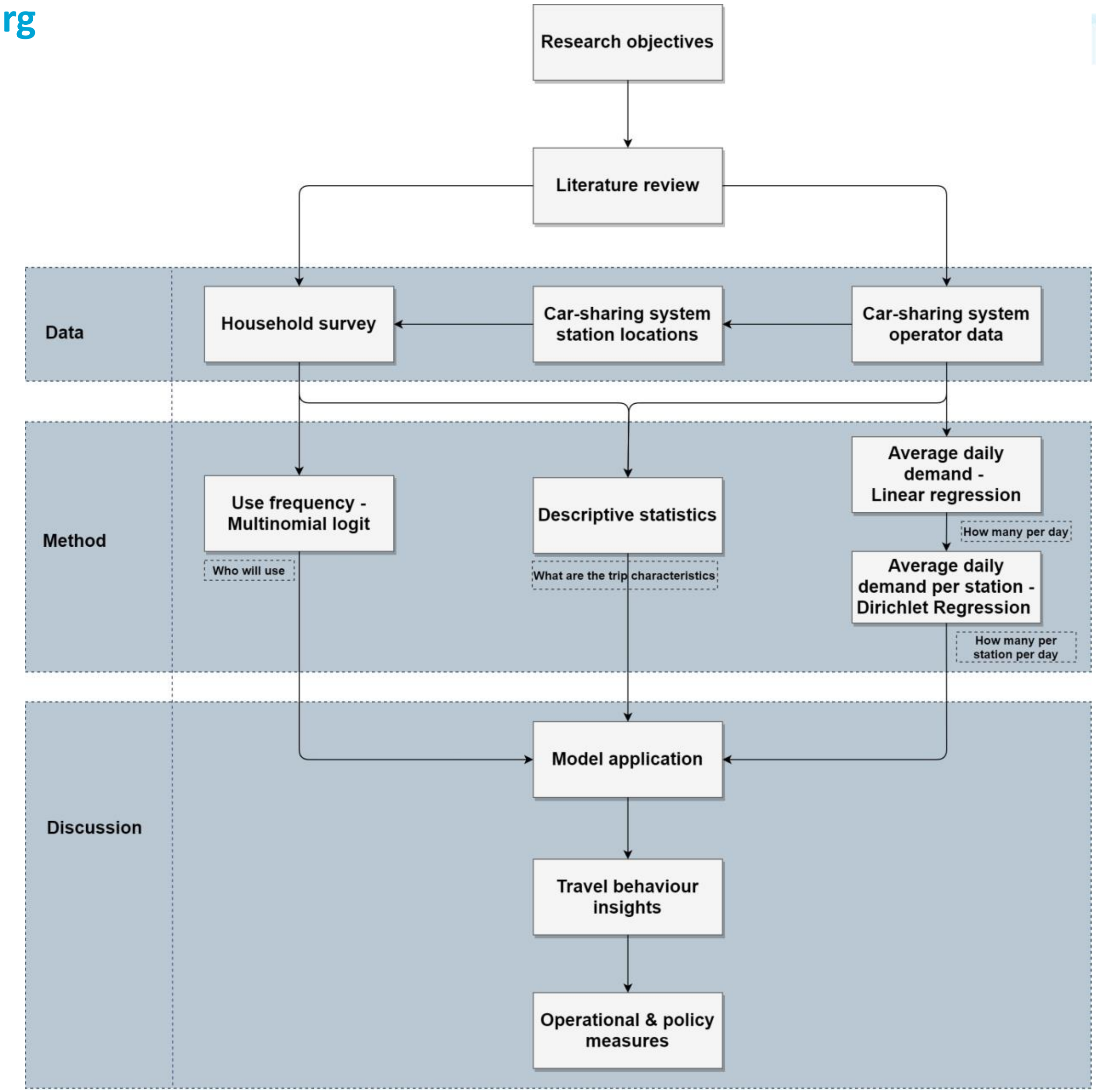
Multi-method framework for car-sharing service in Regensburg
Methodology & data

