The dilemma of demand-responsive transport services: conflicting expectations and weak user acceptance

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Abstract

In the passenger transport sector, strategies to reduce carbon emissions engage politics, practitioners, and scientists worldwide. Inter alia, increasing the use of public transport is a vital part of the current strategies. In the EU, 29 % of citizens live in rural areas, and the provision of traditional public transport in these areas is difficult and, more importantly, inefficient, further complicating its establishment. In this context, demand-responsive transport (DRT) services are presented as a possible solution. Nevertheless, scientific investigations in this domain are sparse and have fallen short of socio-scientific approaches to explain and increase the user acceptance of DRT. Against this backdrop, this systematic literature review presents an analysis of 231 articles on DRT, and a systematic identification of articles with socio-scientific approaches that were subjected to a content analysis (n = 44). This article (1) creates an overview of the development of the research field with a particular focus on user-oriented research, (2) detects a threefold, conflicting performance expectancy towards the services that complicates their success, and (3) identifies a discrepancy between the perception of DRT services and the empirical design of studies. It concludes by systemizing existing research gaps regarding performance expectation, user focus and rurality, and proposes implications for policymakers and practitioners.

Keywords: Demand-responsive transport, systematic literature review, population density, rural area, user acceptance, user focus, user groups, human-centered

Introduction

The reduction of greenhouse gas emissions has entered the spotlight in all economic sectors, and public transport in particular has attracted much attention as a means to reduce traffic-induced emissions (European Commission, 2020; A European Strategy for Low-Emission Mobility, 2016; Hodges, 2010; The World Bank, 2014; UNFCCC, 1992). Yet, especially in regions with low population density and high access to private cars, raising the user acceptance of such services appears to be challenging. In urban areas, public transport services can be provided in an attractive and cost-covering way and, as a result, show higher occupancy rates (Bouwman & Voogd, 2004; Mulalic & Rouwendal, 2020; Pucher & Renne, 2005). Therefore, they contribute to reducing the transport-related carbon emissions as desired. In less densely populated areas, public transport' share in the modal split is small (Ingvardson & Nielsen, 2018; Mendiola et al., 2014). This might be explained by the fact that the provision of demand-satisfying public transport differs strongly according to spatial aspects (Ingvardson & Nielsen, 2018; Porru et al., 2020). Furthermore, less developed infrastructure for public transport, longer travel distances and the lack of private-car-related stress factors typical for urban areas (such as parking, costs, air pollution or congestion) are central hindrances for the acceptance of public transport in rural areas (Mulalic & Rouwendal, 2020; Ostermeijer et al., 2019; Van Ommeren et al., 2011). In 2020, 17.33 % of the citizens of the United States of America (US; Statista, 2021), and 29 % of citizens of the European Union (EU) lived in rural areas (Eurostat, 2020). These numbers are too high to be marginalized – the necessity to explore and develop public transport solutions for the population of rural areas appears obvious.

Demand-Responsive Transport as a solution for rural areas?

In an attempt to improve the public transport network in rural areas, demand-responsive transport (DRT) services are presented as a solution (Alonso-Gonzalez et al., 2018; Mulley & Nelson, 2016; Ryley et al., 2014; Velaga et al., 2012; Vitale Brovarone & Cotella, 2020; Weckström et al., 2018). The rise of information technology is identified as a driver for this form of public transport (Devaraj et al., 2020; Diana, 2010; Jain et al., 2017; Luiu et al., 2018; Sihvola et al., 2012), which can be assigned to the

superordinate concept of Mobility as a Service (Calderón & Miller, 2020). Up to the writing of this article, no clear definition of this form of public transport has been established. Various different service designs exist, all having one feature in common: They react to actual user demand only, thus, need to be booked in advance. DRT services are not bound to a set course or timetable and mostly utilize small floor buses (Ambrosino et al., 2004). Most services lack an integration into existing public transport information and booking systems (Gilibert et al., 2020; König & Grippenkoven, 2020; Luiu et al., 2018; Weckström et al., 2018), and a sufficient promotion within the serviced region (Diana, 2010; Kim et al., 2017; König & Grippenkoven, 2020; Luiu et al., 2018; Politis et al., 2012; Šurdonja et al., 2020; Wang et al., 2014; Weckström et al., 2018). Furthermore, the inconsistently developed wording complicates the comprehension and development of a unified scientific approach (Jain et al., 2017). The outlined circumstances might serve as reason for the observed low occupancy numbers of DRT services and their strong dependence on public funding (Davison et al., 2012; Jittrapirom et al., 2019; Sihvola et al., 2012; Weckström et al., 2018; Wright et al., 2009; Wright & Nelson, 2014). Until now (July 2021), the possible contribution of DRT services to the reduction of carbon emissions is scarcely explored, and findings are inconsistent. Public authorities of the EU emphasize their potential to reduce carbon emissions (Interreg Europe, 2010), and national public authorities reiterate this claim. On the other hand, in a publication about the Swiss public transport system, Petersen (2016) criticizes that DRT achieves occupancy numbers similar to those of taxis, and concludes that DRT in its current form cannot contribute to the reduction of carbon emissions.

Users and their acceptance of DRT

Historically in Europe, public institutions act as providers of public transport, which has made market-oriented approaches unnecessary. The literature on DRT indicates that nowadays, DRT and public transport in general are required to persist and grow on a competitive market with private cars as their main rival. Therefore, it becomes essential to understand mobility demand and transport mode decisions of existing and potential users. This is of special interest in countries where the access to private vehicles is high: In the US only around 9 % of the population live in household without a private car (Statista, 2017). Besides operational and policy-related factors, the psychological element is crucial for users' decisions on public transport modes (Chowdhury & Ceder, 2016). Different concepts such as acceptance, willingness to pay, personal attitudes, user expectation, and user satisfaction address certain aspects of this element. In this article, "user acceptance" serves as a pooling term for the common aim to explore users' decision-making processes. Cambridge Dictionary (2020) lays out acceptance as threefold: "(1) general agreement that something is satisfactory or right (2) the act of agreeing to an offer, plan, or invitation (3) the fact of accepting a difficult or unpleasant situation". Hayes (2001) adds the aspect of pleasure to the concept. In other words, a product or service is accepted when it is viewed as sufficient and favorable, and is willingly received. This concept is widely adopted for the market introduction of new products and technologies (Königstorfer, 2018; Schäfer & Keppler, 2013; Venkatesh et al., 2003) and finds similar attention when exploring public transport solutions (Chen, 2019; Di Pietro et al., 2015; König & Grippenkoven, 2020; Madigan et al., 2017; Schmitz et al., 2016). For DRT services, we derive two important conclusions: First, users must perceive DRT as a sufficient means of transport. Second, the choice for DRT services over the current main mode private car must be made voluntarily; the freedom of change is prerequisite to a sustained use.

Research Questions

Scientific research on DRT services is young, and not well-developed yet. To the authors' best knowledge, at the time of composition of this systematic literature review, no similar work existed. This article provides an overview on existing research on DRT services and pays particular attention to articles with a socio-scientific approach. Reacting on the call for more research on DRT services in rural areas (König & Grippenkoven, 2020; Wang et al., 2014), it distinguishes between DRT in urban (and

sub-urban), and rural areas. It (1) outlines a discovered discrepancy between the general perception and beneficiaries of DRT services and studied areas and subjects, (2) detects discrepancies in the findings on factors influencing user acceptance, (3) identifies the population density of studied areas to influence the results, and (4) introduces a conflicting threefold performance expectancy DRT services are confronted with. To achieve these goals, we formulated the following research questions.

RQ 1. How has research on DRT developed, in general and specifically focused on users (economic or mathematical versus socio-scientific approach)?
RQ 2. What are the most important perspectives stated in current socio-scientific research on DRT services (in form of a short summary) and who is commonly perceived as beneficiary?
RQ 3. Which study designs are used for empirical research on DRT services?
RQ 4. Which factors have been empirically identified to influence the user acceptance of DRT services?
RQ 5. Which strategies for increasing user acceptance of DRT are proposed? Has their success been measured and if so, how?
RQ 6. Does the population density of a studied area influence the scientific exploration and results? If yes, how?

