Modeling Emerging Urban Mobility

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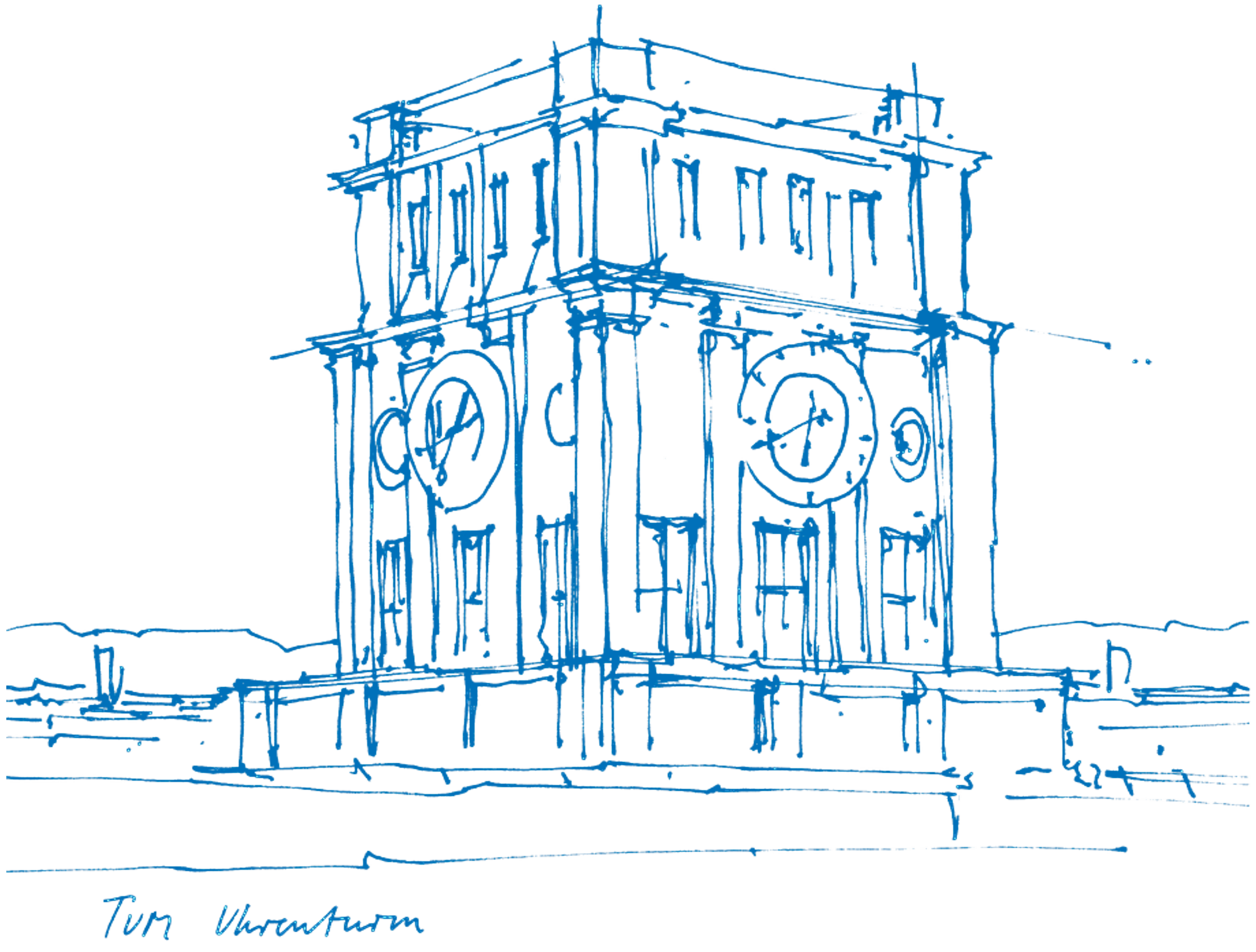
http://tse.bgu.tum.de , http://web.mit.edu/costas/www/

Swiss Transport Research Conference
Exchanging Ideas for Transport

MOMENTUM
Modelling Emerging Transport Solutions for Urban Mobility
https://h2020-momentum.eu