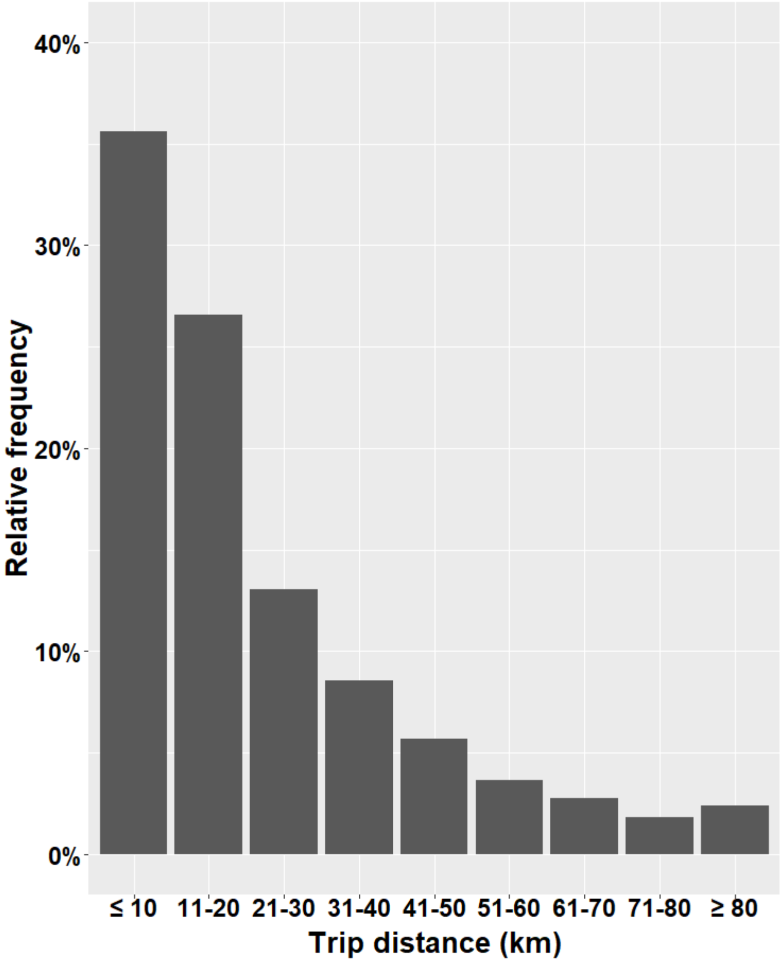
- Household survey
  - Conducted between February 2018 and January 2019, with 2,501 individuals from 1,116 households
  - Frequency of use of the car-sharing system: daily or almost daily, 3 to 4 days per week, 1 to 2 days per week, 1 to 3 days per month, 1 or 2 days per quarter, rare and never;
  - First two categories have 0 sample; Next two categories grouped together as “medium frequency or occasional users” and the next two categories as “low frequency or rare users”