Methodology

This systematic literature review was designed following Petticrews' Practical Guide to Systematic Reviews in the Social Sciences (2006). After a quantitative analysis investigating the chronological development of publications in general and grouped by their scientific approach, a qualitative analysis of all identified socio-scientific articles was conducted.

Study Search

Considering the issue of heterogeneous terms denoting non-traditional, demand-oriented public transport, search terms were defined rather broadly to identify all synonyms for DRT and ensure an exhaustive search. To target the search appropriately, terms referring to transportation network companies (e.g. Uber or Lyft), and consequently, all terms around *Mobility as a Service* were excluded, resulting in the following search string:

"On-demand public transport" OR "on-demand transport" OR "on-demand service" OR "demand-responsive transport" OR "responsive transport" OR "flexible public transport" OR "flexible transport" OR "demand-adaptive system" OR minibus OR microbus OR "micro transport" OR microtransit

The search was conducted in July 2020 in the databases Web of Science, ScienceDirect and Taylor & Francis, producing 1.222 results. The search string was applied on title and, where technically possible, on keywords and abstract. Table 1 illustrates the addressed search fields and the number of identified articles in each database.

Database	Search fields	Search results
Web of Science	Title, Author Keywords, Abstract	839
ScienceDirect	Title, Author Keywords, Abstract	355
Taylor & Francis	Title, Keywords	28

Table 1: Search results in databases

Study Selection and quality assessment

The results of the database searches were joined in an Excel sheet and underwent a selection process to guarantee the quality of the remaining articles, depicted in Figure 1. First, only articles in peer-reviewed scientific journals were identified and other publishing sources were excluded (n = 1199). Duplicates and scholarly work in languages other than English were removed (n = 1.055). Then, the

titles and abstracts of all articles were scanned for the coverage of demand-responsive road transport of individuals. The greatest part of the articles excluded in this step used the keyword *on-demand service* in the context of streaming technology. Similarly, the terms *minibus* and *flexible transport* hold additional meanings other than public transport provision.

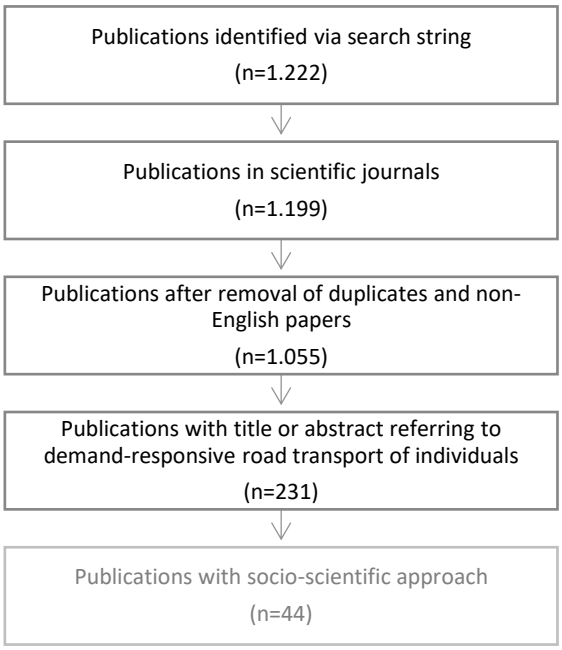

Figure 1: Flowchart of the selection of relevant publications

Table 2 lists these keywords and their parallel meanings. The strict focus on user acceptance of DRT services justified the exclusion of all work on autonomous driving, fleet electrification or isolated technical quality factors, such as passenger or vehicle security. The remaining 231 articles were subjected to a quantitative analysis. For the subsequent qualitative analysis, an additional selection step was performed: Only scientific articles with a socio-scientific approach were taken into account, resulting in 44 items.

Search term	Further meaning
On-demand service	IPTV, ISDN, bus architecture (VOD system) Air taxi Education on-demand system Manufacturing industry Cloud computing
Minibus	Bushmeat transportation Emission inventory development automotive magnetorheological (MR) suspension system on-board load indicator
Flexible transport	crude oil-reliant transport fuel platform

Table 2: List of terms with unclear meanings

Study analysis

The quantitative analysis of all 231 articles was systematically performed in Microsoft Excel, ensuring reproducibility at all stages. The qualitative analysis was conducted in NVivo 12 (release 1.3), a software developed to manage, analyze (Phillips & Lu, 2018), and systematically categorize data from text, audio or visual material (Mortelmans, 2019). Based on an initial reading of the 44 articles with an identified socio-scientific approach, a codebook was developed. All text in any form relating to the research questions was collected in nodes, further refining the codebook with each read article. After

the first reading iteration, the codebook was structured and all articles were read again and coded according to the created codebook.

Results

State of research on DRT services (RQ 1)

To gain an understanding of the development of socio-scientific research within research on DRT, the identified literature was assigned to three categories: socio-scientific, economic and mathematical. For his process, the stated keywords served as indicators. Where a clear assignment was not possible, title and abstract were studied. An example might help to illustrate this process: For their article "Mapping of service deployment use cases and user requirements for an on-demand shared ride-hailing service: MOIA test service case study", Gilibert et al. (2019) used the keywords "Demand Responsive Transportation, Flexible transport, On-demand transport, Shared mobility, Ride-hailing, Ridesharing" that do not allow a clear assignment. Studying the abstract clarified ("Hence, the aim of this research is to identify user requirements and market opportunities, from the case study conducted with the participation of 1211 users of the MOIA service test in Hanover, to contribute to the successful design of this new generation of DRT.") and lead to an assignment to *socio-scientific* and *economic*. Table 3 presents the categorization and according keywords. This analysis resulted in the identification of 44 articles with a socio-scientific approach, 135 with economic and 102 with a mathematical approach, and identified a great number of articles covering more than one research field.

Scientific approach	Keywords
Economic	agent based modelling, argumentation theory, bayesian optimization, business strategy, case study, choice modelling, cost determination, fare level, funding, market opportunities, modality style, modelling, policy, quality contracts, quality partnerships, structural equation modelling, subvention, telematics, transport and employment, transport policy
Mathematical	algorithms, combinatorial auctions, continuum approximation, deep neural network, dial-a-ride problem, discrete event simulation, dynamic fleet management, heuristics, MatSim, metaheuristics, microscopic traffic simulation, mixed integer problems, multiserver queue, optimization, prediction, routing, scheduling, simulation, stochastic programming, thin flows, trip characteristics, uncertainty, vehicle rebalancing
Socio-scientific	attitudes, choice modelling, elderly, habitual behavior, individual factors, pt accessibility, social exclusion, socio-demographic characteristics, stated choice experiments, stated preference survey, transport habits, travel behavior, travel demand, travel habits, user perspective, willingness to pay

Table 3: Keywords indicating the research approach

Figure 2 visualizes the distribution and interdisciplinarity of the 231 examined articles: Of the 44 articles with socio-scientific approach, 14 exclusively cover socio-scientific issues and 26 combine user-focused with economic research. Summed-up, socio-scientific research accounts for 19 % of the identified 231 articles.

