User acceptance of demand-responsive transport services in rural areas: applying the UTAUT to identify influential latent constructs

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2 | Demand-responsive transport (DRT)

Definition

- Intermediate form of public transport between bus and taxi (Ambrosino et al., 2004)
- Utilizing small floor-buses (Calderón, 2019)
- Various service designs possible (routing, schedules, booking mode, tariff system,…)
- Reacting on actual demand in contrast to classic public transport (Mageean, 2003; Ambrosino, 2004) – active users needed!

Heterogeneous wording complicates a unified, scientific exploration (on-demand transport, flexible transport system, adaptive transport system, microtransit, paratransit, minibus,…).

Varying service designs complicate comprehension.

Lara Piery, https://www.meinbezirk.at/villach-land/c-lokales/rufbus-rudi-ist-in-der-region-schon-gross-in-fahrt_a3606144

3 | Research motivation

Global pressure to reduce carbon emissions of transport sector
− Inter alia, increasing the use of public transport is emphasized by scientists and policy papers
− DRT as solution for sparsely populated regions
  − shift of performance expectation,
  − from transport provision with social character to carbon reducer
  − public funding of trial projects, growing scientific interest

Scientifically identified problems
− Missing integration of DRT services into PT network and information systems (Luiu, 2018; Gilibert, 2020; Morsche, 2019; Jittrapirom, 2019; Weckström, 2018)
− Strong rival private car, especially in rural areas (Ingvardson & Nielsen, 2018; Porru et al., 2020)
− Funding and economic feasibility of DRT services (Neven et al., 2015; Vij et al. 2020, …)
− Lack of socio-scientific research (Chen, 2019; Di Pietro et al., 2015; Madigan et al., 2017)

4 | Research goals

Understand the low occupancy rates – understand the lack of user acceptance

(1) Generation of a suitable survey instrument to assess latent constructs influencing transport mode decisions
- Adaption and translation of the UTAUT scale
- Pre-test and exploratory factor analysis of the results

(2) Assessing the impact of DRT on public transport use in rural areas
- Comparison of modal split to Austrian mobility survey *Österreich Unterwegs*
- Quantify DRT's contribution to public transport's share

(3) Identification of psychological constructs influencing transport mode decisions in rural areas
- Survey in model region with active DRT services
- Confirmatory factor analysis of data

5 | Introduction to UTAUT

Unified Theory of Acceptance and Use of Technology (Venkatesh, 2003)
- 18 items (statements to be rated by participants)
- 4 constructs influence the behavioral intention to use (novel) technology
  - Performance expectancy
  - Effort expectancy
  - Social influence
  - Facilitating conditions

- Adaptation for many study fields, inter alia:
  - Automated public transport (Madigan et al., 2017)
  - Mobility as a service (Ye et al., 2020)
  - Automated cars (Kaye et. al., 2020)
  - DRT services (König & Grippenoven, 2020)

- Application for DRT because:
  - Necessity of pre-booking
  - Flexible routes and time schedules of public transport services
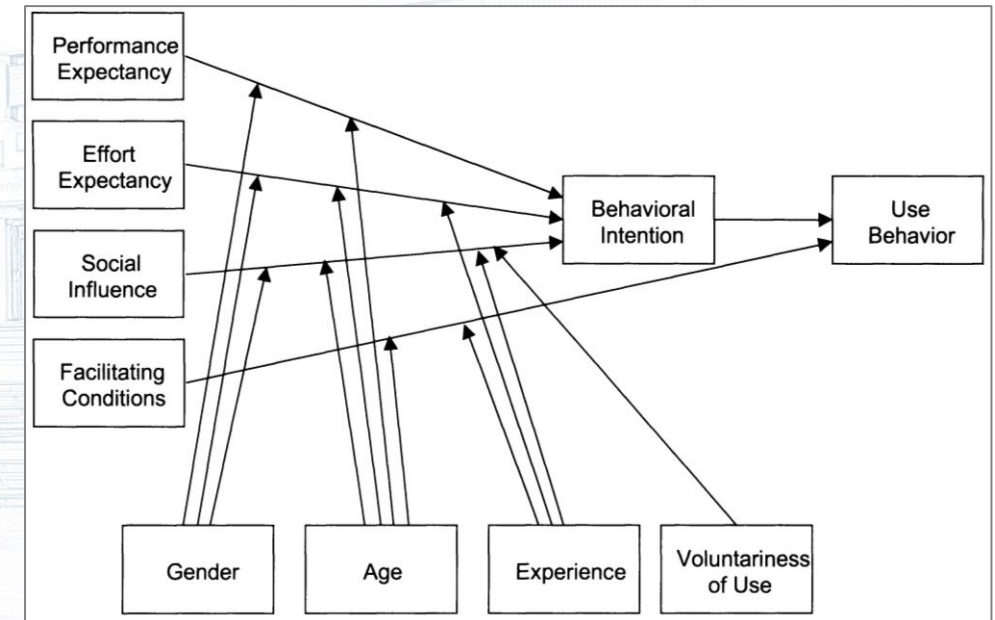
UTAUT model, reprinted from "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology" by V. Venkatesh, Viswanath, J.Y.L. Thong, X. Xu, 2012, Journal MIS Quarterly: Management Information Systems