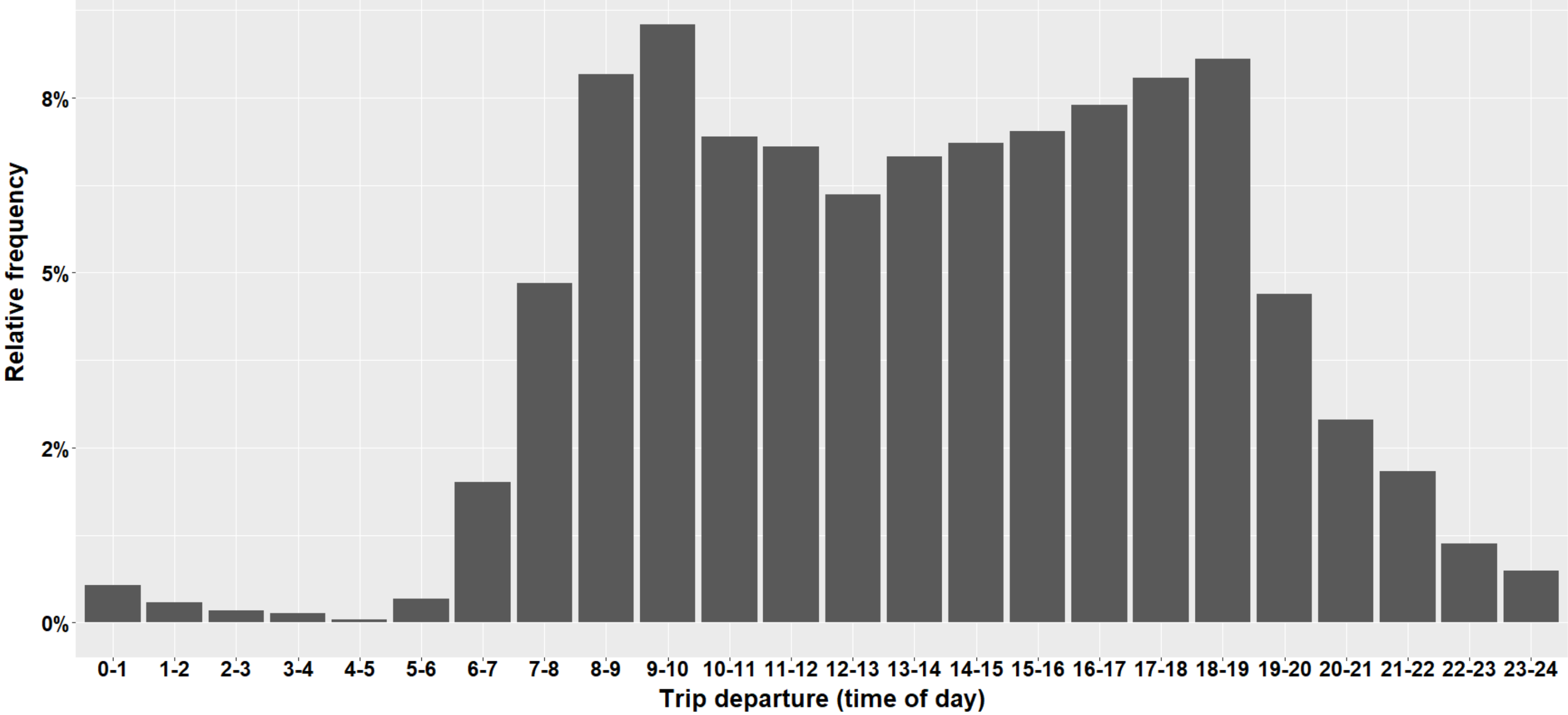
- Operator data
  - A total of 8,567 trips recorded, with Information related to trips occurred between November 2016 and November 2019
  - Details such as booking start and end date and time, pick up and return station (same value because of round-trip system), vehicle make and model, distance travelled during the booking