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

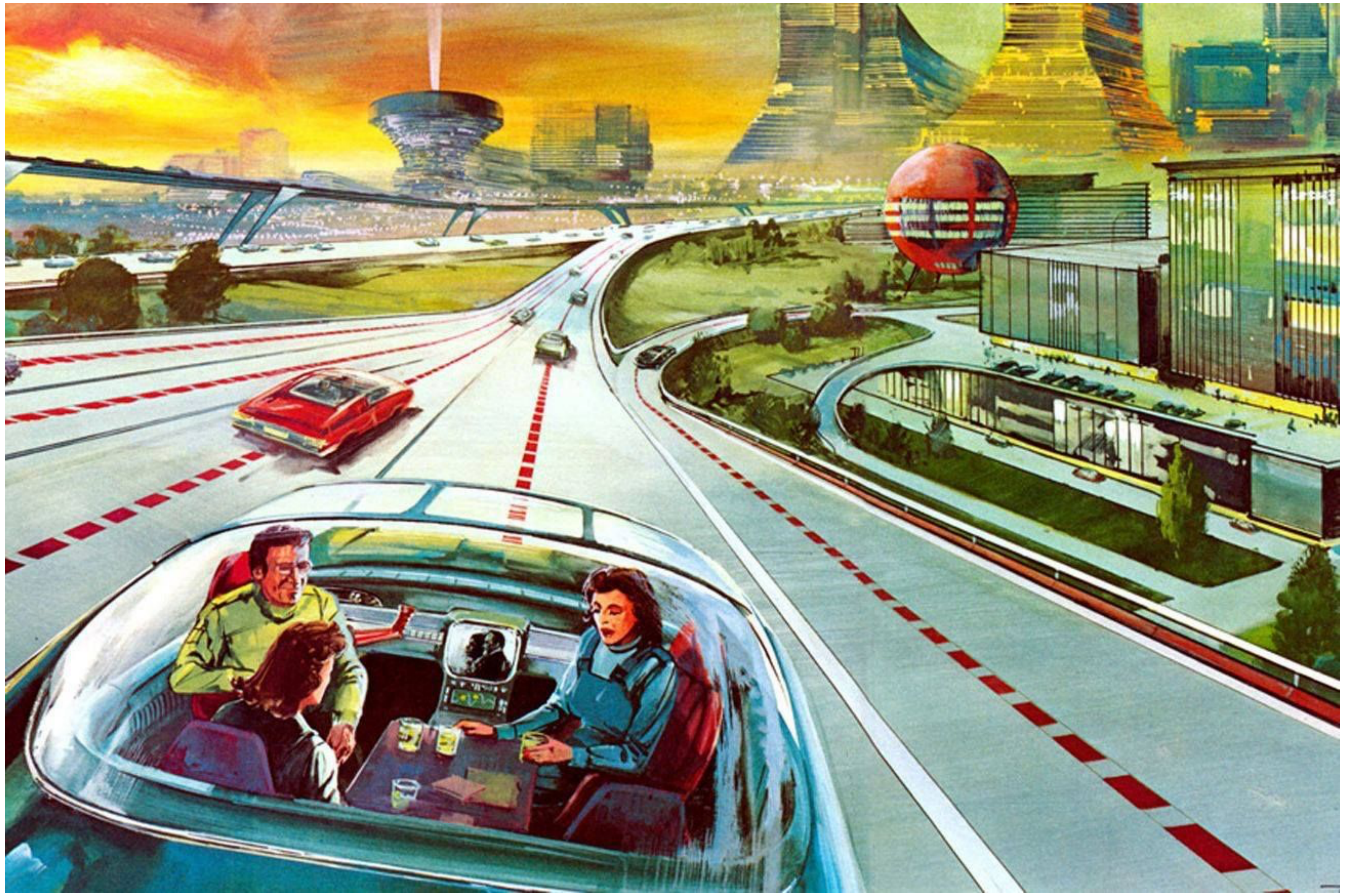


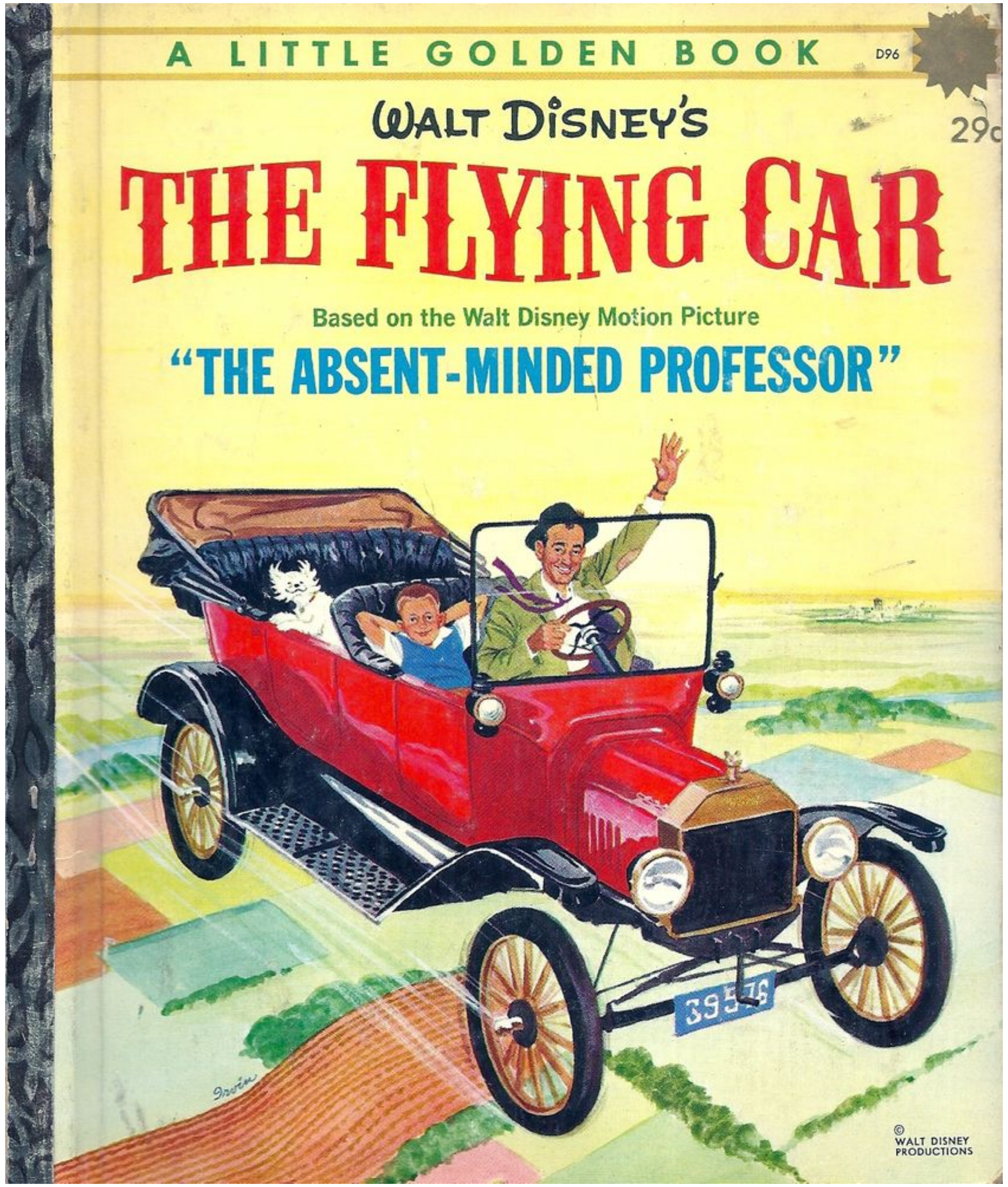
Background and motivation

Overall approach

Case studies

- Disaggregate mode choice model
- Modeling purchase intention/decision for cargo bikes

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WALT DISNEY'S
THE FLYING CAR
Based on the Walt Disney Motion Picture
"THE ABSENT-MINDED PROFESSOR"
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3 Revolutions. What are they?

Electrification

Hybrid electric and all-electric vehicles

Automation

Automated vehicles, eliminating the need for a driver

Shared Mobility

Shared vehicle trips and public transport

https://3rev.ucdavis.edu


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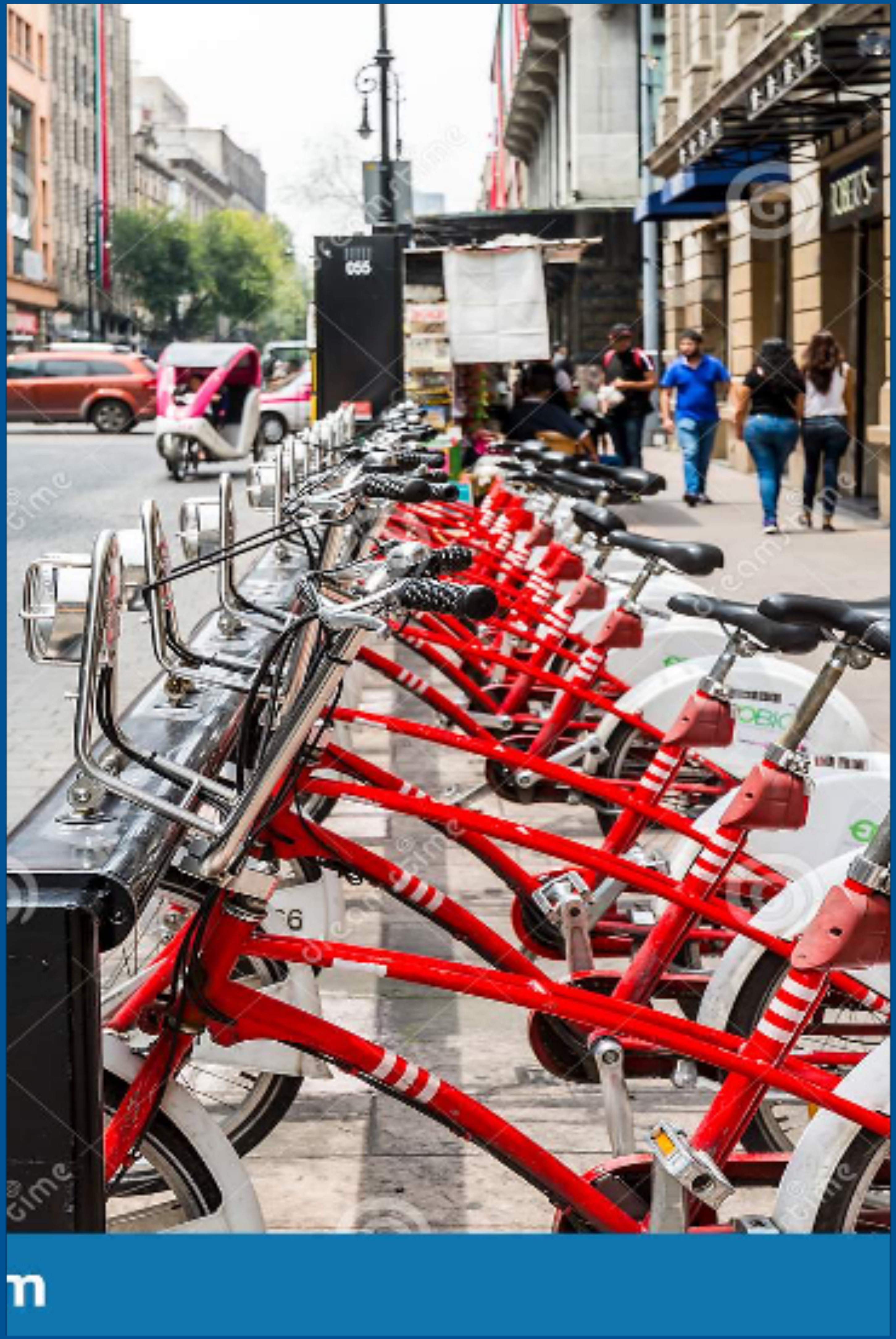


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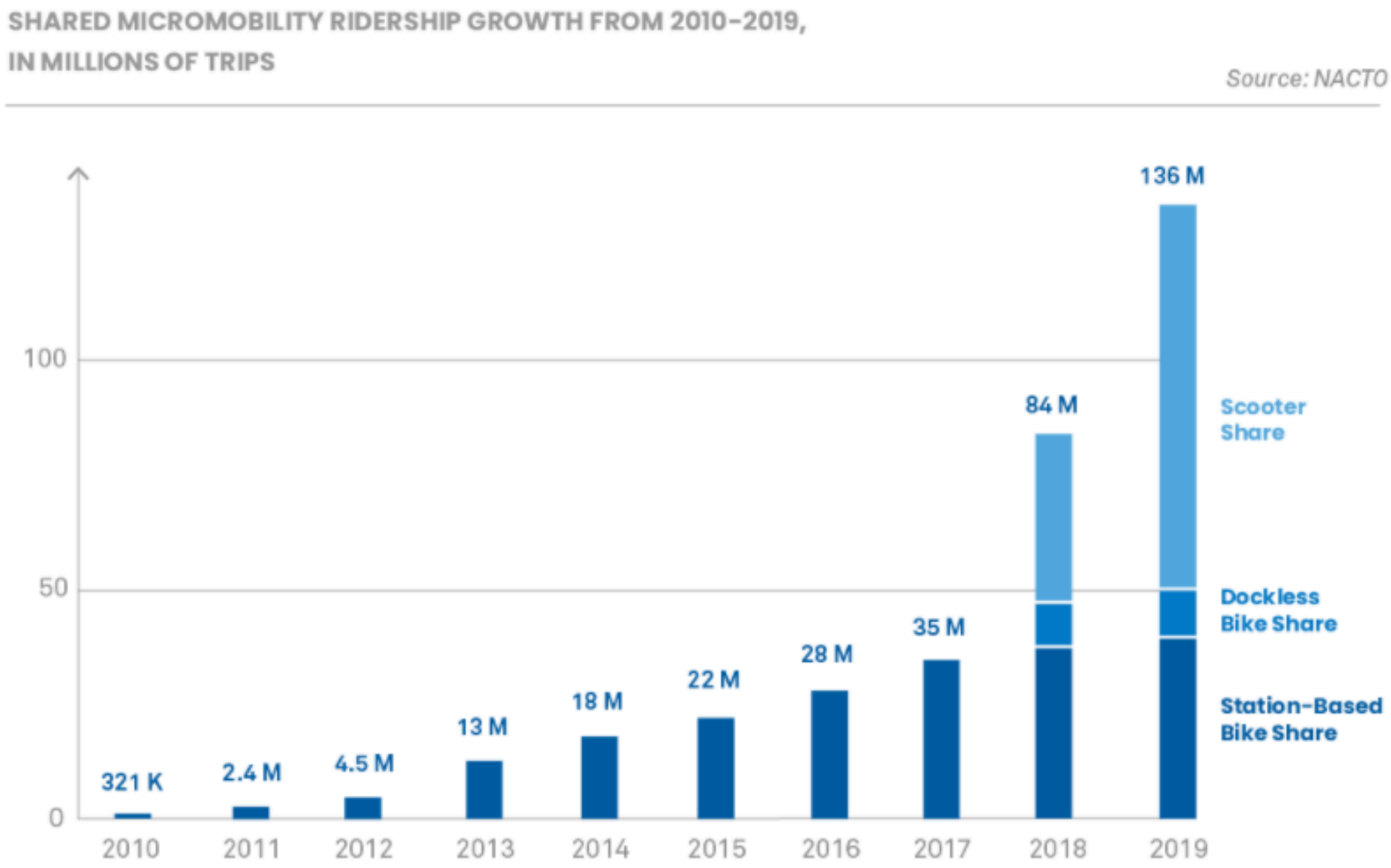