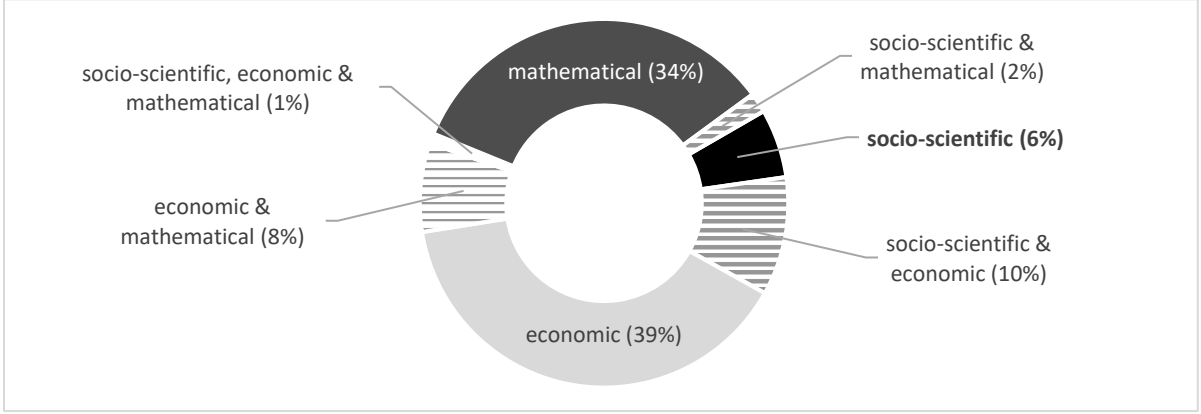

Figure 2: Distribution of scientific approaches in DRT research (share of articles, n = 231)

The chronological analysis identified the first scientific publication on DRT in 1985. As Figure 3 shows, irregular and low publication frequencies can be observed until 2006 (22 articles in total), when a first increase occurs. Then, in 2011, the number of publications experienced another moderate rise. In 2020, we can observe a strong increase in published research. We emphasize that the database search was conducted in July 2020, and the described figure for the year 2020 comprises only half a year's worth of publications. Figure 3 also visualizes the relative scarcity of research with socio-scientific approach, experiencing a first remarkable increase in 2019.

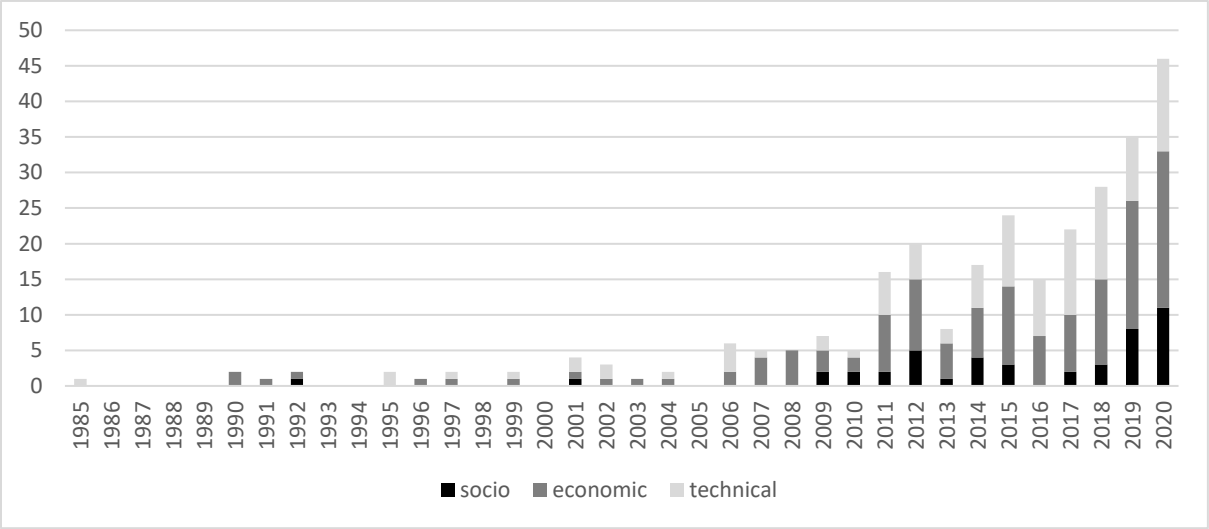

Figure 3: Chronological development of research activity by approach (number of published articles per year, n = 231)

The analysis of publishing outlets identified 21 journals that published more than three articles; the distribution of the total 231 articles is listed in Figure 4, also categorizing the publications according to their scientific approach. The closer investigation of the articles with a socio-scientific approach that conducted empirical studies (Figure 5) outlined that 17 were conducted in three European countries: A large share investigated regions in the United Kingdom (10) followed by markedly smaller numbers for Germany (4) and The Netherlands (3). All other countries were targeted only twice or less by scholarly investigations.

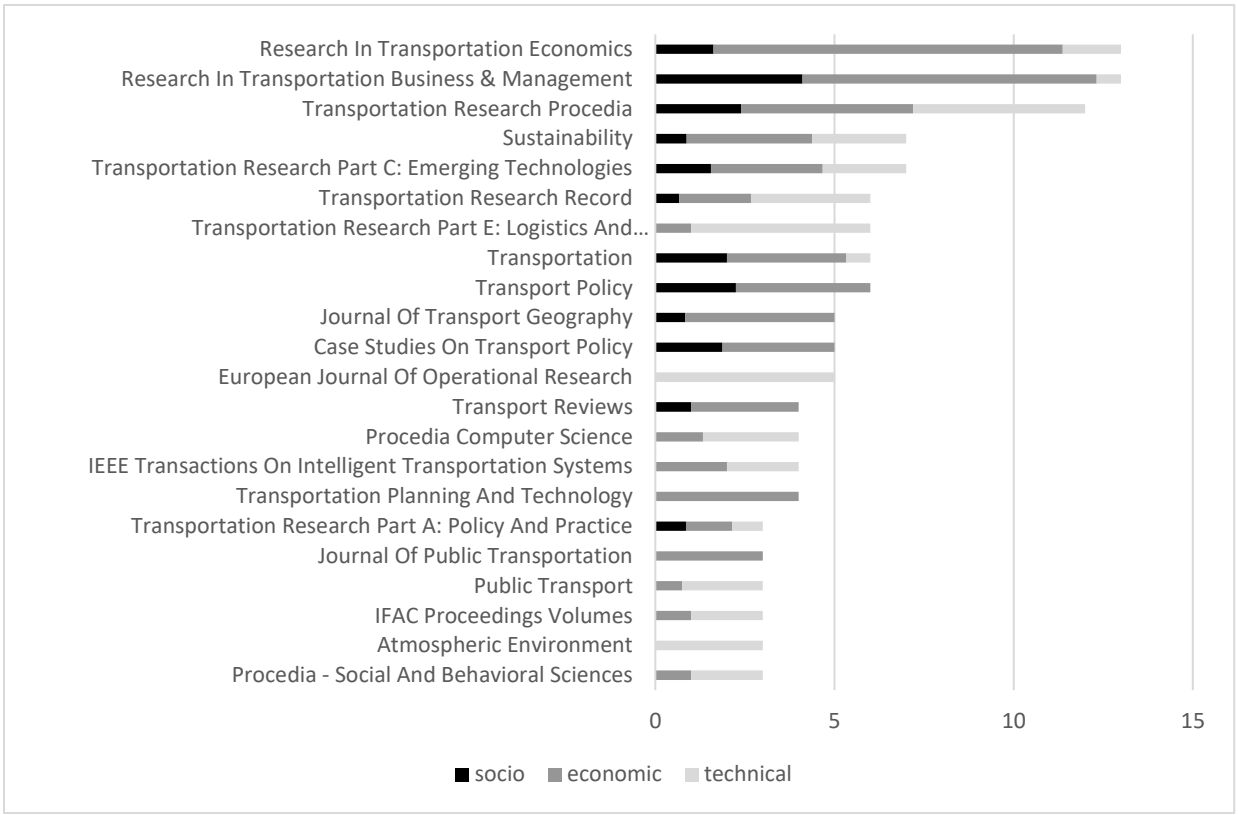

Figure 4: Journal outlets (number of published articles including their scientific approach per journal)

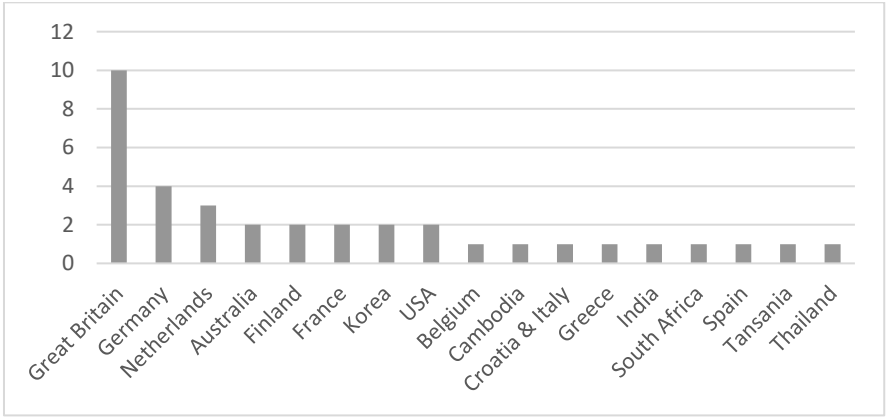

Figure 5: Geographical distribution of conducted empiric research (number of articles per studied country, n = 36)

