



Predicting susceptibility to use demand responsive transport using demographic and trip characteristics of the population



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ABSTRACT

Shared transportation providing point-to-point services on demand, although not an unknown element in urban mobility, has started gaining more presence with the growth of information technology in the transport sector. These forms of transport modes will supplement or compete with the existing public and private transport. Their mixed reception in the past is a matter of concern especially before making investment decisions. To find feasible opportunities of implementation, an estimation of the demand patterns in the target city is desirable. This paper will provide and evaluate a methodology for this estimation that avoids ambivalent and expensive user preference surveys. Demand patterns are caused by the spatial variation of demographic characteristics, and travel behavior over the city. Usability patterns of the proposed services can be learned from the experience of similar services operating elsewhere. Variations of the identified favorable characteristics can be found out in the target city using travel surveys of a population sample. The resulting spatial patterns can be used to find the more favorable areas for implementation of such transport modes. The methodology can be validated by applying it on the existing transport modes in the target city, which will also help in understanding the nature of competition among the proposed and existing transport modes. As the review of operating services is generic, it can be used in conjunction with respective travel surveys in different places. Similarly, a review can be done for any proposed transport mode and provided methodology can be applied for exploring demand patterns.

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1. Introduction

Population mobility and transportation accessibility is a problem for growing cities. To meet these challenges in a sustainable manner, taking into account congestion, environmental impacts and fuel consumption, new forms of transport are needed to be explored. One of the possible solution is to encourage demand responsive transport (DRT) modes, which provide flexible point-to-point service on casual demand. Different types of public and private on-demand transport services operate in various parts of the world, which provide shared forms of transport. Depending upon the population characteristics, current trip patterns and available transport options, different regions of a city respond differently to newly suggested transport services. Therefore, before implementing any particular service, it is essential to identify the

potential regions which are more susceptible to use DRT, and also the potential trips that can be converted.

Demand patterns of travel in a city are needed to be predicted realistically and efficiently for better transport planning. They are aggregates of the individual behaviors. In transport planning, predicting the travel behavior has always faced methodological challenges (Goodwin et al., 1990). To meet these challenges, initially, the transport researchers adopted methods to measure travel attitudes (Golob et al., 1979; Koppelman and Lyon, 1981; Pas, 1990). In later stages and currently also, the stated-preference, stated-choice, and stated-adaptation methods are prevalent (Jordan, 1988; Louviere, 1988; Timmermans and Golledge, 1990; Hensher, 1994; van Bladel et al., 2008).

Characteristics of households and individuals within a population are used to examine 'who, when, how, and where', the individuals travel (Axhausen and Gärling, 1992). The travel diaries for a sample of the population contain the details of trips such as purpose, time, origin, destination, distance, duration, waiting time, walking time, and mode of transportation. Using these diaries, the overall travel demand in the city, its distribution across the

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regions, and existing transportation mode distribution can be estimated. In this research, however, the travel demand patterns will be predicted for a new transport mode, which is not captured in these household transport surveys. Hence, the challenge of this research is to identify the trips among the existing demand, which can possibly be converted to the new mode of transport after its implementation (conservatively neglecting that any new mode may also raise new demand).

Piatkowski and Marshall (2015) mention in the context of bicycling that appropriate strategies for encouraging a transport mode vary greatly across different population groups; thus, identifying groups that are more prone to change in travel behavior, may act as an important strategy for rapidly and effectively impacting the commute mode choice. The shift to a new mode of transportation depends on several factors such as its affordability, travel time and cost, convenience, flexibility, technology, and its level of service compared to the existing modes of transportation. But as these factors are not known at the time of the inception of new services, and depend on their uptake in the market, they are not available in advance for an assessment of mode shift. Hence, the alternative approach of this research is to look for the target market of these services, identify individuals who will be willing to use these new services, and which of their trips they will be converting. In principle, one of the possible solutions for this is to conduct a stated preference or a stated adaptation survey to explore the willingness to shift to new modes of transport. These methods which predict the travel demand on the basis of responses of users, lack substantial theoretical underpinning (Levin and Louviere, 1981; Gärling et al., 1995). Hence, it is difficult to provide validation for the predicted results (Gärling et al., 1998). Surveys are better to be used in the circumstances, when the issues under study are clearly defined and the participant responses are anticipated. Survey methods may not be suited to the exploratory areas of research, where issues remain unidentified, and the researchers seek to answer a question (Clifton and Handy, 2003). The main criticism levelled at the static preference methods is that individuals' stated and actual preferences do not necessarily coincide, and there are more serious consequences for demand prediction of even random error in the static preference responses as a result of scale factor problem (Wardman, 1991). Hence, the results from preference or adaptation surveys can be misleading, because the surveyed people lack awareness about features and service details of the new mode, and had no time to adapt to the existence of a new mode available to them. This argument is even more applicable if the proposed services are novel in their character, which may be the case with the DRT, which is in the focus of this study. Also, the stated preference and adaptation surveys are expensive and time consuming. Hence, this research develops an alternative methodology, avoiding a service-specific survey. This research proposes a methodology to predict the travel demand patterns in a city for DRT, using demographic characteristics of the population, current trip characteristics, and the usage patterns of existing similar services elsewhere.