Source: Nacto, https://nacto.org/shared-micromobility-2019/

Motivation

Shared mobility services were abruptly introduced

No prior planning, no understanding and evaluation

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Open questions include

- Spatio-temporal demand patterns for the different services
- Factors impacting demand
- Factors attracting users from other modes of transport to shared services
- Interaction between the different shared services (incl. “internal” competition)
- Shared services’ impact on the VKT
- Identification of policies required for efficient and effective urban operations

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Modelling of shared mobility requires agent based approaches (based on the literature)

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H2020 MOMENTUM - Needs & objectives

Many cities continue to use the traditional strategic four-step modelling approach

(Especially) small & medium sized cities do not have the resources to develop new models

Need for an intermediate modelling approach, which can be integrated into the existing models

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H2020 project, topic LC-MG-1-3-2018 **‘Harnessing and understanding the impacts of changes in urban mobility on policy making by city-led innovation for sustainable urban mobility’**

Start: 1st May 2019 | Duration: 36 months | Budget: 2.9 M€

Consortium: EMT Madrid (Coordinator) + 3 cities (Thessaloniki, Leuven, Regensburg) + 2 providers of technology solutions for transport planning (Nommon, Aimsun) + 1 transport consultancy (TML) + 3 research institutions (CERTH, TU Munich, Deusto) + POLIS + UITP

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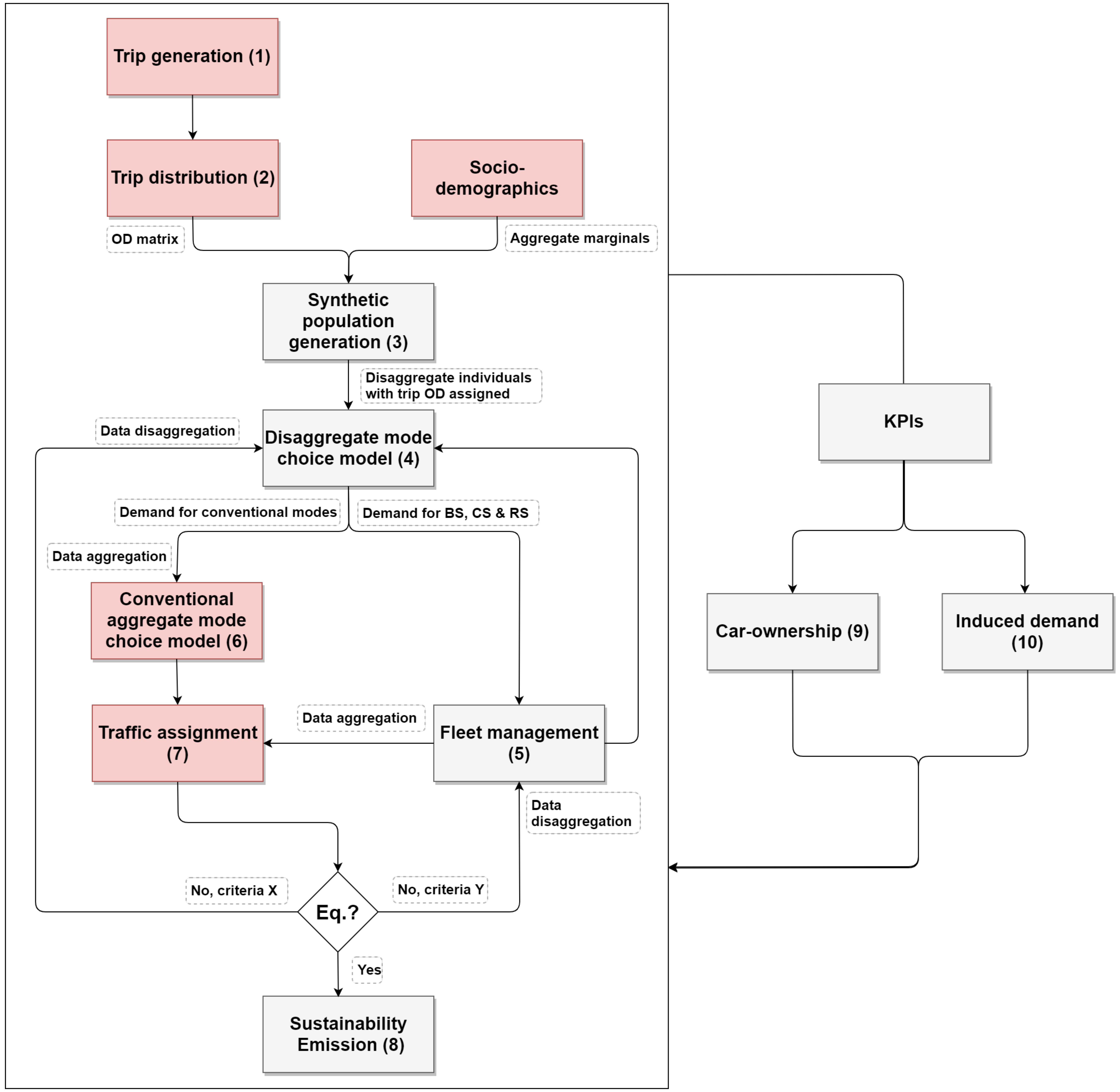
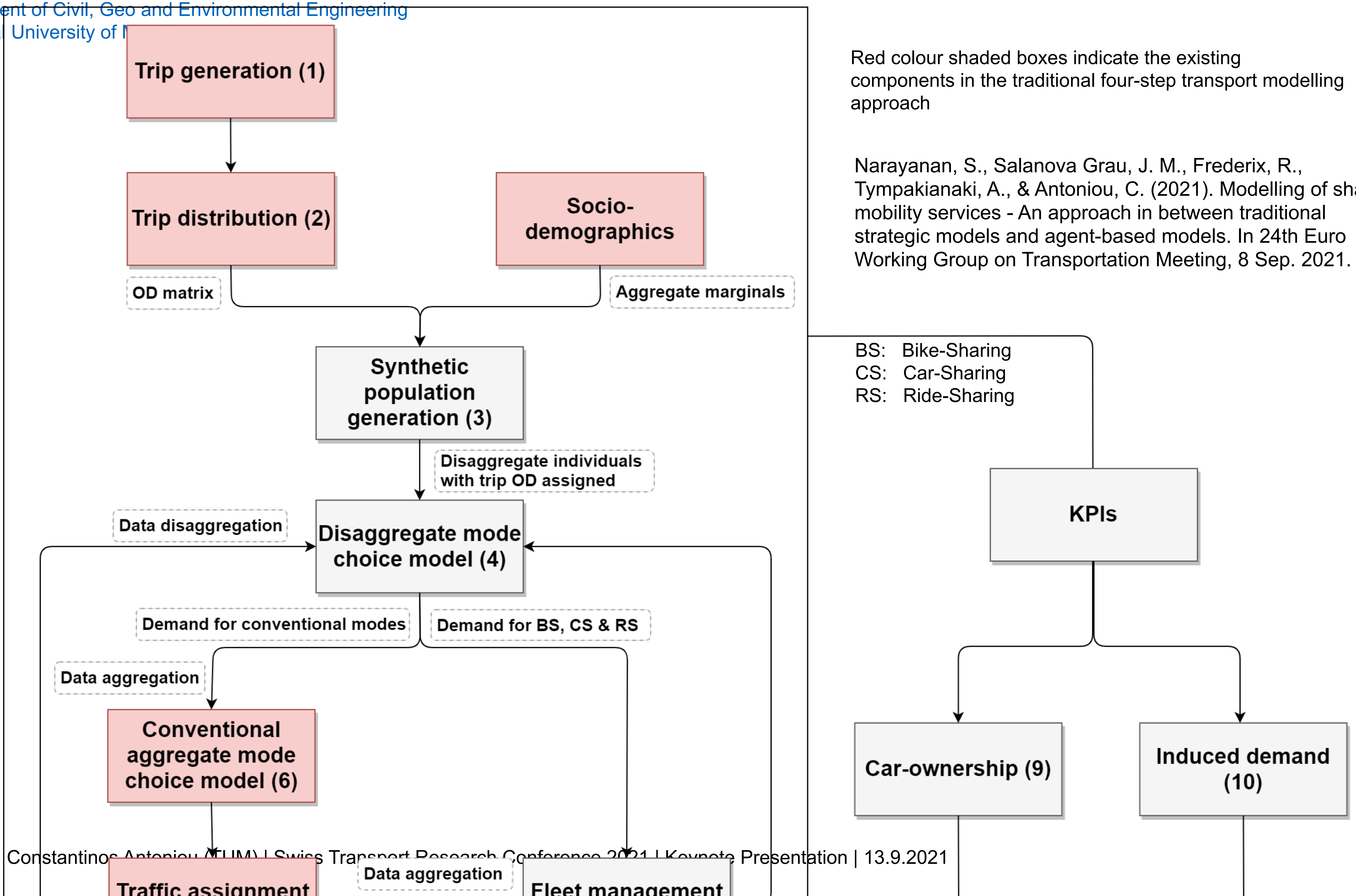
Intermediate modelling approach

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

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 Meeting, 8 Sep. 2021.