Perspectives and beneficiaries stated in current socio-scientific research on DRT services (RQ 2)

As explained when introducing the applied method, all further results ground on the content analysis of the 44 identified articles with a socio-scientific approach. The analysis of the perspectives and corresponding performance expectancies of DRT services resulted in a structure that is similar to the three pillars of the "Triple Bottom Line" (Elkington, 1997). The mainly perceived performance expectancy are the contribution to a higher geographic coverage of the public transport network, and the delivery of social benefits (see Figure 6). A great part of the articles highlights the potential of DRT services for specific target groups, mostly commuters, elderly people, and impaired people (Bridgman, 2018; Davison et al., 2012, 2014; Devaraj et al., 2020; Diana, 2010; Ericson, 2011; Gilibert et al., 2019; Jain et al., 2017; Luiu et al., 2018; Mulley & Daniels, 2012; Nelson & Phonphitakchai, 2012; Nyga et al., 2020; PARK & JUNG, 2019; Ryley et al., 2014; Sihvola et al., 2012; Šurdonja et al., 2020; Vij et al., 2020; Wang et al., 2014; Weckström et al., 2018; Woolf & Joubert, 2013; Wright et al., 2009; Wright & Nelson, 2014). Some authors regard DRT services suitable for the general public (Al Maghraoui et al., 2019; Dejoux et al., 2010; Diana, 2010; Wang et al., 2014; Weckström et al., 2018). Ecological aspects are less

frequently framed as a merit of DRT services: 14 articles mention DRT services' potential contribution to the reduction of carbon emissions and 11 its positive influence on congestions. The financial feasibility is often highlighted as a problematic aspect, which is why many articles in turn underline the necessity of governmental involvement by funding or subsidiaries for DRT services to keep up operation. Regardless, 16 studies position DRT services as possible substitution of traditional public transport services, many additionally highlighting a possible cost reduction for public authorities.

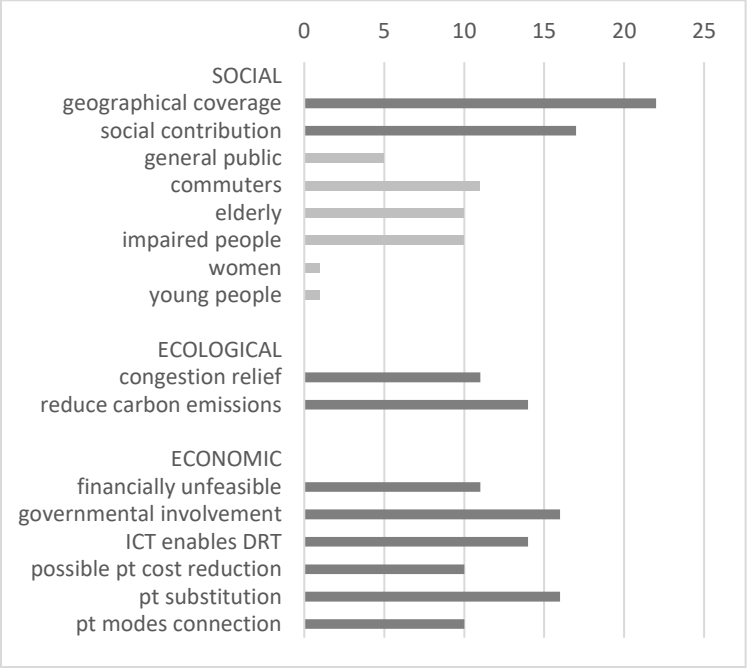

Figure 6: General perception of DRT services (number of articles, n=44)

Design of conducted empirical research (RQ 3)

36 of the 44 articles with user focus conducted empirical research. Figure 7 visualizes their empirical approach, targeted participants, and the population density of the examined area. The comparison of applied methods shows that 9 articles applied a mixed methods approach, 20 used qualitative and 25 quantitative methods. Of those applying quantitative methods, ten designed stated choice experiments. Half of the conducted qualitative research required active participant involvement, as in interviews, focus groups or workshops; the remaining qualitative methods were observations, case studies, scoping reviews, and one systematic literature review which focuses on transport-related social deprivation of the older population of rural areas (Bridgman, 2018). 31 of 36 articles publishing empirical research were based on human participation with almost half (15 articles) studying users of DRT services or pilot projects and 12 addressed the general public and 8 questioned specific population groups. Interestingly, of the studies targeting specific groups, six addressed commuters, while only one study each addressed elderly people and people with disabilities. More than two thirds of the articles (72 %) conducted research in urban or sub-urban areas, 39 % in rural areas.

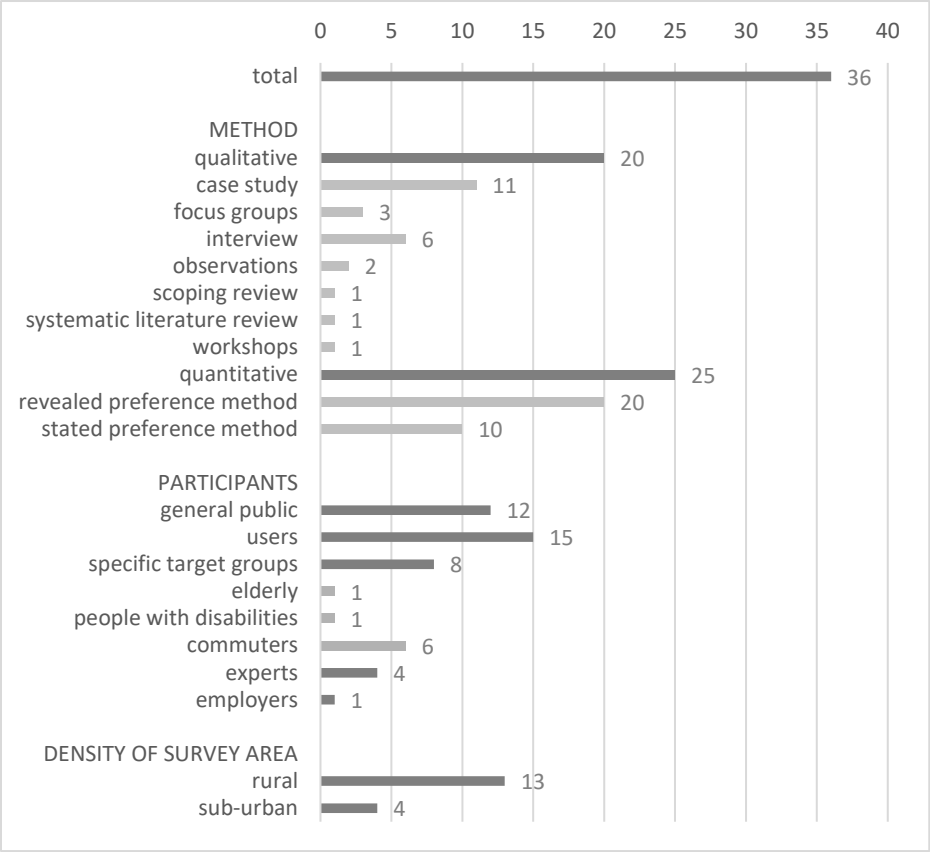

Figure 7: Methodological overview of empirical research (number of articles, n=36)

Factors influencing user acceptance of DRT services (RQ 4)

