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Modeling the demand for a shared-ride taxi service: An application to an organization-based context

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ABSTRACT

Traffic congestion has become a worldwide concern. One way to address this problem is to enhance the performance of the transport system by means of sound public transportation that is capable of appropriately addressing the demand of travelers, especially in highly urbanized areas of the world. The implementation of shared-ride transportation has been a viable transportation solution in many areas. The purpose of this study is to evaluate the market demand potential of a Shared-Ride Taxi (SRT) service in an organization-based context. It presents an integrated choice and latent variable modeling framework for modeling the number of times per week a Shared-Ride Taxi would be used if it were implemented at an organization. The study involves extensive analysis of practical policy scenarios through which the impact of cost incentives (subsidies) and multiple SRT attributes on travelers' behavior is examined.

Using stated preference data, the model is applied to a case study of the students at the American University of Beirut in Lebanon. Research results are expected to provide an initial evaluation of the market potential for a Shared-Ride Taxi in a university setting in Lebanon. Results reveal that 30–50% of the students are willing to utilize the Shared-Ride Taxi service under practical scenarios and that subsidies are likely to play a key role in increasing the SRT ridership.

1. Introduction

Road traffic congestion is a serious growing problem. Large segments of the population in many urban areas of the world are in need for adequate urban mobility that would cater for the diversity of their activities. Since the beginning of the 21st century, auto ownership has continued to increase dramatically (Dargay et al., 2007), deteriorating the environment as well as the quality of urbanized life that it brings forth. The implementation of shared-ride transportation since the 1940s was a viable transportation solution in many areas of the world. Shared-ride transport modes are a form of public transportation that involves several schemes of multiple-occupant vehicles such as carpools and vanpools (ridesharing), jitneys, and demand responsive transit (DRT) which in turn encompasses a range of modes such as paratransit, Dial-A-Ride Transit, and shared-ride taxis.

This paper develops a modeling framework for modeling the number of times per week a Shared-Ride Taxi (SRT) would be utilized if it were implemented in an organization-based context. The models employed are integrated choice and latent variable (ICLV) models for users of public transport (including jitney and bus users) and users of private cars. Our paper contributes to a better understanding of the market potential of a Shared-Ride Taxi at an organization through estimating a model that captures the taxi service attributes, including original attributes such as internet availability and vehicle size as well as the level of service attributes, the socioeconomic characteristics of the users, and the latent (or unobserved) attitudes of the users that are assumed to influence their choices. Many integrated choice and latent variable models exist in the literature as reviewed in the next section. In our paper, we extend this literature and develop an ICLV model with discrete count choices. This paper also comprises robust policy scenarios, using the developed model, that serve as a decision support tool for the provision of a Shared-Ride Taxi service in an organization-based context.

The modeling framework is applied to a case study of the American University of Beirut (AUB), Lebanon. This application is part of the Congestion Studies supported by the Neighborhood Initiative at AUB and is an extension to another study (Al-Naghi,

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2014) which presents an evaluation framework for organization-based ridesharing with an application to the students at AUB.

This paper aims at examining the potential use of a Shared-Ride Taxi, one form of DRT, for AUB students residing inside the Greater Beirut Area (GBA). More specifically, the case study investigates whether students would utilize a SRT service if it were implemented. Through an online stated preference (SP) survey, AUB students were asked questions about their current travel patterns as well as their hypothetical behavior towards the new SRT service. The objective is to bring quantitative answers that would help forecast the potential SRT ridership (in terms of percentage of students willing to utilize the SRT 0, 1, 2, 3, 4, and 5 times weekly), assuming that such service is available for students. The findings of the case study are relevant to other similar organization-based contexts, particularly in areas lacking reliable public transport services.

The paper is structured as follows. First, we present a literature review on shared-ride transportation. Second, we define the modeling methodology to which this paper contributes. Third, we present the study area, discuss its current transport system, and present descriptive information about the sample used for modeling and the survey design. Then, we present and discuss the model estimation results and use the model for policy analysis. We finally summarize our findings and conclude.

2. Literature review

Shared-ride transportation has started to become a mainstream public transport mode. Many DRTs have been implemented in several areas in the world and especially in low demand areas (Enoch et al., 2006) or in relatively small areas (Takeuchi et al., 2003). In order to respond to travelers' requests, these systems operate based on routes and timetables that may be fixed or flexible. SRTs usually have scheduling methods that are automated and require advance reservation. Also, there is a wide range of communication schemes including telephone and web interfaces that are provided to deploy the SRT services.