6 | Research procedure and methods

- Scale development
  - Analyze comparable UTAUT scales
  - Select and translate items
  - Pre-test of the scale
- Exploratory factor analysis (EFA) to validate the translated scale
- Survey
  - Design
  - Data collection
- Confirmatory factor analysis (CFA)
- Structural equation model (SEM)

7 | Research procedure and methods

Analyze comparable UTAUT scales
- Original theory (Venkatesh, 2003)
- Study on automated public transport (Madigan et al., 2017)
- Application in DRT context (König & Grippenoven, 2020)

Select and translation of items
- Translation process according to Behr et al. (2016)
- 28 items (statements to be rated by participants)

Latent construct	ID	Translated item
Facilitating Conditions	FC1	Ich weiß, wo ich alle Informationen über Mikro-ÖV finden kann.
	FC2	Ich kenne die Fahrpläne und das Servicegebiet des Mikro-ÖV in meiner Gemeinde.
	FC3	Ich kenne die Ticketpreise des Mikro-ÖV in meiner Gemeinde.
	FC4	Ein Mikro-ÖV Haltepunkt befindet sich ganz in der Nähe meines Wohnorts.
Attitude towards DRT	AD1	Die Fahrt mit dem Mikro-ÖV ist (wäre) komfortabel.
	AD2	Die Fahrt mit dem Mikro-ÖV ist (wäre) flexibel.
	AD3	Die Fahrt mit dem Mikro-ÖV ist (wäre) jederzeit möglich.
	AD4	Die Fahrt mit dem Mikro-ÖV ist (wäre) schnell.
	AD5	Ich glaube, dass die Fahrt mit dem Mikro-ÖV komfortabel ist.
	AD6	Ich glaube, dass die Fahrt mit dem Mikro-ÖV schnell ist.
	AD7	Ich glaube, dass Mikro-ÖV eine gute Verfügbarkeit hat.

Selected items of the pre-tested UTAUT scale

EN / DE   EFA   CFA   SEM

8 | Research procedure and methods

Test of the developed scale
- Online survey
- Distribution amongst students of the university of Klagenfurt
- 284 responses

Exploratory factor analysis (EFA)
- Atheoretical, data-driven method to identify underlying mechanisms (Hayton et al., 2004, Matsunanga, 2010), and for scale translation (Behr et al., 2016)
- Statistical technique based on shared variance (Yong & Pearce, 2013)
- Software: JASP, Version 0.14.1

EN
DE

EFA

CFA   SEM

Survey design

- Survey design according to the latest mobility study *Österreich Unterwegs* (Tomschy et al., 2016)

Data collection

- Model region for climate and energy *Unteres Drautal* (Carinthia, Austria)
- Rural area with 43 inhabitants/km²
- 3 active DRT services
  - Operating in different parts, partly overlapping
  - Different booking modes
- Survey conducted in spring 2021
- 56 responses

EN DE

EFA   CFA   SEM

10 | Research procedure and methods

Confirmatory factor analysis (CFA)

- Theory-driven
- Method for the verification of expected relations between variables, i.e. of latent constructs in a set of observed variables, and for testing hypotheses (Brown, 2015; Hurley et al., 1997; Suhr, 2006)
- Software: JASP, Version 0.14.1

Structural equation modeling (SEM)

- Theory-driven
- Collection of statistical techniques for the examination of relationships between one or more independent variables and dependent variables (Ullman & Bentler, 2012)
- Software: JASP, Version 0.14.1

EN DE   EFA   CFA   SEM

11 | Results

(1) Generation of a suitable survey instrument to assess latent constructs influencing transport mode decisions