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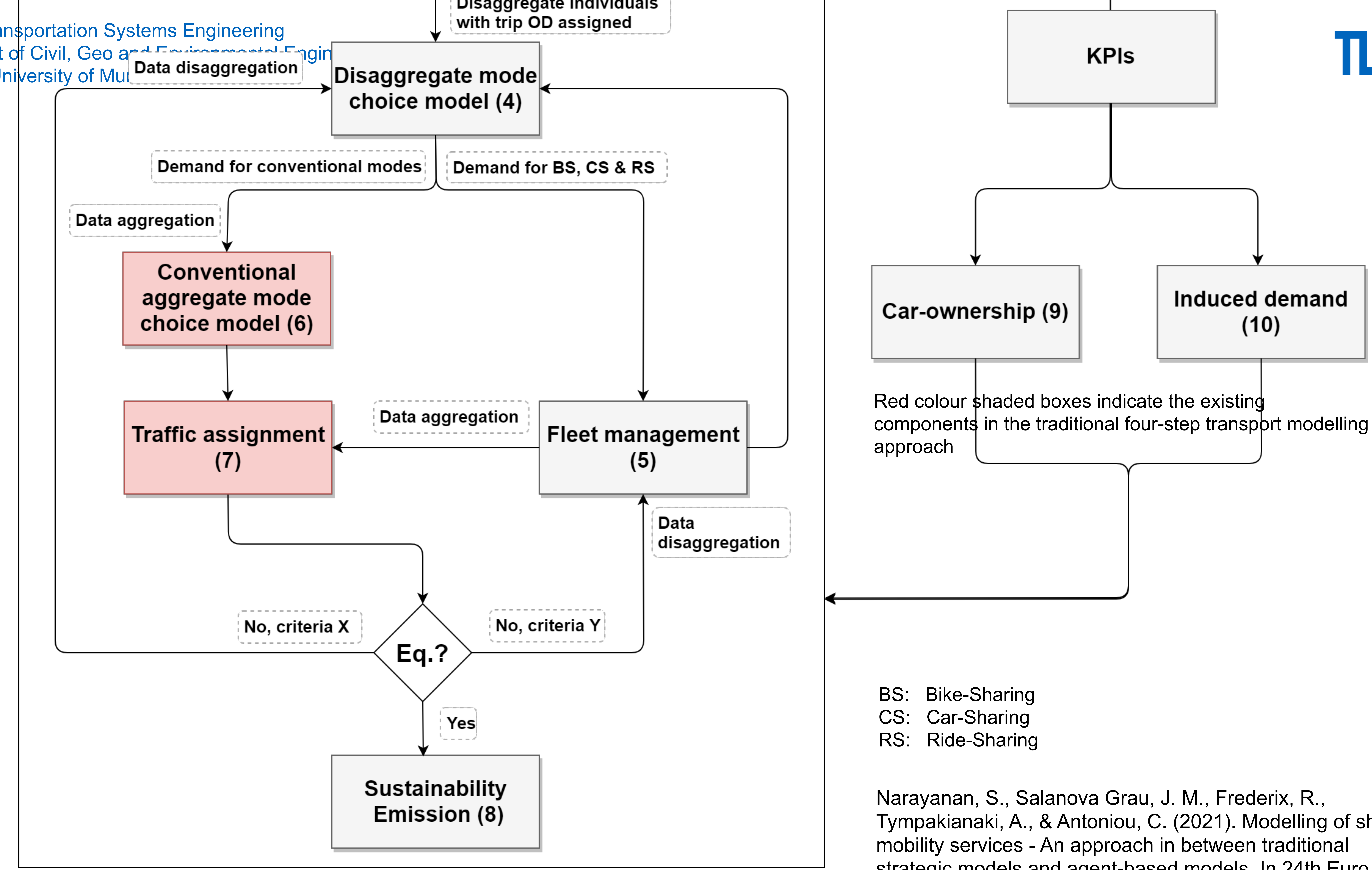

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Step	Type
3. Synthetic population generation	Iterative proportional updating algorithm and data-driven sampling and statistical matching procedure for enrichment
4. Disaggregate mode choice model	Multinomial logit model based on smoted household survey data
5. Fleet management	Service optimization (methods from OR) and service simulator (Aimsun Ride)
8. Emission calculation	Macroscopic emission model (COPERT model)
9. Car-ownership	Multinomial logit model
10. Induced demand estimation	Nested logit model

- 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

OR – Operations Research
COPERT - COmputer Programme to estimate Emissions from Road Transport

MOMENTUM GitHub repository

Some of the individual model codes are being made available in a GitHub repository
Framework application: Tests in Madrid, Leuven, Regensburg and Thessaloniki, as part of EU H2020 project MOMENTUM

https://github.com/h2020-momentum/MOMENTUM

https://h2020-momentum.eu

Background and motivation

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Shared mobility services towards
Mobility as a Service (MaaS): What, who and when?

Narayanan, S., & Antoniou, C. (2021). Shared mobility services towards Mobility as a Service (MaaS): What, who and when?. Under review.

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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Disaggregate choice model
Methodology and data

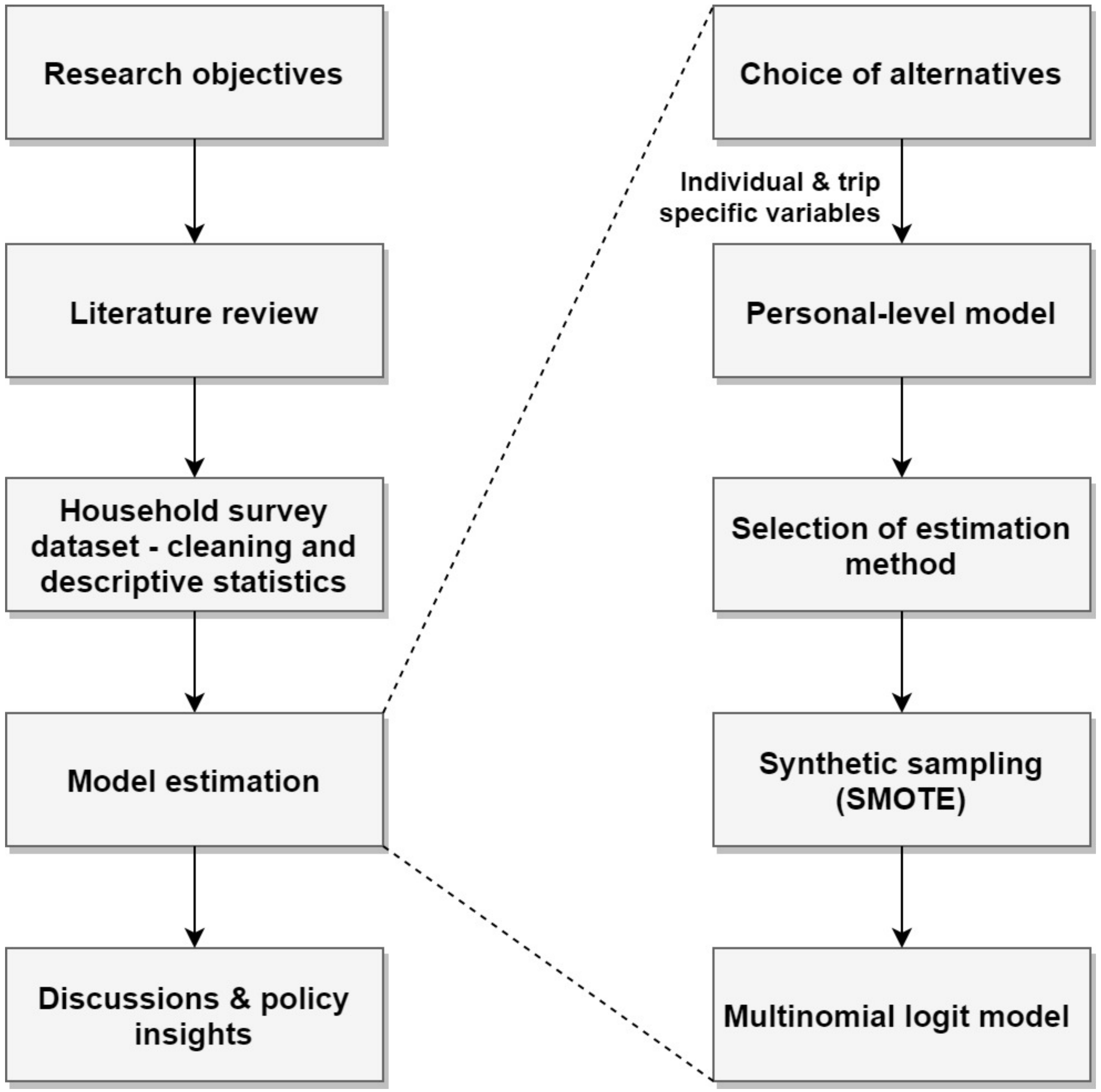
Household survey collected by the Madrid regional government between February 2018 and June 2018

85,064 individuals from 58,490 households

Reduced sample of 25,463 individuals from 20,916 households (based on the traffic zones where shared systems are available)