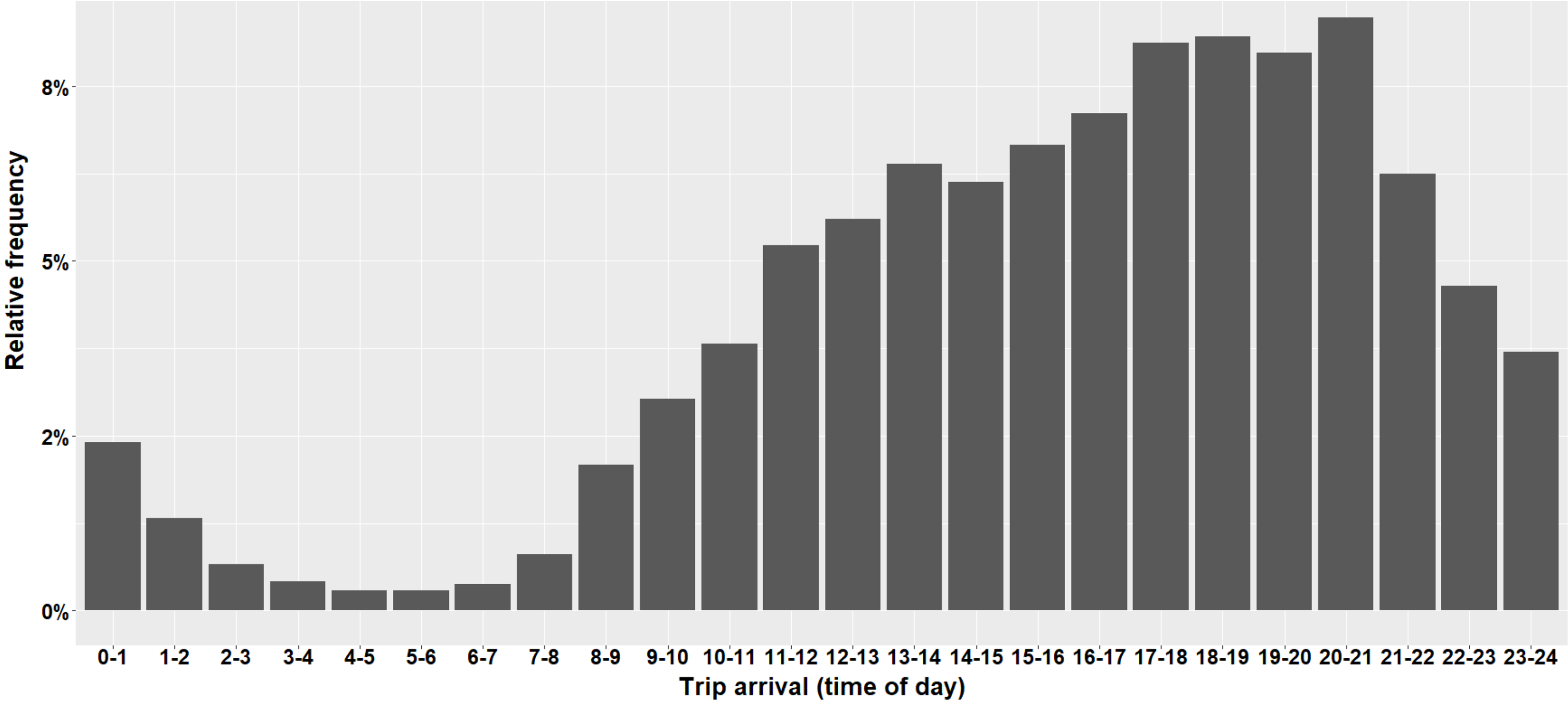


Multi-method framework for car-sharing s

Some descriptive statistics







Multi-method framework for car-sharing service in Regensburg

Estimation results – Use frequency (multinomial logit model)

Variable	Estimate	S.E.	z-value
Age(both O & R)	-0.04	0.01	-4.51 (***)
$\text{Employment}_{\text{Student}}$(O)	1.56	0.46	3.41 (***)
$\text{Employment}_{\text{Student}}$(R)	2.05	0.38	5.39 (***)
$\text{Employment}_{\text{Full}}$(O)	1.14	0.45	2.55 (*)
$\text{Employment}_{\text{Full}}$(R)	1.68	0.37	4.54 (***)
$\text{Employment}_{\text{Half}}$(both O & R)	1.63	0.39	4.14 (***)
hasLowIncome(R)	0.72	0.37	1.95 (.)
hasUniversityDegree(both O & R)	0.61	0.23	2.62 (**)
HHBicyclesNum(R)	0.17	0.05	3.29 (**)
HHCarsNum(both O & R)	-0.33	0.14	-2.35 (*)
$\text{BicycleUse}_{\text{Often}}$(O)	1.55	0.39	3.94 (***)
$\text{BicycleUse}_{\text{Occasional}}$(R)	0.54	0.24	2.23 (*)
$\text{PTUse}_{\text{Often}}$(O)	1.01	0.37	2.75 (**)
$\text{PTUse}_{\text{Occasional}}$(R)	0.50	0.22	2.21 (*)
$\text{PrivateCarUse}_{\text{Rare}}$(R)	0.68	0.33	2.07 (*)
isPTAndCarUser(R)	-0.71	0.35	-2.03 (*)
SharedCarsInTheDistrict(O)	0.24	0.09	2.76 (**)
SharedCarsInTheDistrict(R)	0.14	0.06	2.24 (*)
Intercept (O)	-5.24	0.57	-9.20 (***)
Intercept (R)	-4.21	0.48	-8.86 (***)

