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## **Value of Reliability for the Waiting Stage, In-vehicle Stage and Transfer Stage of Demand Responsive Transport (DRT) Services**

**María J. Alonso-González · Sascha Hoogendoorn-Lanser · Niels van Oort · Oded Cats · Serge Hoogendoorn**

### **Abstract**

On-demand modes are playing an ever-increasing role in urban transportation. In particular, Demand Responsive Transit (DRT) (shared on-demand modes such as shared ride-hailing and microtransit) can complement scheduled public transport thanks to their collective nature. These services offer flexible and convenient mobility: they are not bound to fixed routes or schedules as public transport is. However, this flexibility also encompasses an extra risk related to service reliability and availability: “(When) will I get the requested ride?”. This work analyses and quantifies the Value of Reliability (VoR) of these new services via a stated preference survey. The study covers both the reliability components intrinsic to DRT as well as the transfer penalty when in combination with scheduled public transport. Unobserved components of the choice behaviour are captured via latent variables in the choice model. This study contributes to the inclusion of DRT services in transportation demand models, and to better understand the role of collective transport in future integrated mobility solutions.

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## 1 Introduction

On-demand services (car-sharing, bike-sharing, ride-hailing and Demand Responsive Transport (DRT)) are growing in popularity. They are flexible, offer tailor-made mobility and can help public transport provide a more convenient door-to-door service. Among these services, Demand Responsive Transport (DRT) provides collective mobility. DRT services are, in short, shared taxis: DRT match riders to be moved together in cars or personal minivans, and the offered route and schedule matches the riders' needs. Different DRT variants have appeared, such as shared ride-hailing and microtransit, and partnerships between these services and scheduled public transport are arising both in the USA and in Europe.

However, the increased flexibility of these on-demand services (no fixed schedules or routes) is accompanied by a risk of unavailability (will I get the requested ride?) and by a new understanding of reliability (when is a trip delayed?). There is the need to understand how these uncertainty aspects are perceived by travellers.

This paper aims at obtaining the passenger disutility incurred due to the intrinsic variability in DRT. This study addresses the Value of Reliability (VoR) for waiting and in-vehicle time regarding these services, as well as the transfer penalty incurred when transferring from these on-demand services to schedule-based public transportation and vice versa (i.e., the impact of this flexibility/reliability in intermodal trips).

The rest of the extended abstract introduces the background of the research topic, describes the survey design and research methodology, and presents expected results of the final paper, as well as a full paper outlook.

## 2 Background

### 2.1 Potential of DRT

Shared mobility services are evolving rapidly. In particular, popularity of ride-hailing services is growing rapidly, with ride-hailing services now being more popular than car-sharing in the USA, despite their later introduction (Clewlow, 2016).

There are two main factors that suggest that DRT may follow the same trend as the individual ride-hailing variant. First, individual trips in urban areas can be matched together with little inconvenience for the passenger. Santi et al. (2014) found that more than 95% of taxi trips in New York could be shared with less than five

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minutes delay; very different urban network structures around the world also show a similar potential (Tachet et al., 2017). Secondly, in the context of a stated preference experiment, we found that DRT has the potential to reach a broader share of the Amsterdam Metropolitan Region population than individual ride-sharing (Alonso-González et al., 2017), presumably due to its lower trip cost.

## 2.2 Importance of reliability and availability

Reliability plays a key role in travel behaviour, and it is necessary to consider its impact in order to model scheduled public transport demand accurately (Van Oort et al., 2015). Same happens with on-demand services: variability in the experienced service needs to be accounted for.

Moreover, flexibility of on-demand services also means uncertainty in their availability. This unguaranteed availability plays a key role in the probability of subscribing to shared mobility alternatives (Kim et al., 2017), and even a low probability of unavailability may be unacceptable for users that daily rely on on-demand services (Fricker & Gast, 2016). In fact, the main reason to stop using the DRT service Kutsuplus (Helsinki, Finland) among the higher income groups was vehicle unavailability and long response times (Weckström et al., 2017). Therefore, we need a deep understanding of how these aspects influence behaviour.

Finally, there is the transfer component, which increases the traveller's disutility. Since travellers are generally risk-averse, the transfer penalty is partly due to the risk of missing the connection (Ceder et al., 2013). In scheduled public transport, that risk is quantified via the headway (Schakenbos et al., 2016) and the (perceived) reliability of the modes of transport involved in the transfer. Given that DRT are schedule-free, reliability needs to be explicitly described to assess this risk. Hence, this aspect is also covered in the current study.

## 3 Survey design and methodology

In order to understand the reliability and availability of DRT and the transfer penalties associated with these services, a survey was developed. A series of stated preference (SP) experiments and 5-point Likert-scale indicators comprise the main body of the survey.

The survey respondents are part of the Netherlands Mobility Panel (MPN), a nationwide longitudinal household panel in the Netherlands. The MPN yearly collects mobility information on both the household level and the individual level (Hoogendoorn-Lanser et al., 2015). This implies that a wide range of information on the survey respondents and their travel patterns is available prior to the survey. Only respondents living in (sub)urban areas were targeted for the current study.