Shared mobility services: <1%

Bike-sharing supply data from Nommon



Group	Variable	Estim.	S.E.
Who	Age$_{20-44}$(B)	1.11 (***)	0.04
	Age$_{20-44}$(C)	1.07 (***)	0.04
	Age$_{20-44}$(R)	0.80 (***)	0.04
	isMale(B)	1.44 (***)	0.03
	isMale(C)	1.27 (***)	0.03
	hasUnivOrVocationalDegree(B & R)	0.92 (***)	0.03
	hasUnivOrVocationalDegree(C)	1.48 (***)	0.04
	hasAnyLicense(R)	-0.19 (***)	0.04
	hasPTPass(B)	1.13 (***)	0.04
	hasPTPass(C)	0.89 (***)	0.04
	hasPTPass(R)	-0.27 (***)	0.03
	HHCarsNum(B)	-0.69 (***)	0.02
	HHCarsNum(C)	0.45 (***)	0.02
When	TripDistance$_{KM\leq 2}$(B)	1.45 (***)	0.06
	TripDistance$_{KM>2\&\leq 5}$(B)	2.18 (***)	0.06
	TripDistancet$_{KM>2And\leq 5}$(R)	1.47 (***)	0.04
	TripDistance$_{KM>2And\leq 5}$(C) & TripDistance$_{KM>5and\leq 15}$(R)	1.77 (***)	0.03
	TripDistance$_{KM>5And\leq 15}$(C)	2.02 (***)	0.05
	TotalTravelTime$_{Mins\leq 15}$(C)	2.04 (***)	0.06
	TotalTravelTime$_{Mins\leq 15}$(R) &	1.35 (***)	0.04

	hasPTPass(R)	-0.27 (***)	0.03
	HHCarsNum(B)	-0.69 (***)	0.02
	HHCarsNum(C)	0.45 (***)	0.02
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	$\text{TripDistance}_{KM>2And\leq5}$(C) & $\text{TripDistance}_{KM>5and\leq15}$(R)	1.77 (***)	0.03
	$\text{TripDistance}_{KM>5And\leq15}$(C)	2.02 (***)	0.05
	$\text{TotalTravelTime}_{Mins\leq15}$(C)	2.04 (***)	0.06
	$\text{TotalTravelTime}_{Mins\leq15}$(R) & $\text{TotalTravelTime}_{Mins>15And\leq30}$(C)	1.35 (***)	0.04
	$\text{TotalTravelTime}_{Mins>15And\leq30}$(R) & $\text{TotalTravelTime}_{Mins\leq30}$(B)	0.87 (***)	0.04
	SharedBikesInTheTrafficZone[1](B)	1.36 (***)	0.04
–	ASC(B)	-4.57 (***)	0.11
	ASC(C)	-5.85 (***)	0.11
	ASC(R)	-2.47 (***)	0.06

Summary statistics

Log-likelihood: -35216.21
McFadden R^2: 0.22
AIC: 70482.42
BIC: 70545.21

Note:

- B: Bike-Sharing; C: Car-Sharing; R: ride-hailing; HH - HouseHold

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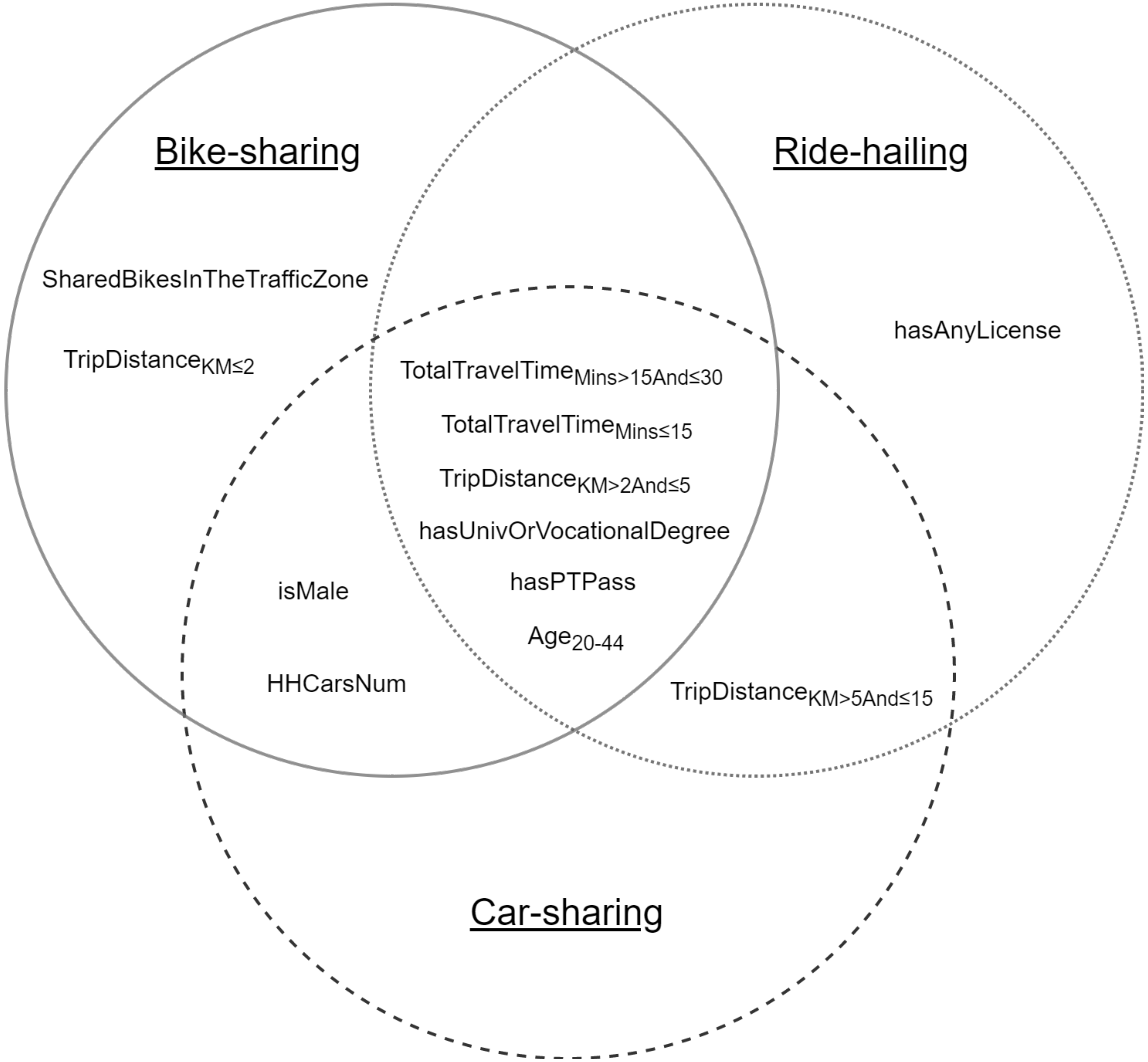
Common characteristics



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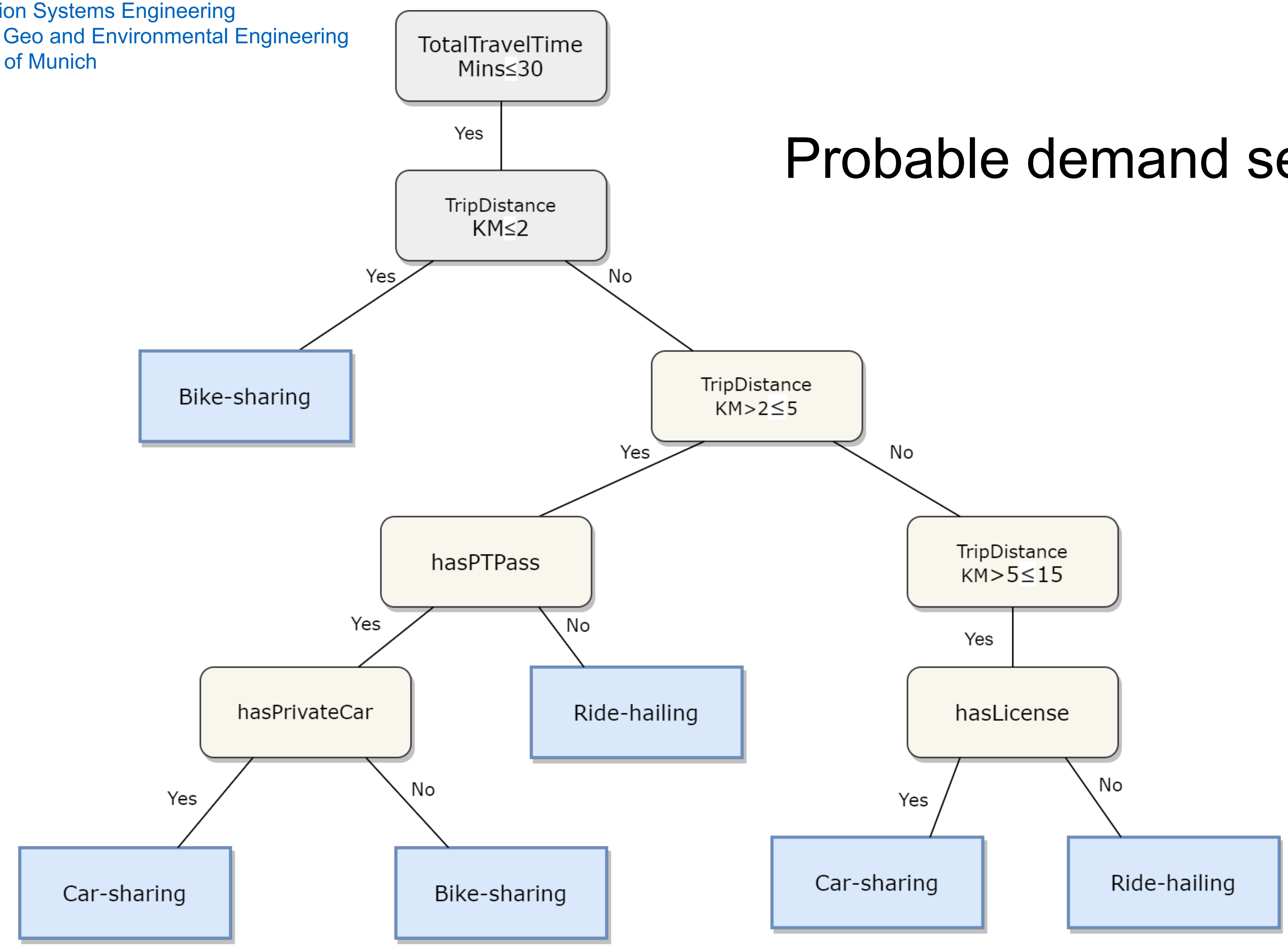
Probable demand segments



Purchase intention and actual purchase of cargo cycles: Influencing factors and policy insights

Narayanan, S., Gruber, J., Liedtke, G., & Antoniou, C. (2021). Purchase intention and actual purchase of cargo cycles: Influencing factors and policy insights. Transportation Research Part A: Policy and Practice (Under 2nd review).