In the 44 articles with socio-scientific approach, various frameworks and concepts were applied to analyze travel habits of users and non-users, such as willingness to pay (Kim et al., 2017; Nyga et al., 2020; Ryley et al., 2014; Vij et al., 2020; Wright & Nelson, 2014) or customer satisfaction (Al Maghraoui et al., 2019; Avermann & Schlüter, 2019; Davison et al., 2012; Diana, 2010; Kim et al., 2017; Nelson & Phonphitakchai, 2012; Weckström et al., 2018; Witchayangkoon et al., 2015), without one emerging as dominant. 30 articles present factors influencing the mode choice and the user acceptance of DRT services. Besides *age* (Asgari & Jin, 2020; Avermann & Schlüter, 2019; Jain et al., 2017; Jittrapirom et al., 2019; Kim et al., 2017; Luiu et al., 2018; Nelson & Phonphitakchai, 2012; Nyga et al., 2020; Shamshiripour et al., 2020; Vij et al., 2020; Wang et al., 2014, 2015; Wright et al., 2009) and *gender* (Avermann & Schlüter, 2019; Gilibert et al., 2020; Jain et al., 2017; Morsche et al., 2019; Nelson & Phonphitakchai, 2012; Nyga et al., 2020; Wang et al., 2014, 2015; Wright et al., 2009; Wright & Nelson, 2014), the *access to private cars* appears as a central, personal factor (Asgari & Jin, 2020; Avermann & Schlüter, 2019; Dejoux et al., 2010; Devaraj et al., 2020; Diana, 2010; Jain et al., 2017; Kim et al., 2017; König & Grippenkoven, 2020; Luiu et al., 2018; Morsche et al., 2019; Nyga et al., 2020; Politis et al., 2012; Shamshiripour et al., 2020; Wang et al., 2014). Figure 8 visualizes all factors and categorizes them in personal and service-related, the line strength indicating the number of articles the factor is discussed in.

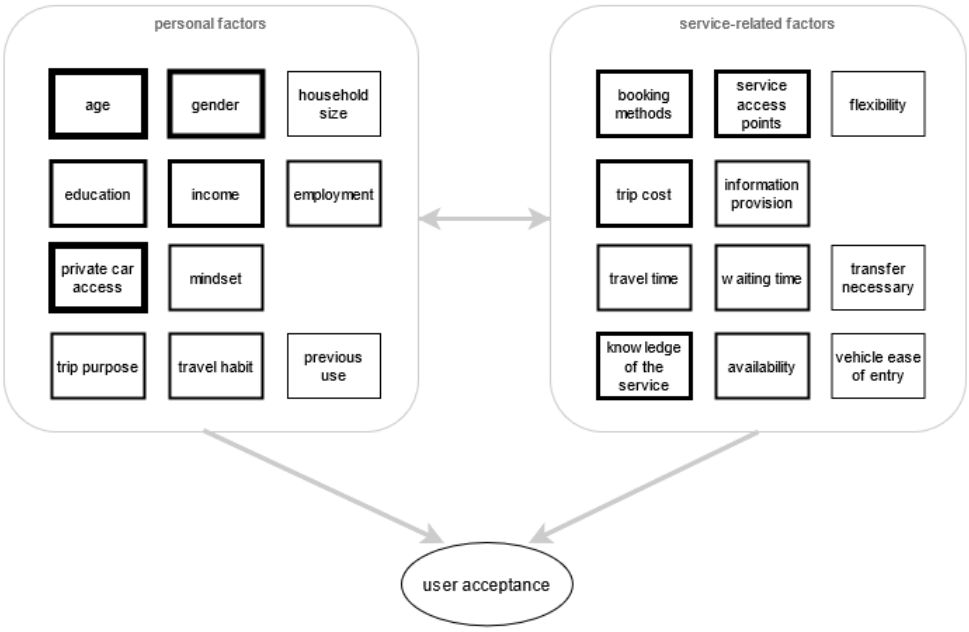

Figure 8: Factors influencing user acceptance of DRT services

Scientific findings on the influence of personal factors on user acceptance reveal several discrepancies. Jittrapirom (2019), Wang at al. (Wang et al., 2015) and Nelson & Phonphitakchai (2012) discuss elderly people as a promising target group, especially in combination with telephone booking and short walking distances. In contrast, studies stating that users of DRT services are not mainly elderly were published by Avermann & Schlüter (2019), Gilibert (2019), Nyga (2020), Shamshiripour et al. (2020) and Vij (2020), although Avermann & Schlüter and Gilibert argue that the study design (online survey) might have influenced their results. Both, Shamshiripour (2020) and Jittrapirom (2019) suggest that elderly people's unfamiliarity with information and communication technologies is the biggest barrier for user acceptance in this age group. Analyzing findings on the influence of income and education uncover similar discrepancies. While some authors argue that a lower income results in a higher demand for public transport and DRT services (Asgari & Jin, 2020; Ryley et al., 2014; Wang et al., 2014; Xie et al., 2019), Shamshiripour et al. (2020) claim that individuals with higher incomes value the possibility to use their travel time productively. These authors and Vij (2020) identify the level of education as a positive predictor of the use of DRT services. In the same vein, evidence on the predictive quality of private car access is ambiguous. Some studies claim that lower car ownership positively influences the user acceptance of DRT services (Nelson & Phonphitakchai, 2012; Nyga et al., 2020; Shamshiripour et al., 2020; Wang et al., 2014) and that positive attitudes towards personal cars (flexibility, speed, comfort) lead to a lower intention to use DRT services (König & Grippenkoven, 2020). Other studies find that high car ownership frequencies do not exclude DRT use (Gilibert et al., 2019, 2020; Weckström et al., 2018). Weckström (2018) identifies car-related issues such as congestion and parking as a reason for the use of a mass DRT service in Helsinki. Other factors are presented as negatively influencing the user acceptance of DRT services, such as the wish to combine various purposes in one trip (Devaraj et al., 2020; Sihvola et al., 2012) or the need to accompany household members (Gilibert et al., 2020; Morsche et al., 2019). The main travel purposes of users of DRT services are work (Gilibert et al., 2020; Nyga et al., 2020; Shamshiripour et al., 2020; Wang et al., 2015; Weckström et al., 2018) and leisure (Jittrapirom et al., 2019; Nyga et al., 2020; Vij et al., 2020; Weckström et al., 2018). Despite a clear case for commuters, in Gilibert's previous study (2019), decentral living commuters show rather weak intentions to commute via DRT services.

Findings on service-related factors highlight travel time and costs, access to the service and information provision as central elements. Avermann & Schlüter (2019) and Jittrapirom (2019) present

waiting time to be a highly significant predictor of the overall satisfaction of passengers. Moreover, a guaranteed arrival time is frequently stated as important factor in the mode decision (Nelson & Phonphitakchai, 2012; Wright & Nelson, 2014). Besides, studies show that the influence of time-related factors (waiting time, punctuality) decreased with age and increased with an active work status (Alonso-González et al., 2020; Gilibert et al., 2019; Shamshiripour et al., 2020; Xie et al., 2019). Adding to that, a required transfer between services (Nelson & Phonphitakchai, 2012; Wang et al., 2015) and a prolonged travel time (Morsche et al., 2019; Weckström et al., 2018) are presented as negatively influencing the user acceptance of DRT services. In general, the aim of reducing travel costs influences mode decisions (Devaraj et al., 2020; Gilibert et al., 2020; Morsche et al., 2019; Nyga et al., 2020; Politis et al., 2012; Vij et al., 2020; Weckström et al., 2018; Wright & Nelson, 2014; Xie et al., 2019). While Vij (2020) targets a different sample (the general public rather than actual DRT users), and Xie et al. (2019) focuses on the value of time factors, two studies exploring the willingness to pay for DRT services present comparable results. The maximum price users are willing to pay for DRT services lies at € 3.50 (Gilibert et al., 2020) and € 3.75 compared to € 4.21 for cars (Nyga et al., 2020). Several articles present the access to DRT services as pivotal, be it the distance to stops (Jain et al., 2017; Jittrapirom et al., 2019; Luiu et al., 2018; Ryley et al., 2014; Shamshiripour et al., 2020; Vij et al., 2020; Wright et al., 2009), available booking methods (Davison et al., 2012, 2014; Gilibert et al., 2020; Luiu et al., 2018; Weckström et al., 2018; Wright & Nelson, 2014; Xie et al., 2019), operating times (Davison et al., 2014; Gilibert et al., 2020; Kim et al., 2017; Sihvola et al., 2012; Weckström et al., 2018) or the ease of vehicle entrance (Avermann & Schlüter, 2019; Luiu et al., 2018). Finally, knowledge about DRT services (König & Grippenkoven, 2020; Luiu et al., 2018; Mulley & Daniels, 2012; Ryley et al., 2014; Sihvola et al., 2012; Weckström et al., 2018; Wright & Nelson, 2014) and the form and quality of information provision are highlighted as central for user acceptance (Jørgensen & Solvoll, 2020; König & Grippenkoven, 2020; Luiu et al., 2018; Weckström et al., 2018).