Summary statistics

Log-likelihood:	-516.92
McFadden R^2:	0.17
AIC:	1073.85
BIC:	1186.70

Note:

- **O**: Occasional; **R**: Rare; **HH**: Household
- (.) - p <0.1; (*) - p <0.05; (**) - p <0.01; (***) - p <0.001

Multi-method framework for car-sharing service in Regensburg
Estimation results – Average daily demand (linear regression)

Variable	Estimate	S.E.	t-stat
StationCount	1.82	0.03	55.78 (***)
isFriday	0.56	0.22	2.55 (*)
isSaturday	-0.46	0.22	-2.11 (*)
isSunday	-2.58	0.22	-11.87 (***)
isFebruary	1.23	0.29	4.32 (***)
isInMarch/April/May	1.52	0.18	8.52 (***)
isJuly	0.79	0.27	2.90 (**)
Intercept	0.91	0.17	5.23 (***)

Summary statistics

Adjusted R^2: 0.75

AIC: 5139.35

BIC: 5184.44

Note: (*) - $p < 0.05$; (**) - $p < 0.01$; (***) - $p < 0.001$

Multi-method framework for car-sharing service in Regensburg
Estimation results – Average daily demand per station (Dirichlet regression)

Variable	Estimate	S.E.	z-value
AverageDailyDemand(B)	2.85	0.59	4.84 (***)
AverageDailyDemand(C)	3.10	0.38	8.10 (***)
AverageDailyDemand(D)	2.07	0.38	5.40 (***)
AverageDailyDemand(K)	2.37	0.41	5.78 (***)
AverageDailyDemand(R)	1.97	0.32	6.11 (***)
AverageDailyDemand(P)	2.77	0.36	7.57 (***)
AverageDailyDemand(S)	1.96	0.43	4.55 (***)
AverageDailyDemand(T)	3.06	0.41	7.37 (***)
isMonday(C)	-0.46	0.25	-1.83 (.)
isTuesday(S)	0.40	0.22	1.85 (.)
isWednesday(R)	0.38	0.22	1.75 (.)
isWednesday(P)	0.51	0.18	2.88 (**)
isFriday(D)	-0.35	0.21	-1.67 (.)
isFriday(S)	0.33	0.20	-1.64 (.)
isSaturday(C)	0.49	0.21	2.32 (*)
isSunday(B)	0.79	0.37	2.12 (*)
isSunday (S)	0.51	0.29	1.73 (.)
Intercept(B)	-7.84	1.65	-4.75 (***)
Intercept(C)	-7.84	1.06	-7.38 (***)
Intercept(D)	-4.36	1.05	-4.16 (***)
Intercept(K)	-6.01	1.13	-5.31 (***)
Intercept(R)	-4.73	0.89	-5.33 (***)
Intercept(P)	-6.39	1.01	-6.32 (***)
Intercept(S)	-4.43	1.20	-3.70 (***)
Intercept(T)	-7.92	1.15	-6.90 (***)