— 17 items remained
— Explanatory power for the tested constructs
  — Exception: Attitude towards DRT services (AD)
— Path estimates (>0.4) indicate construct validity
— Fit indices validate model
  — Chronbach's alpha: 0.808
  — Bartlett's test: <.001
  — KMO: 0.815
  — Chi-squared test: p = 0.05
  — RMSEA: 0.038
  — TLI: 0.969

Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Uniqueness
PE1	0.672				0.570
PE2			0.800		0.404
PE3			0.753		0.539
PE4	0.349		0.319		0.680
EE1	0.673				0.484
EE2-1	0.437				0.739

Factor Loadings

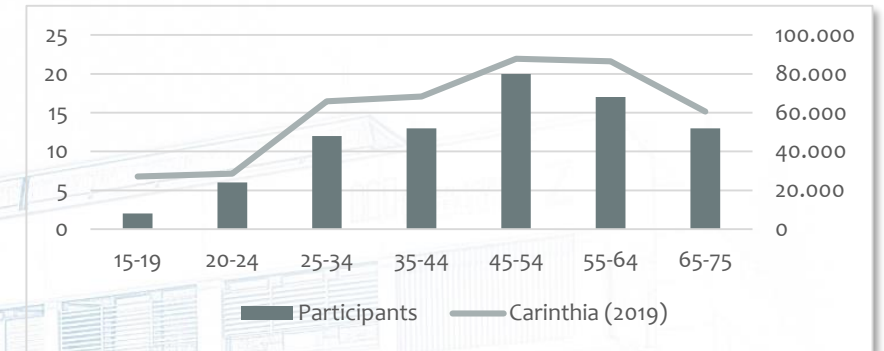|	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
PE2				0.676		0.391
PE3				0.607		0.513
EE1	0.784					0.373
EE3	0.792					0.394
EE4	0.867					0.319
SI1					0.563	0.651
SI4					0.527	0.676
FC1		0.603				0.531
FC2		0.943				0.182
FC3		0.822				0.345
FC4		0.435				0.746
AD1	0.468					0.568
AD2	0.639					0.613
AD4	0.658					0.485
AC1			0.758			0.413
AC2			0.676			0.412
AC4			0.687			0.539

Note. Applied rotation method is promax.

Factor loadings after cleaning process

12 | Results

(2) Assessing the impact of DRT on public transport use in rural areas

Age distribution of the sample in comparison to the Carinthian population

- General information about the sample
  - Age distribution similar to Carinthian population
  - Constant access to private cars: 85 %
  - Knowledge about DRT services: 96,75 %
  - Previous use of DRT services: 25 %
  - Frequent use of public transport: 32.5 %
    - Train: 19.48 %
    - Bus: 10.38 %
    - DRT: 7.15 %
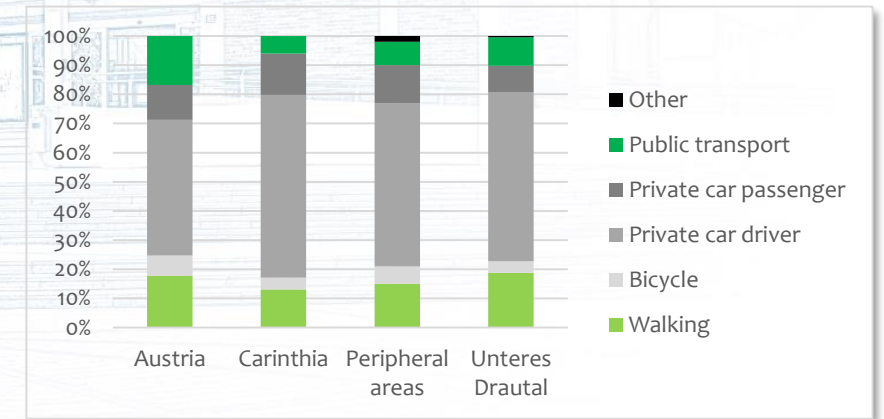
Modal split of Unteres Dratual, in comparison with national figures

- Public transport' share in the modal split
  - Peripheral regions: 8 %
  - Carinthia: 6 %
  - Model region: 9.8 %
  - Higher share with active DRT services

13 | Results

(3) Identification of psychological constructs influencing transport mode decision in rural areas

- Minimal respecification
  - FC4 removed
  - 2 residual covariances included
- Latent construct *social influence* lacks explanatory power
  - Removed