Strategies for increasing user acceptance of DRT (RQ 5)

Authors agree on the importance of a further exploration of travel habits, personal attitudes and user needs (Alonso-González et al., 2020; Asgari & Jin, 2020; Devaraj et al., 2020; Diana, 2010; Franco et al., 2020; König & Grippenkoven, 2020; Morsche et al., 2019; Nyga et al., 2020; Politis et al., 2012; Sihvola et al., 2012; Wang et al., 2014; Weckström et al., 2018). The exploration of users‘ travel patterns is found to be essential for the simulation and planning of multimodal trips and is framed as potential contribution to generating enough demand for commercially sustainable DRT services (Alonso-González et al., 2020; Devaraj et al., 2020; Franco et al., 2020; Wang et al., 2014; Weckström et al., 2018). Based on the identified correlation between past (public) transport experiences and the intention to use (new) DRT services (Asgari & Jin, 2020; Davison et al., 2012; Gilibert et al., 2020; Morsche et al., 2019), authors suggest the facilitation of a try-out to raise user acceptance (Gilibert et al., 2020; König & Grippenkoven, 2020; Weckström et al., 2018; Woolf & Joubert, 2013). Figure 9 lists all suggestions categorized according to their focus, identifying more than 55 % of suggestions as user-focused. Authors most frequently suggest the improvement of the information provision about existing DRT services, followed by the integration of DRT services into public transport information and booking systems. Additionally, authors underline the importance of user-focused interventions. Table 4 lists the authors of all scientific articles with user-focused suggestions.

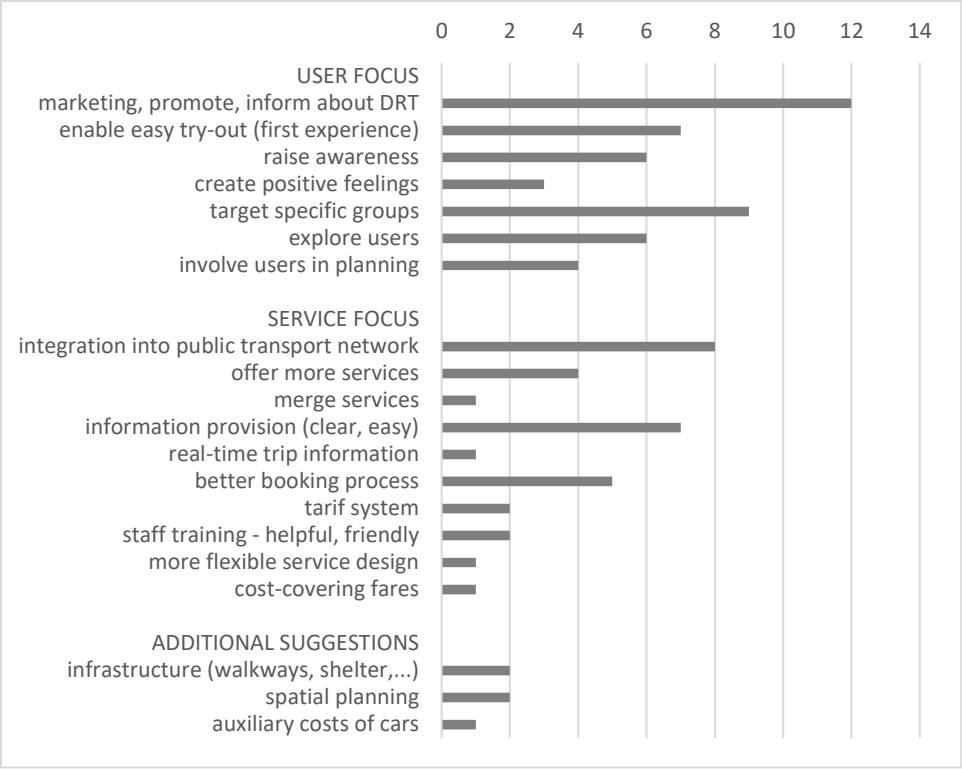

Figure 9: Suggestions for raising user acceptance of DRT services (number of articles, n = 44)

Authors	**information provision (clear, easy)**	**enable easy try-out (first experience)**	**raise awareness**	**explore users**	**involve users in planning**	**create positive feelings**
Woolf, S. E.; Joubert, J. W.		x	x			x
Luiu, C.; Tight, M.; Burrow, M.	x		x		x	
Davison, L.; Enoch, M.; Ryley, T.; Quddu,s M.; Wang, C.		x				
Politis, I.; Papaioannou, P.; Basbas, S.	x		x	x		
Preston, J.				x		
Al Maghraoui, O.; Vallee, F.; Puchinger, J.; Yannou, B.	x			x	x	
Gilibert, M.; Riba,s I.; Rosen, C.; Siebeneich, A.		x				
Morsche, W.; La Paix Puello, L.; Geurs, K.						x
Jain, J.; Ronald, N.; Thompson, R.; Winter, S.				x		
Mulley, C.; Daniels, R.		x	x			
Šurdonja, S.; Giuffrè, T.; Deluka-Tibljaš, A.			x		x	
König, A.; Grippenkoven, J.	x	x	x	x		x
Jittrapirom, P.; Van Neerven, W.; Martens, K.; Trampe, D.; Meurs, H.	x				x	
Sihvola, T.; Jokinen, J.; Sulonen, R.	x					
Weckström, C.; Mladenović, M.; Ullah, U.; Nelson, J.; Givoni, M.; Bussman S.	x	x		x		

Table 4: Authors of scientific articles with user-focused suggestions (n = 15)

Influence of population density (RQ 6)

Analyzing the previously presented results according to the population density of the empirically studied areas shows the impact of this spatial factor on previously conducted research. Articles studying rural areas mostly accredit DRT services a social and economic performance orientation, while an ecological performance orientation is mainly explored in an urban study context (see Figure 10).

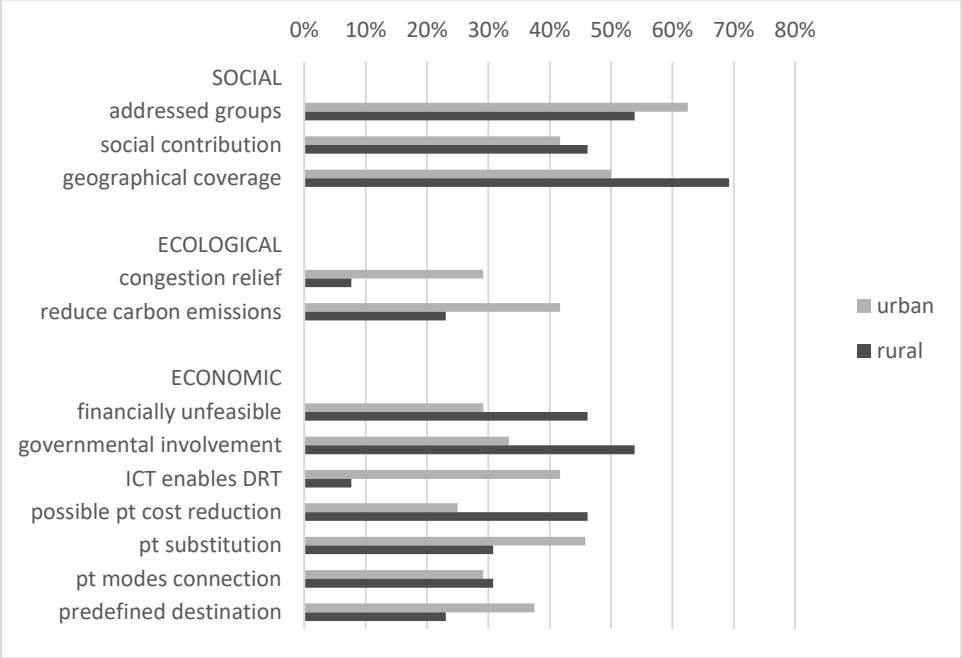

Figure 10: Perceived benefits according to population density of studied areas (share of articles, n = 44)

Additionally, discrepancies regarding the perceived performance orientation and the identified factors influencing user acceptance exist. In rural areas, the personal factors *age*, *gender* and *private car access* are found to be of stronger influence; while in urban areas, *income* and *education* appear more frequently. There, the service-related factors *time reliability* and *booking methods* seem of greater influence on the transport mode decision, while in rural areas *waiting time* and *travel time* have a higher impact. In rural areas, the factors *knowledge of DRT service* and *information provision* are of higher influence than in urban areas.