The methodology is based on census data and data collected in conventional travel surveys. Travel surveys are used in metropolitan cities to understand the people's (current) travel behavior and demand for transport planning. These travel surveys record demographic characteristics, household attributes, and travel details/diaries. In these surveys, each individual in the sample has a travel diary comprising of sequence of trips in a representative day, trip attributes such as origin and destination region, travel mode, trip purpose, departure time, trip duration, waiting time, walking time, and distance. Details of these travel diaries along with the demographic characteristics of individuals and households in the population such as age, gender, relationship in household, vehicle ownership, employment type, household size and structure,

household income, and driving licence availability are available for predicting the travel demand patterns for new modes of transportation.

To identify usability, user profile, usage pattern, and dominant favorable characteristics of users and trips for DRT, a review of features and usability pattern of some of the existing similar transport services in different regions of the world has been conducted, which allows to identify the certain trip characteristics, individual, and household characteristics that are likely to switch to DRT. Extracted patterns from the travel survey data will be summed up to explore the overall spatial pattern of susceptibility of DRT in the target city. These patterns can be mapped to find the more favorable areas for implementation of DRT services. A similar exercise can be performed to find the susceptibility for existing forms of transport in the target city, for example, conventional public transport, where the resulting estimated patterns can be compared with existing ones in order to validate the approach.

Hence, this research will provide a methodology on how demand for new modes of transport, DRT in particular, can be predicted. This methodology can be evaluated, and thus its predictive capacity is expected to be realistic and reliable.

This paper will investigate the research hypothesis that usability patterns of (demand responsive) transport services in different regions of the world combined with the demography and current trip characteristics of the target city can be used to predict the susceptibility for novel transport services, eliminating the requirement of service-specific surveys. Section 2 of the paper will introduce DRT and travel behavior research on analyzing effect of the demographic and trip characteristics on travel decisions. Section 3 presents the relevant findings from review of various DRT services operating in the world. Section 4 explains the parameters favorable to DRT identified in Section 3, and provides a methodology to use them to explore DRT susceptibility in Metropolitan Melbourne. Section 5 presents the results of this study in the form of a map of Melbourne with its regions having varying susceptibility to DRT. Section 6 provides an approach to validate the methodology by applying it on existing public transport. Section 7 concludes the paper by presenting main findings and implications.

2. Research background

2.1. Demand responsive transport (DRT)

DRT has been studied under multiple terminology such as dial-a-ride (Cordeau and Laporte, 2007) or ad-hoc ride-sharing (Winter and Nittel, 2006; Braun and Winter, 2009). Correspondingly, there is no consistent body of knowledge, and different communities have developed similar solutions for DRT modes, and increasingly for real-time DRT systems. The common challenge, however, has always been optimization between the transport demand and supply, and thus, the demand patterns determine the constraints of the whole system.

According to Ambrosino et al. (2004), DRT is an “intermediate form of transport, somewhere between the bus and taxi, which covers a wide range of transport services, ranging from less formal community transport through to area-wide service networks”. According to Bakker (1999), DRT is a “transportation option that falls between private car and conventional public bus services. It is usually considered to be an option only for less developed countries and for niches like elderly and disabled people”. The latter comment is clearly becoming outdated, observing the global success of various commercial ad-hoc DRT.

DRT can solve the challenges of the public transportation in low density urban areas, and more theoretically, short distance pickup and delivery problem (Wang and Winter, 2010). It has the poten-

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