DRT is defined as “a car or small passenger van that picks travellers’ at a virtual bus stop situated around two walking minutes from their current location, and drops them off at a (virtual) bus stop situated around two walking minutes from their destination”.

The VoR depends largely according to trip purpose. This study includes two different settings (note that each participant gets only one of the two settings to lower respondents’ burden): 1) commuting trips, and 2) trips unrelated to work or studies. This second trip purpose is especially important since on-demand modes are mostly used for non-work related purposes.

Reservations are made real-time (i.e., there is no advanced booking option available). Therefore, the respondent is explained that he/she needs to be ready to depart when booking the ride. Depending of the available vehicles, different waiting times can be expected. The first SP experiment offers respondents two different services (see Figure 1), each one with different waiting time distributions (following the design of Small et al. (1999)). The second SP experiment shows a similar outline, but focusing on in-vehicle time (given the shared nature of DRT, detours to pick up other passengers can lead to varying in-vehicle times for the same ride) (see Figure 2). Therefore, these SP experiments address the variability both in the booking stage and in the in-vehicle stage.



Figure 1: Example of a choice task of the first SP experiment.



Figure 2: Example of a choice task of the second SP experiment.

The third SP experiment (see Figure 3) addresses the transfer penalty between different DRT services and scheduled public transport. Three travel options are offered to respondents, two of which involve a transfer. The transfer waiting time is illustrated with the planned waiting time and a distribution of transfer waiting time values coming from experience. Respondent were asked for both their preferred and their second preferred alternatives.

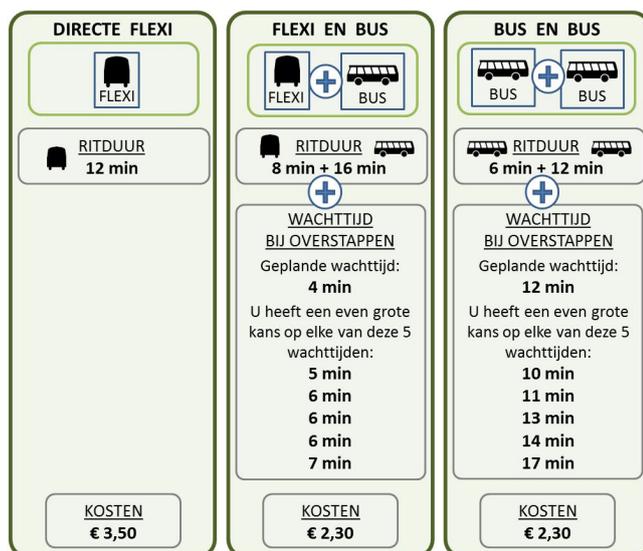


Figure 3: Example of a choice task of the third SP experiment.

The experimental design of the SP experiments is a fractional factorial design. The random utility maximization framework is used to analyse the survey results. Different choice model specifications, containing latent variables with the researched attitudes, will be analysed. The modelling package Biogeme is used for the model estimation and cross-sectional panel data is accounted for.

#### 4 Expected results

After a pilot survey, the main survey fieldwork took place in May. A total of 1077 surveys were completed. Data analysis is still in progress. Based on previous research, we have formulated the following hypothesis that we will study in our analysis.

Hypothesis 1: Out-of-vehicle variability (related to waiting) has a higher disutility to the traveller than in-vehicle variability (due to detours and passenger pick-ups).

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Waiting time disutility is larger than in-vehicle time disutility (Wardman, 2004). A similar direction is expected in time variability for shared on-demand modes. A better understanding of the reliability construct will enable the design of services that better match travellers' needs.

Hypothesis 2: Attitudinal variables can explain part of the unobserved heterogeneity regarding the Value of Reliability (VoR) of different travellers.

Previous research has shown that attitudinal variables play an important role in the decision-making process. By including latent factors in the choice model, we expect to 1) better account for choice heterogeneity among different respondents and 2) observe the importance of different factor components.

Hypothesis 3: Car users favour to a higher extent the convenience of a direct ride than current public transport users, who are more willing to include DRT as a leg in a public transport trip.

DRT can potentially be used as a door-to-door means of transport or as a feeder as part of a multimodal public transport trip. Current mobility patterns help explaining the extent to which a transfer is preferred over a more costly yet direct trip.

## **5 Summary and full paper outlook**

This study tackles three aspects concerning DRT:

- 1) It quantifies their Value of Reliability (VoR) for waiting and in-vehicle time.
- 2) It analyses the underlying travellers' attitudes towards DRT services.
- 3) It quantifies the transfer penalty between DRT and scheduled public transit.

As a result, the outcome of this research will contribute to the knowledge concerning the inclusion of these on-demand modes in transportation demand models. Moreover, the analysis of the transfer penalty between DRT and scheduled public transport helps better understand the role of collective transport in future integrated mobility solutions.

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