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

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

NATIONAL CLIMATE INITIATIVE

Cargo bikes purchase patterns

Previous research shows the influence of possession of cargo cycles on household car-ownership - Can cargo bikes substitute cars?

Can cargo cycles replace cars in commercial transport?

hasCargoBike (1)	-0.72	0.40	-1.78	The availability of a cargo bike in the household decreases the likelihood of having a car (especially, in the case of two or more cars). This could be due to the distinctive features of cargo bikes, which turn them into effective car-substitutes for activities such as shopping, transport of mid-size/weight cargo, etc.
hasCargoBike (2)	-2.19	0.48	-4.52	
hasCargoBike (3)	-3.10	1.13	-2.74	
hasPTPass (1)	-0.85	0.22	-3.88	Possession of a PT pass negatively influence car-ownership.
hasPTPass (2 & 3)	-1.22	0.25	-4.85	
isUnwillingToUseCS (1)	0.61	0.22	2.75	With respect to the attitude of citizens towards car-sharing services, the unwillingness to use car-sharing in the future, as stated by the survey participants, is shown to be related with higher car-ownership levels.
isUnwillingToUseCS (2)	1.04	0.26	4.03	
isUnwillingToUseCS (3)	1.38	0.45	3.10	
CSSupplySubscription Interaction (1, 2 & 3)	-0.12	0.02	-5.27	When a car-sharing subscription is available, an increase in car-sharing supply results in lower probability to own cars. Besides the interaction effect, there is generally a decrease in utility to own two or more cars, with an increase in the number of car-sharing vehicles in the district.
CSSupply (2)	-0.05	0.02	-2.28	
CSSupply (3)	-0.09	0.04	-1.96	
CommuteSpeed (1)	0.03	0.01	4.47	Higher commuting speeds are found to be associated with higher car-ownership levels. A model with coefficient for travel distance suggested an increase in car-ownership for higher distances. These two indicate that existing alternatives to car-ownership are not competitive enough for longer distances.
CommuteSpeed (2 & 3)	0.04	0.01	4.70	
Intercept (2)	-1.00	0.51	-1.98	-
Intercept (3)	-2.66	1.22	-2.18	-

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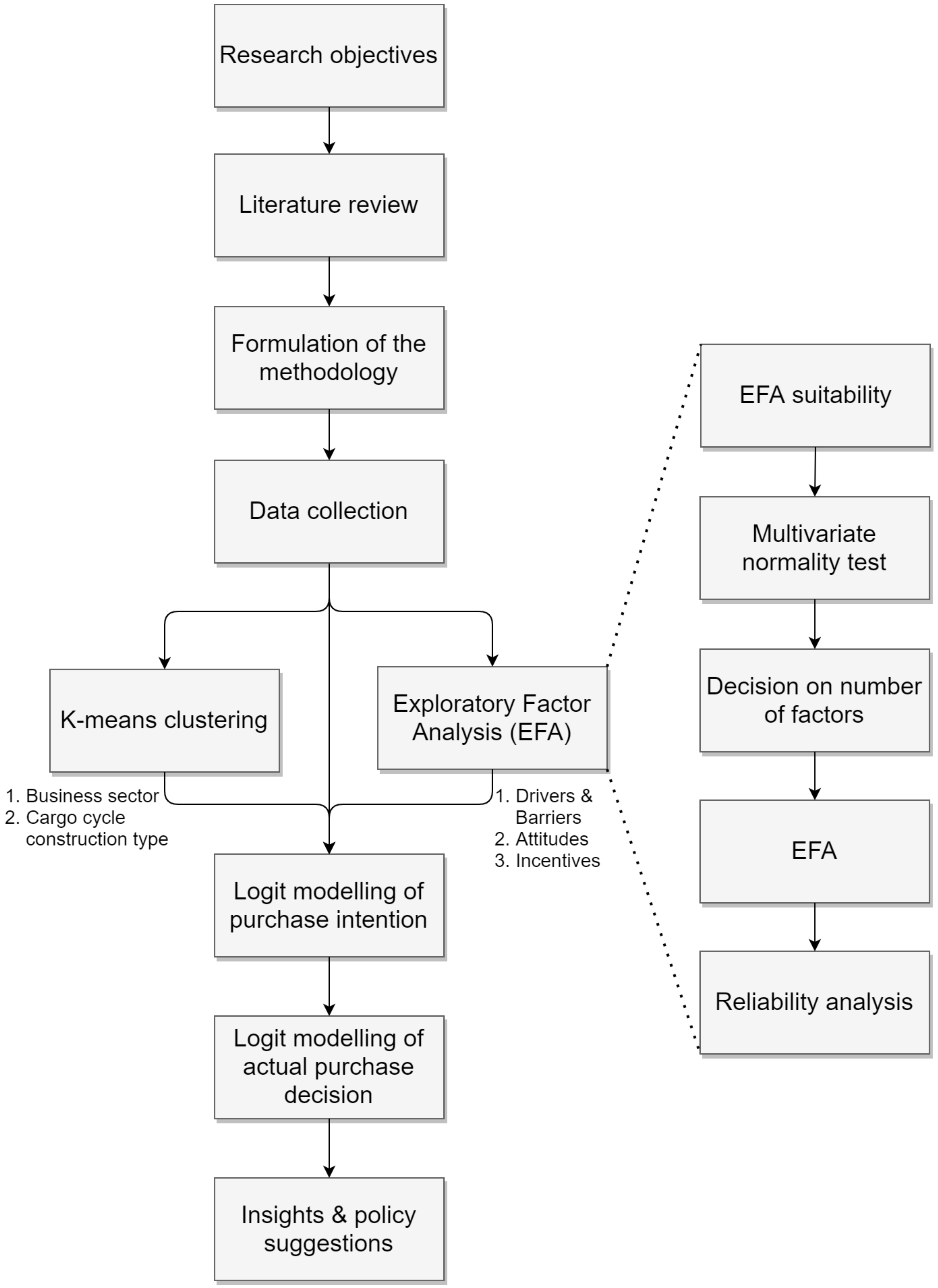
Methodology



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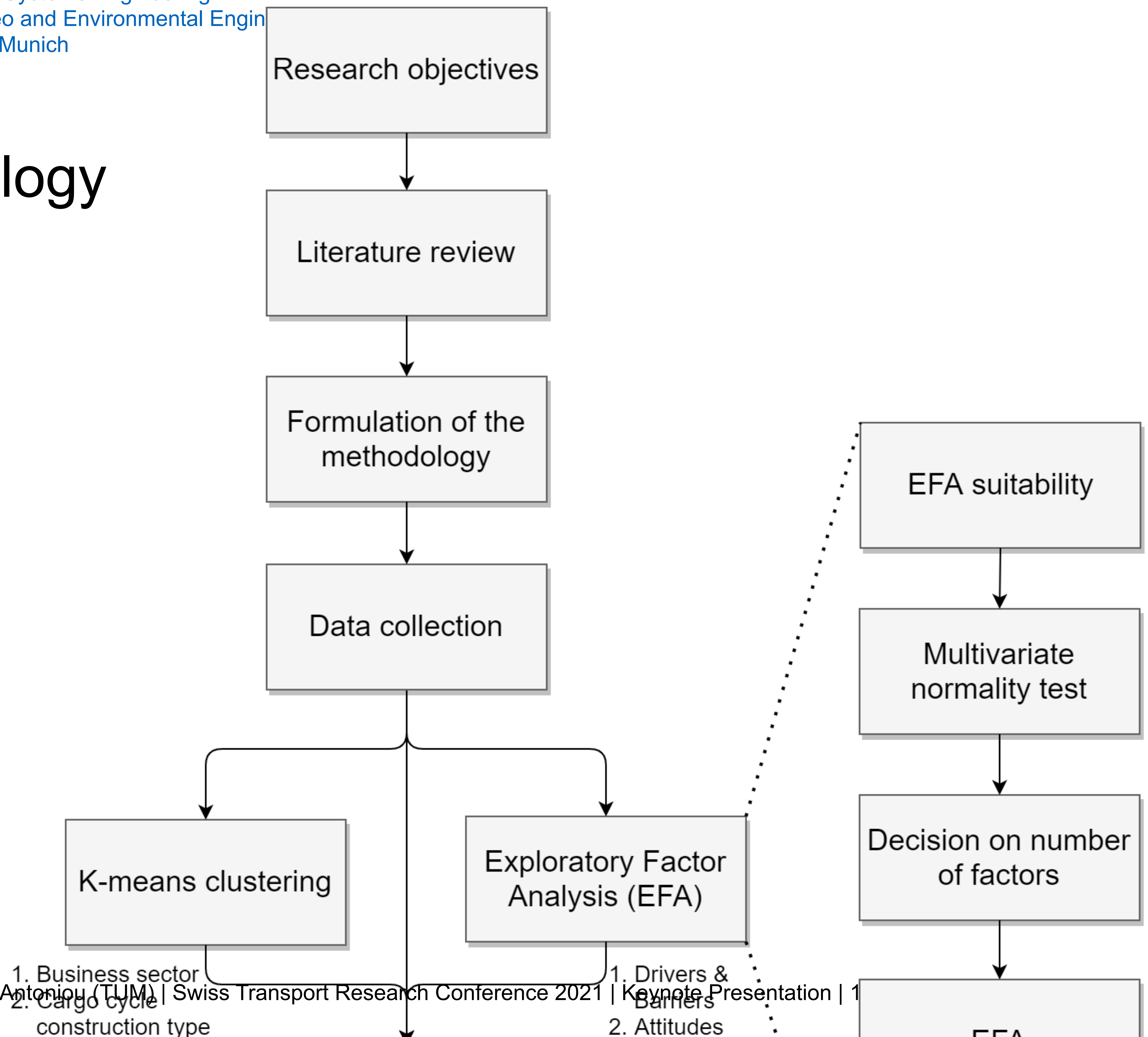