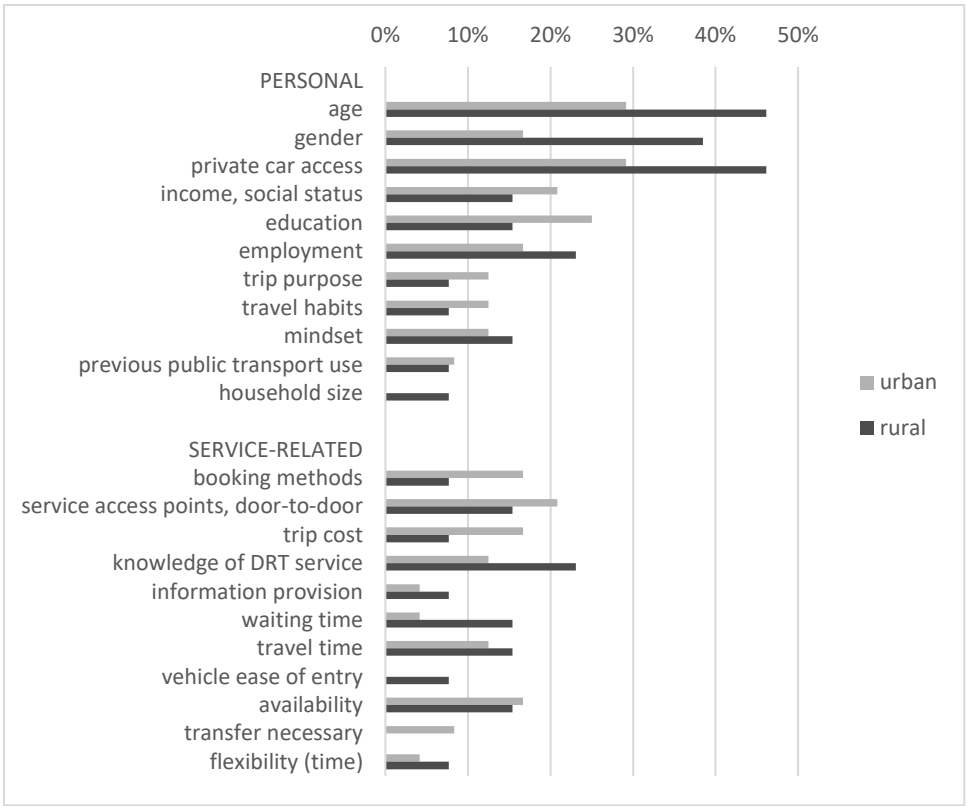

Figure 11: Factors influencing user acceptance according to population density of studied areas (share of articles, n = 44)

Discussion

In this systematic literature review, we discovered a threefold performance expectancy towards DRT services and identified the population density as a significant factor for operating and studying DRT services, and discovered a significant discrepancy between the general perception and the design of empiric studies on DRT. These findings might serve to understand the widespread failings of DRT service ventures, offering implications for policy and practice as well as further research potential. For decades, DRT services have existed as established transport means in low- and middle-income countries (Cervero, 2000), and as niche transport providers for target groups who have difficulties in relying on individual transport forms, such as the elderly or people with disabilities. However, this form of transport has received little scientific attention. As visualized in Figure 3, scientific exploration slowly picked up after 2010 and has been growing rapidly over the last few years. Extrapolating the numbers for the first seven months of 2020, the final figure of publications in 2020 should reach 78, more than doubling the number of 2019 and further accentuating the already steep rise in scholarly work in this research domain. We offer two explanations for this. Firstly, the rise of information technology and the resulting opportunities for commercially viable DRT services (Alonso-Gonzalez et al., 2018; Devaraj et al., 2020; Diana et al., 2007; Gilibert et al., 2019, 2020; Jain et al., 2017; Luiu et al., 2018; Nyga et al., 2020; Sihvola et al., 2012; Šurdonja et al., 2020; Weckström et al., 2018) must be considered as driving factors in accelerating development and innovation with respect to DRT, which in turn has led to a greater number of available services and academic interest in those services. Secondly, we argue here that the increasing interest in DRT services has largely been triggered by an intensified interest in public transport solutions as part of the wider array of measures aimed at decreasing carbon emissions. It is for this same reason, we believe, that performance expectations towards DRT have shifted.

The threefold performance expectation towards DRT services first became visible in the course of the content analysis of the 44 articles with a socio-scientific approach focusing on general perceptions and stated beneficiaries. It resulted in a structure of social, ecological and economic perceptions and benefits, strikingly similar to the concept of the *Triple Bottom Line* (Elkington, 1997). This concept

proposes the incorporation of social and ecological aspects into business performance measurement systems, and finds high attention in the field of sustainable business reporting (Slaper & Hall, 2011). Even though authors criticize the concept's application to businesses (Norman & MacDonald, 2004), in the context of this qualitative analysis, the *Triple Bottom Line* naturally lends itself to gain a better and more systematic understanding of the existing performance expectations. It highlights the attention social and ecological aspects of DRT services have gained up to present and the conflicts that result between these performance expectations. First, it is obvious that DRT providers need to consider economic aspects in order to guarantee an economically sustainable service. Besides the need to succeed economically, several articles highlight DRT services as a cost-effective alternative to traditional public transport in rural areas. Second, a strong social performance expectation towards DRT services exists: DRT services are expected to offer mobility to niche groups, such as elderly people or people with disabilities. This aspect has received scientific attention predominantly in countries with a well-established social welfare, which is supported by our analysis of the countries in which DRT services are studied. European countries lead this figure (see Figure 5), despite the fact that China and the USA generally contribute most research to the broader field of public transport research (Heilig & Voß, 2015). The third performance dimension concentrates on the potential contribution of DRT services to efforts geared at reducing carbon emissions in the transport sector. As one example of many national and international legislative efforts geared at reducing emissions, the EU's 2020 climate and energy package created increasing interest in this particular research field. It was enacted in legislation in 2009 (European Commission, 2010), stating binding goals for all members to be reached by 2020 (20 20 by 2020 Europe's Climate Change Opportunity, 2008). Summarizing the above, this article concludes that DRT services are confronted with a threefold performance expectation: To function as cost-covering businesses while at the same time reducing the cost for public transport, to provide social benefit, and lastly, to deliver an ecological contribution. Turning to literature on sustainability dealing with discussions of strong and weak sustainability (cf. D'Amato et al., 2017; Landrum, 2018), these goals can be expected to conflict, and the questions of tradeoffs that arise are everything but trivial. Efforts geared at better understanding and potentially resolving these conflicts thus call for comprehensive and interdisciplinary research approaches. As will be discussed in the following paragraphs, the relative emphasis on these dimensions and the associated conceptualization carry important implications for policymakers of different public levels and practitioners.