Shared-ride transportation started in the early 1900s in North America where trips were assigned along fixed routes (Takeuchi et al., 2003). Later, such systems were mainly concerned with the provision of enhanced mobility for the elderly and disabled (Takeuchi et al., 2003). By the beginning of the 1990s, these systems in Europe began to utilize advanced information and telecommunication technologies with flexible routes and timetables responding to users' demand. This had paved the way for the use of new transportation services with enhanced application of technologies including geographic information systems and information management systems (Benjamin et al., 1998). Many studies in the literature also underlined the reasons hampering the development of shared-ride transportation services such as Enoch et al. (2006). The latter study shows that the barriers are regulatory, fiscal, institutional and cultural, occurring at the level of the government, the operator, and the users. Another problem identified by Enoch et al. (2006) was the difficulty to convey the nature of the services to many users and especially the elderly and disabled.

In order to understand the market response to shared-ride transportation service improvements, previous research such as Benjamin et al. (1998), Takeuchi et al. (2003), and Ben-Akiva et al. (1996) utilized discrete choice models that quantified the impacts of attributes such as travel cost and travel time, in-vehicle time, and individual characteristics and attitudes. Such models provide a decision support tool for planning new shared-ride transportation services or improving the efficiency of existing ones. As presented by Benjamin et al. (1998), public transit alternatives in Winston-Salem, North America included the current bus system, a bus-route deviation system, the existing dial-a-ride service, and a dial-a-ride feeder service. Benjamin et al. (1998) quantitatively examined the issues of the adoption of advanced public transportation systems by the elderly and disabled. A disaggregate discrete mode choice model was developed to forecast the travelers' response to the introduction of the new services. The results showed that improved reservation schemes for the existing Dial-A-Ride service produce shifts in mode shares and that the demand for the Dial-A-Ride service increases with the increase in user awareness. Other research examined the effect on demand of the level of service of these systems including the waiting time. According to Takeuchi et al. (2003), results of a demand model showed that users prefer shorter waiting time and shorter in-vehicle time. Further, Ben-Akiva et al. (1996) concluded that age, difficulties in walking, and employment status are main decision factors that capture users' readiness to use a Dial-A-Ride service.

Other studies have examined how psychological factors influence people's decisions and choices. According to Danthurebandara et al. (2013), these factors are individual-specific and include latent (or unobserved) attitudes, lifestyle, values, and perceptions. Such latent variables have been integrated with choice models in studies such as those presented by Ben-Akiva et al. (2002), Danthurebandara et al. (2013), Paulssen et al. (2013), and Temme et al. (2008). The key advantage of these models is that they assume heterogeneity among the respondents through incorporating latent variables which decrease the unexplained parts of the heterogeneity (Danthurebandara et al., 2013). In the shared-ride transportation context, some studies also examined how abstract motivations such as attitudes affect traveler behavior and decisions, e.g., Chan and Shaheen (2012) who showed that travelers see attractiveness in carpooling but refuse to carpool because it does not provide them with equivalent flexibility and convenience as a private car. Also, the findings from the studies implemented by Ben-Akiva et al. (2002) and Danthurebandara et al. (2013) demonstrated that the implementation of the ICLV framework results in an improved goodness of fit over choice models without latent variables and that these models perform very well in prediction.

While there are numerous cases of ridesharing services that were open to the public use, fewer efforts focused on the provision of organization-based shared-ride transportation. A lot of research has focused on modeling the demand for carpooling services on an organizational level, especially for university students such as Erdoğan et al. (2015) who studied the demand for carpooling and vanpooling in UMD University, Baltimore, Washington D.C. Others studied dynamic ridesharing in similar contexts without developing econometric demand models. Amey (2010) proposed a design for a technology-focused rideshare trial for faculty, staff, and students at the Massachusetts Institute of Technology, focusing on the importance of incentives and personalized marketing to overcome the rideshare challenge. As cited by Siddiqi and Buliung (2013), examples of shared-ride transportation services in an organizational context include: (1) Smart Traveler Program sponsored by the University of Washington and restricted to the university's faculty and students, (2) Bellevue Smart Traveler which was restricted to the employees living in Bellevue (Washington) and who work in the downtown location, and (3) Facebook-user driven goCarShare service in Edinburgh, Scotland which was open to the public but targeting Facebook users. While some of such types of services still operate until this day (such as goCarShare), many discontinued due to inefficient pricing regime, poor level of service, and technological limitations. A study by Aoun et al. (2013) examined possible ways that make high-income users use high-occupancy modes rather their private cars. Google employees in San Francisco benefit from 32 free of charge Google shuttle