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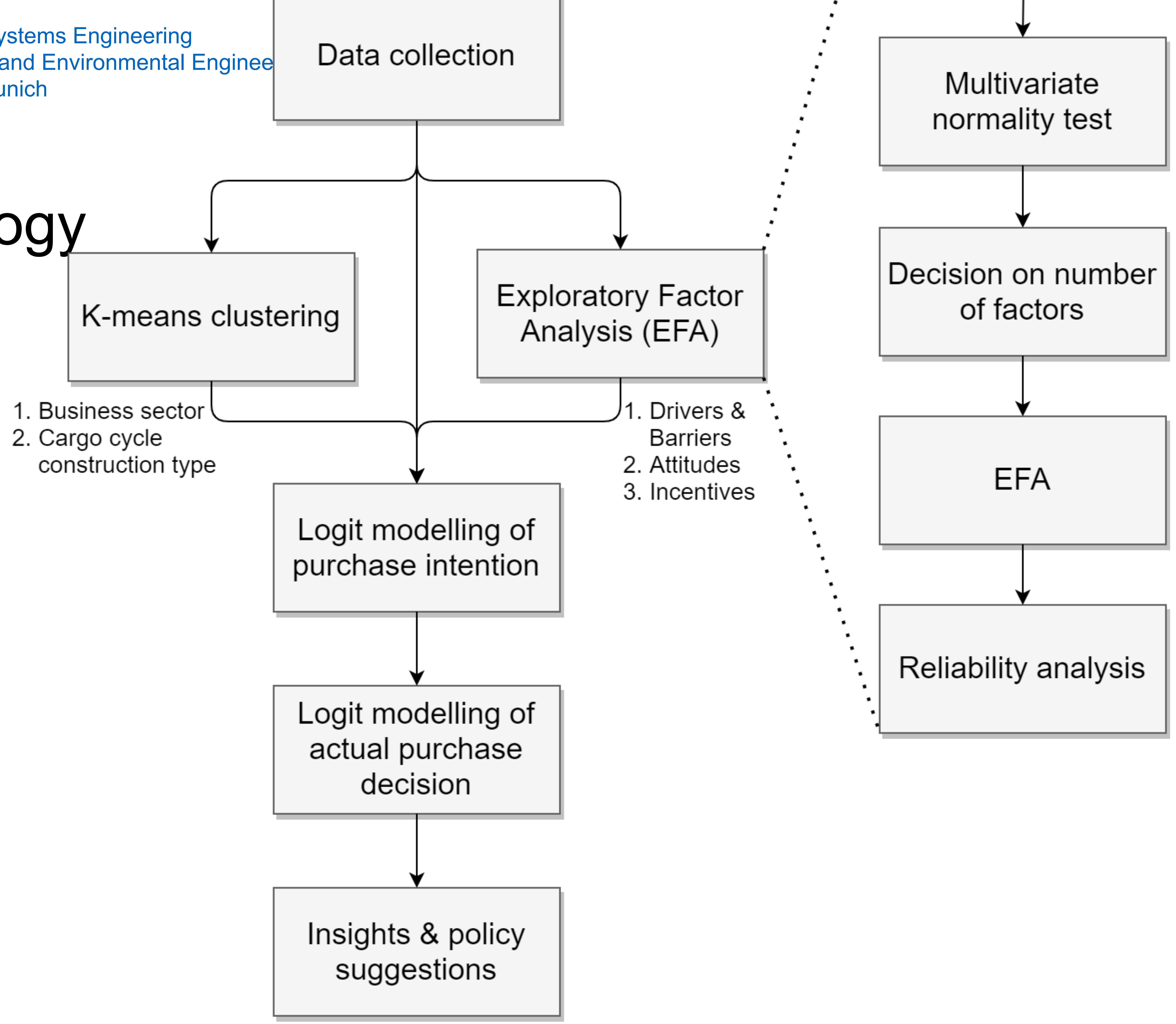

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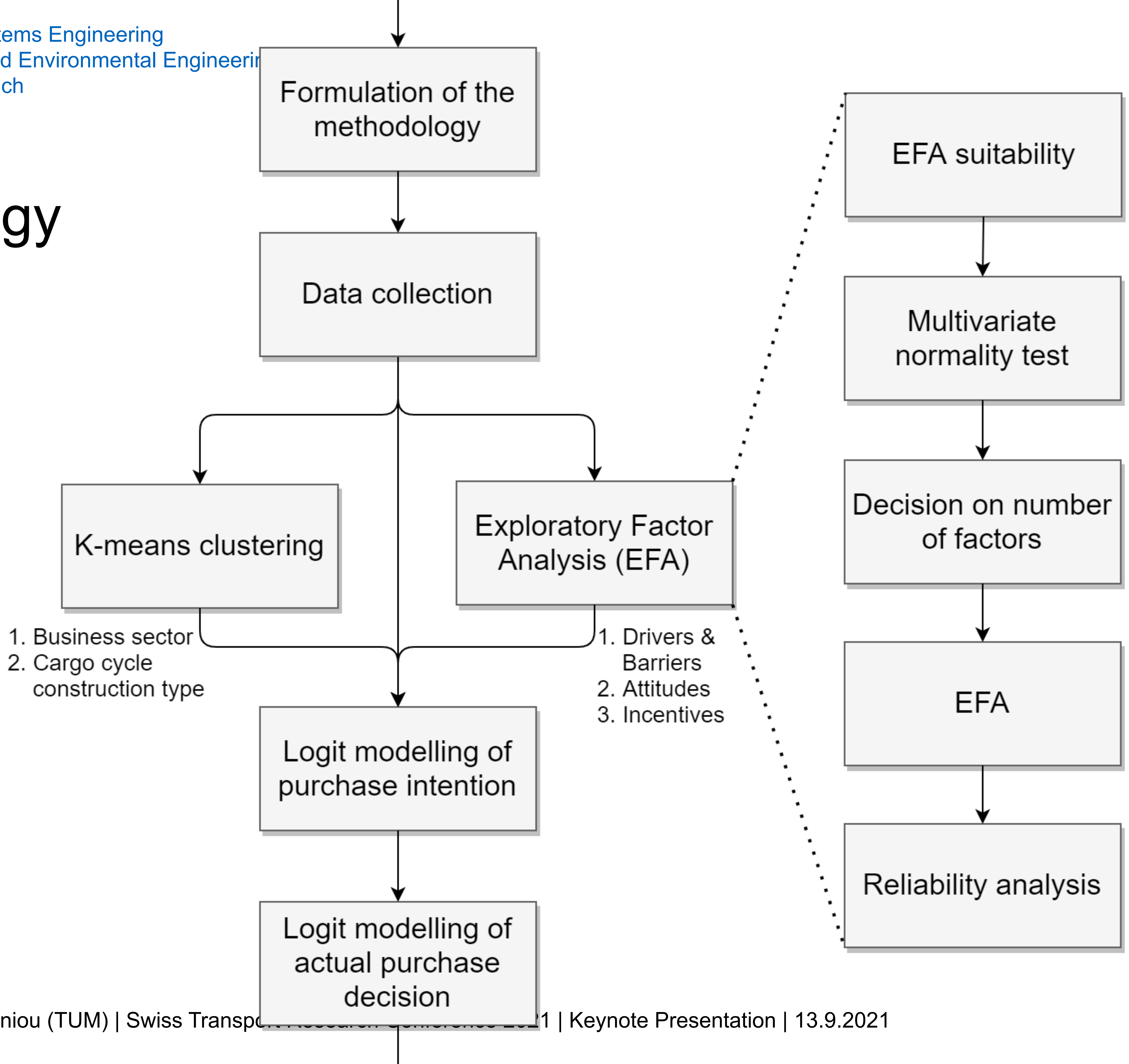