We identified differing performance expectations and influencing factors according to the population density of studied areas (see Figure 10). Historically, sparsely populated areas have been positioned as main target areas for DRT services. It is these contexts where the social performance dimension is most central (geographical coverage, public transport for all population groups etc.), and a potential to reduce costs by substituting traditional public transport with DRT services is highlighted. The bulk of articles, however, studies urban areas. Whenever the ecological performance expectation is scientifically discussed, this takes place in an urban context. This mismatch generates a serious impediment to the transferability and applicability of results, even more so when considering the significant differences in urban and rural environments that were outlined in the introduction. Summarizing the results that have looked at factors considered influencing user acceptance, such as *age*, *income*, *education* and *access to a private car,* no clear pattern emerges from scholarly work so far. Some factors allow clear implications, such as the travel purpose *work* requiring fast and regular transport, or increasing age and inactive work status allow more time flexibility. Others remain unexplained. This existence of conflicting findings thus far, and a detected lack of systematic, theory-driven research should lead to a cautious interpretation and could point to the existence of moderating factors not appropriately captured yet. Especially in rural areas, the reviewed articles highlight the missing provision of information about existing service offers and a lack of integration in existing information and booking systems. Although the results of research question 5 underline the

scientifically perceived impact of information provision on user acceptance of DRT services, we emphasize that the provision of information as sufficient means to raise acceptance has been widely criticized in the scientific discourse (McDivitt, 2016; Owens & Driffill, 2008; Toomey et al., 2017). This strengthens our call for more socio-scientific research on potential DRT users.

Besides the influence of spatial aspects on the results of studies, we highlight the importance of an a-priori determination of the performance orientation of DRT services. An example helps to illustrate this claim: Services that aim to perform on an ecological dimension (hence, aim to increase occupancy rates and optimize service routes) can hardly perform on a social dimension simultaneously, where individual routing and single occupancy are common. For an ecological performance orientation, regular users such as commuters seem a promising target group, a social performance orientation rather addresses users with increasing age and other needs, such as a short walking distance to the access points. Furthermore, service-oriented factors such as *distance to access point*, *booking method* or *guaranteed arrival time* seem to be depending on the targeted group, hence, on the expected service performance orientation. This strengthens the presented connection between the performance orientation of a DRT service and its potential target groups. Turning to the economic dimension of DRT services, evaluating the business success strictly based on classic, economic performance indicators does not consider the threefold, conflicting performance expectations DRT services are increasingly confronted with (such as social impact or emissions reduction). Reacting to this imbalance, the application of integrative performance measurement methods would ensure a holistic impression of the services. Several sustainability reporting methods and key performance indicators have been established (Büyüközkan & Karabulut, 2018; Székely & Brocke, 2017), some specific to sustainable transport (Richardson, 2005; Vassallo & Bueno, 2020) but none for DRT services as of now.

We observed a divergence in empirical studies relating to the coordination of the targeted participants and survey designs. Emphasizing the social dimension, DRT services are conceptualized to be most suited for specific user groups rather than a wide target audience. We find here that previous studies have majorly focused on the general public instead of specifically targeting certain groups such as elderly or commuters. On top of that, most empirical studies target actual users of DRT services, which certainly connects to the predominant application of revealed preference methods, a suitable to explore observed choices (Wardman, 1988). For DRT services as a novel form of public transport, this choice of method must be scrutinized. While this method might be well-suited for the small number of actual users with experiences with DRT services, it seems inappropriate to explore the large share of potentially new users without previous experience with this means of public transport. Stated preference methods, on contrary, appear more promising when aiming to investigate preferences towards previously unused travel modes (Kroes & Sheldon, 1988).

Scientific implications

For future socio-scientific studies on DRT services, we suggest to consider the population density in the sample design and to focus on rural areas. We identified a lack of research on the ecological performance potential of DRT services, and on factors hindering user acceptance, specifically in rural areas. Thus, we encourage future scientific explorations to address the fact that the overwhelming majority of the population perceives DRT services as a novel product in future studies, even more so in rural areas where the acceptance of public transport is generally rather low. We offer three recommendations: Future studies should (1) adapt their sampling strategies to the studied DRT service's performance orientation, (2) explore potential target groups' specific (conflicting) demand and factors influencing their acceptance of DRT services and (3) consider the novelty of this form of public transport when selecting survey methods.

Practical implications

For operators, private or public, we emphasize the integration of the outlined performance expectations into all business operations. Based on the presented evidence, we propose two suggestions: (1) Operators should define the purpose and beneficiaries of the services (target groups) and set a clear performance orientation, and should then (2) align the service access possibilities, information provision and booking modes accordingly. Thus, a target-oriented public transport offer can emerge. As an example, a DRT service could be designed and advertised strictly for commuters and offer transport from different access points to generic connection points only with and allow recurrent bookings and reserved seats. In off-times, the service could deliver individual transport requests. Regarding the proposed strategies to raise use acceptance, we highlight one suggestion that goes beyond pure information provision: Engage potential users and enable first experiences with a DRT service and thus, lower the entry barrier to DRT services and create positive experiences. Finally, we emphasize the integration of social and/or ecological performance into business reports. It bears a significant advantage: Their impact on all dimensions will become visible in a professional, comparable and extensive manner moving beyond the users' feedback communicated within their operative realm.

Policy implications

This article fosters the recognition of the outlined, threefold performance expectations towards DRT services that bear significant potential for conflict. Currently, many DRT services struggle to operate cost-effectively (Avermann & Schlüter, 2019; Jittrapirom et al., 2019; Luiu et al., 2018; Nyga et al., 2020; Ryley et al., 2014; Sihvola et al., 2012). This might result of the expectation to succeed on all performance dimensions. As one way to react to this finding, we suggest policies to accept DRT services as part of the traditional public transport network. This could include granting DRT services similar financial support to prevent failure because of unfulfilled economic performance expectations. In this respect, it is also imaginable that policymakers establish a reporting framework of economic, social and ecological indicators. This way, authorities could ensure a comprehensive evaluation of the return on investment while at the same time establishing a baseline and standard for future comparisons. Such a framework could further require the inclusion of the ecological performance dimension to foster the reduction of carbon emissions, and to monitor progress on that pressing matter. We strongly suggest including actors of different governmental levels and regions, experts on social, economic and ecological matters and citizens in the development process on several levels.

To react to the outlined impact of the regional population density on DRT services' performance orientation, target groups and factors influencing the user acceptance, we propose to grant a greater degree of freedom of regional decision-makers to design policies. On a national level, we propose to create a regulative framework fostering the integration of small DRT services in the information and booking networks of the existing public transport networks. This could also address the call for a better information provision on DRT services; information on established platforms supports the general publicity of such services amongst public transport users, which contributes to lifting DRT services out of their (publicity) niche.

Conclusion

In this article, we report a recent rise in scholarly interest on demand-responsive transport services, and a reorientation with respect to the performance expectations towards DRT services. We identified the performance dimensions as conflicting by nature, a finding that should be considered when evaluating such services. Connecting to the conflicting performance expectations, we identified discrepancies affecting the transferability of study results. Although DRT is viewed as a public transport mode for rural areas, well suited to address specific target groups, empirical inquiries more often than not ignore this context and focus on the more recently established ecological dimension in an urban context. Adding to that, the studied population groups do not match the groups positioned as main

beneficiaries. Structuring the articles according to the involved research fields identified that mathematical issues such as algorithmic optimization or simulation and economic aspects such as modelling, cost determination or business strategies have received the most attention in research on DRT services. Despite the fact that the analyzed articles clearly point to its importance, socio-scientific research only accounts for 44 publications out of 231 eligible for this review. This identified gap calls for more research on that matter, as user acceptance represents a pivotal factor for any successful practical development of DRT services. Strategically, in rural areas with high access to private cars, further research on user decisions is needed when seriously attempting to reduce the use of private combustion engine vehicles in favor of public transport and successfully establish DRT services. Hence, based on the findings of this systematic literature review, we call for further research focusing on the specific settings of rural areas, and on specific user-groups. We propose the empiric exploration of areas with existing DRT services and the inclusion of qualitative methods in the study design to identify area-specific conditions. We believe that acknowledging the existence of the three, potentially conflicting performance dimensions of DRT services will enable this form of public transport to be estimated realistically by practitioners and policymakers, hence, to be assessed holistically. It is for this reason that we argue that the present literature review represents a timely addition to extant literature and can serve as a guide for future research efforts in this particular domain.

CRediT authorship contribution statement

Stephanie Schasché: Conceptualization, Methodology, Validation, Investigation, Writing - original draft, Visualization. **Robert G. Sposato**: Conceptualization, Writing - review & editing. **Nina Hampl**: Conceptualization, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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