- The data confirms the applied model and the adaption of the scale
  - All items significant (p < 0.01)
 - Path estimates > 0.6 support scale validity

Factor	Indicator	Est.	Std. Error	95% Confidence Interval		Std. Est. (all)
				Lower	Upper	
Performance Expectancy	PE2	1.534	0.163	1.215	1.852	0.981
	PE3	1.415	0.169	1.084	1.746	0.909
Effort Expectancy	AP2	1.266	0.161	0.950	1.581	0.853
	AP4	1.220	0.146	0.934	1.506	0.884
	EE1	1.063	0.165	0.740	1.387	0.747
	EE3	1.209	0.152	0.912	1.506	0.860
	EE4	1.251	0.152	0.954	1.549	0.879
Facilitating Conditions	FC2	1.441	0.229	0.993	1.890	0.950
	FC3	1.368	0.241	0.896	1.841	0.830
Attitude towards Private Cars	AC1	0.526	0.151	0.229	0.823	0.736
	AC4	0.624	0.173	0.286	0.963	0.825

Results of the adapted UTAUT model on DRT use in the model region

14 | Results

(3) Identification of psychological constructs influencing transport mode decisions in rural areas

- *Effort expectancy* and *performance expectancy* explain the greatest part of use intention of DRT services
- Fit indices validate the model
  - Chronbach's alpha: 0.865
  - Chi-squared test: p = 0.026
  - X²/df : 1.41
  - RMSEA: 0.086
  - TLI: 0.940
- Model explains 31 % of variance
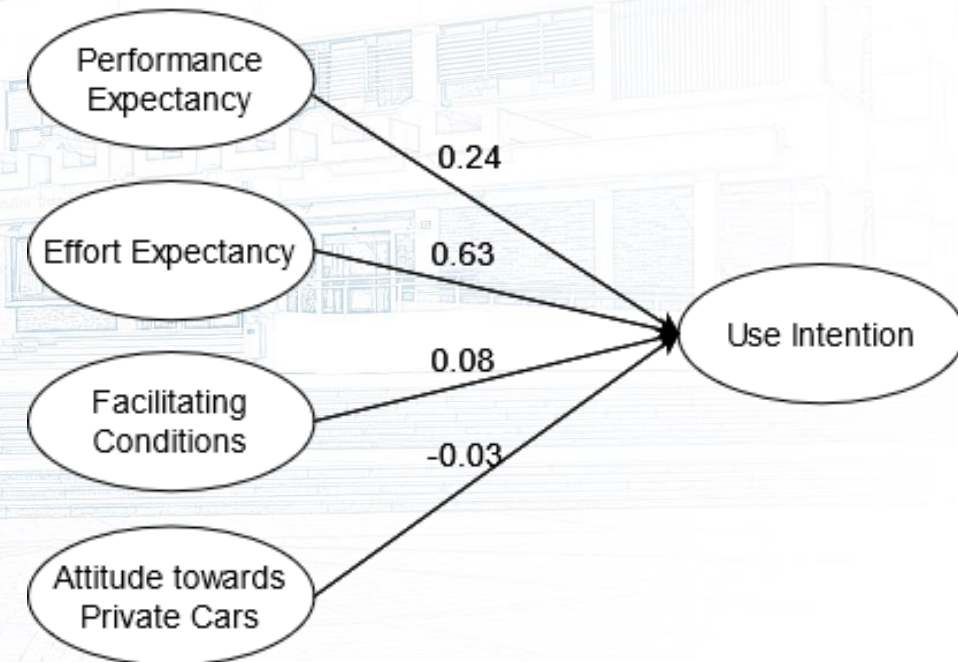
SEM showing latent constructs influencing the use intention of DRT services

15 | Conclusion and outlook

- The adapted scale is valid and applicable for the planned cause.
  - › Develop and add further items explaining *performance expectancy* and *social influence*

- The share of public transport in the modal split is higher in the model region than in Carinthia.
  - › Analyze the relation of active DRT services and public transport in a wider study
- Almost all participants know DRT services, only 25 % have used them before.
  - › Explore other factors that influence DRT use, besides existing offer and access

- *Effort expectancy* and *performance expectancy mainly* influence the use intention.
  - › Verify in a wider study
  - › Include moderating variables
- The model explains the use intention of DRT services.
  - › Integrate undetected factors influencing the behavioral intention to use DRT services