Summary statistics

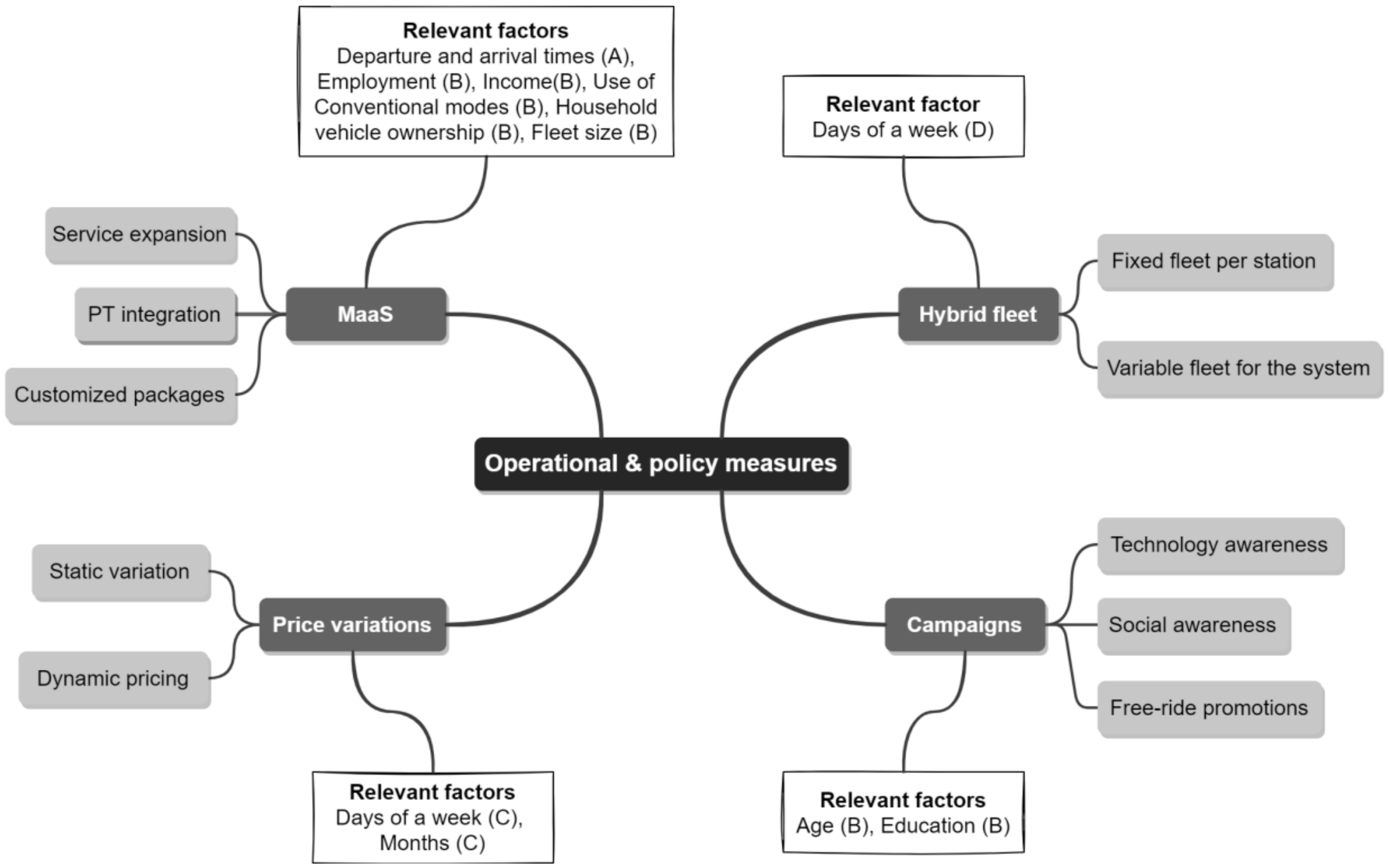
AIC: -1176

BIC: -1125

Note:

- **B**: Burgweinting; **C**: Candis; **D**: Dachauplatz; **K**: Koenigswiesen; **L**: Landratsamt; **P**: Petersweg; **S**: Stadtamhof; **T**: Techbase
- (.) - p <0.1; (*) - p <0.05; (**) - p <0.01; (***) - p <0.001

Multi-method framework for car-sharing service in Regensburg
Insights



Note: A - Based on descriptive statistics; B - Factor from multinomial logit model; C - Factor from linear regression model; D - Factor from dirichlet regression model

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