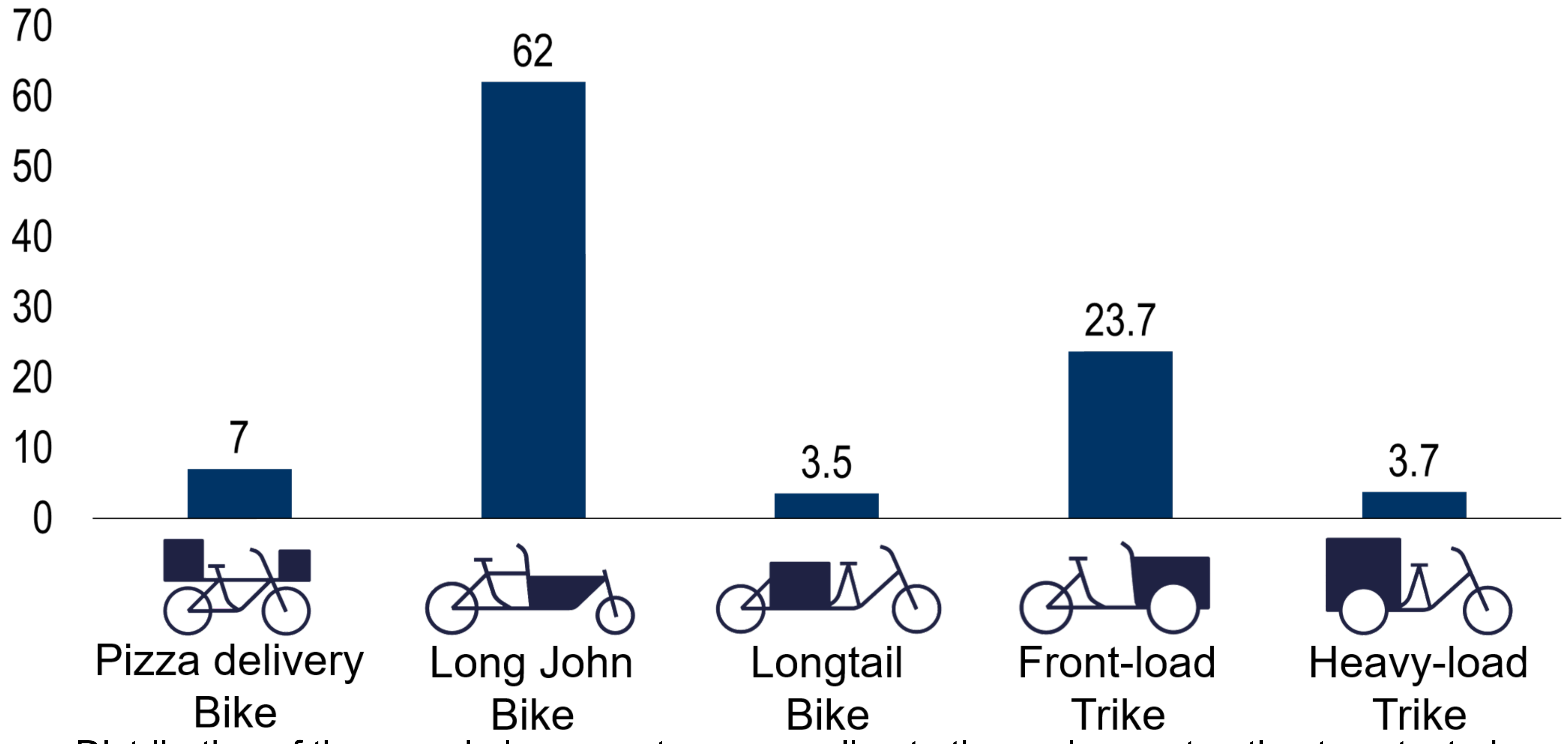
Data

Empirical data from Europe’s largest cargo cycle testing scheme - “Ich entlaste Städte” (Sept. 2017 and Dec. 2019)

Longitudinal survey – (i) before, (ii) at the end, and (iii) 3-12 months after the end of the usage

Tracking of cargo cycle use - a smartphone project application, as well as through a GPS device attached to the cycles

400 organizations located in 187 different municipalities spread across (all the) 16 states of Germany



Distribution of the sample in percentage according to the cycle construction type tested

Estimation results – EFA 1 (Drivers & Barriers)

Loadings	Factor 1	Factor 2	Factor 3	Factor 4
Possible to access areas that are closed to CVs	0.66			
CCs are faster than CVs for my case	0.56			
CCs offer greater flexibility concerning parking or loading/unloading	0.80			
Travel time can be reliably planned	0.59			
Payload could be damaged during transport		0.59		
Using CCs in mixed traffic is dangerous		0.67		
Riding CCs requires experience		0.61		
Cycling infrastructure is inadequate		0.46		
Implementation of CCs requires organizational effort		0.60		
There is no established service network for CCs		0.50		
CCs could get stolen		0.47		
Employees enjoy using CCs			0.63	
CCs help to reach corporate environmental goals.			0.51	
CCs improve the health of the employees			0.73	
CCs promote the image of the organization			0.54	
CCs are cheaper than CVs (purchase cost)				0.76
CCs have lower maintenance costs than CVs				0.48
SSL	2.30	2.27	1.84	1.12
Proportion variance	0.14	0.13	0.11	0.07
Cumulative Variance	0.14	0.27	0.38	0.45
Cronbach alpha	0.72	0.71	0.65	-
Factor interpretation: Perception of	Operational Benefits (F-OB)	Risks & Operational Concerns (F-OC)	Soft Benefits (F-SB)	Cost benefits (F-CB)

Note:
- SSL: Sum of Square of Loadings; CVs: Conventional Vehicles (Diesel/petrol operated cars, vans and trucks); CCs: Cargo Cycles
- Loadings lower than 0.4 are not shown

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Estimation results – EFA 2 (Attitudes)

Loadings	**Factor 1**	**Factor 2**
Willing to invest into climate protection	0.56	
Policymakers should restrict CV traffic	0.73	
All stakeholders of society should fight global warming	0.57	
Economy is more important than environment	-0.52	
CCs are a temporary phenomenon	-0.58	
CCs can be used by all as an alternative to the car	0.51	
CCs will generally prevail in my industry	0.40	
Following technological progress is important		0.77
We use new technologies, even if they are expensive		0.75
We are pro innovation organization		0.62
SSL	2.29	1.72
Proportion variance	0.23	0.17
Cumulative Variance	0.23	0.40
Cronbach alpha	0.69	0.72
Factor interpretation: Interest towards	Sustainability Transformation in Transport (F-ST)	Technology and Innovation (F-TI)

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Estimation results – EFA 3 (Incentives)

Loadings	Factor 1	Factor 2
Interest towards cargo cycles will increase if		
Parking cost for CVs increases	0.80	
Fuel (diesel/petrol) becomes more expensive	0.83	
More access restrictions for CVs are implemented	0.83	
Purchase cost incentive is provided for CCs		0.79
Purchase cost of CCs is reduced		0.78
SSL	2.05	1.31
Proportion variance	0.41	0.26
Cumulative Variance	0.41	0.67
Cronbach alpha	0.89	-
Factor interpretation: Importance of	Deterioration of Conditions for CVs (F-DC)	Purchase Cost of CCs (F-PC)

Note:

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- Loadings lower than 0.4 are not shown

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Estimation results – Binary logit models

Purchase Intention					Actual Purchase Decision				
Variable	Coeff.	Estim.	S.E.	t-stat	Variable	Coeff.	Estim.	S.E.	t-stat
Intercept	$\boldsymbol{\beta_{CON}}$	**-0.36**	**0.19**	**-1.85**	**Intercept**	$\boldsymbol{\beta_{CON}}$	**-1.81**	**0.31**	**-5.84**
catchmentArea (km^2)	$\boldsymbol{\beta_{CA}}$	**-0.01**	**0.01**	**-1.84**	**catchmentArea (km^2)**	$\boldsymbol{\beta_{CA}}$	**-0.01**	**0.01**	**-1.78**
dailyMileage (km)	$\boldsymbol{\beta_{M}}$	**0.11**	**0.04**	**3.00**	**dailyMileage (km)**	$\boldsymbol{\beta_{M}}$	**0.11**	**0.04**	**2.89**
winterTesting (D)	$\boldsymbol{\beta_{WT}}$	**0.98**	**0.48**	**2.03**	**winterTesting (D)**	$\boldsymbol{\beta_{WT}}$	**0.74**	**0.45**	**1.64**
operationalBenefits (L)	$\boldsymbol{\beta_{OB}}$	**0.42**	**0.11**	**3.98**	**operationalBenefits (L)**	$\boldsymbol{\beta_{OB}}$	**0.29**	**0.12**	**2.39**
softBenefits (L)	$\boldsymbol{\beta_{SB}}$	**0.37**	**0.10**	**3.55**	**softBenefits (L)**	$\boldsymbol{\beta_{SB}}$	**0.36**	**0.11**	**3.13**
operationalConcerns (L)	β_{OC}	-0.24	0.10	-2.32	costBenefits (L)	β_{CB}	0.23	0.12	1.89
technologyInnovation (L)	β_{TI}	0.20	0.10	1.94	deteriorationOfConditions (L)	β_{DC}	0.34	0.11	3.00
					carSubstitution (P)	β_{CS}	0.67	0.32	2.10
					lightVehicleSubstitution (P)	β_{LS}	1.79	1.09	1.64
					businessSector (D)	β_{BS}	0.84	0.24	3.45
Summary statistics					Summary statistics				
ρ^2 (McFadden):	0.10				ρ^2 (McFadden):	0.12			
AIC:	496.78				AIC:	448.20			
BIC:	528.40				BIC:	491.69			

Note:

- D: Dummy variable; L: Latent variable; P: Percentage in decimal format
- t-stat value displayed is the actual one, and may be different to the value obtained through *Estim./S.E.*, due to rounding off to two decimal places.
- For coefficient description and interpretation, please refer to Table 7
- Variables that are common to both purchase intention and actual purchase decision are made bold

Insights – Purchase intention vs actual decision

A higher share of intent is observed (48.5%), compared to the actual purchase (32.0%)

Operational concerns -> purchase intention

Cost benefits and deterioration of conditions for conventional vehicles -> actual purchase decision.

Enthusiastic when they state their intention to purchase cargo cycle.

However, they perceive more disadvantages (e.g., catchment area of operations), reducing their interest to purchase cargo cycles.

There is a need to convert intention to actual purchase decision

https://www.eltis.org/in-brief/news/electric-cargo-bike-pilot-project-launched-tartu

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http://web.mit.edu/costas/www/publications.html

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