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Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach ☆

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ABSTRACT

This paper assesses the demand for a flexible, demand-adaptive transit service, using the Chicago region as an example. We designed and implemented a stated-preference survey in order to (1) identify potential users of flexible transit, and (2) inform the service design of the flexible transit mode. Multinomial logit, mixed-logit, and panel mixed-logit choice models were estimated using the data obtained from the survey. The survey instrument employed a d_p-efficient design and the Google Maps API to capture precise origins and destinations in order to create realistic choice scenarios. The stated-preference experiments offered respondents a choice between traditional transit, car, and a hypothetical flexible transit mode. Wait time, access time, travel time, service frequency, cost, and number of transfers varied across the choice scenarios. The choice model results indicate mode-specific values of in-vehicle travel time ranging between \$16.3 per hour (car) and \$21.1 per hour (flexible transit). The estimated value of walking time to transit is \$25.9 per hour. The estimated value of waiting time at one's point of origin for a flexible transit vehicle is \$11.3 per hour; this value is significantly lower than the disutility typically associated with waiting at a transit stop/station indicating that the 'at-home' pick-up option of flexible transit is a highly desirable feature. The choice model results also indicate that respondents who use active-transport modes or public transit for their current commute trip, or are bikeshare members, were significantly more likely to choose flexible and traditional transit than car commuters in the choice experiments. The implications of these and other relevant model results for the design and delivery of flexible, technology-enabled services are discussed.

1. Introduction

Travel demand in low-density areas can be highly variable over time, and the presence (or absence) of high-quality transit service in these areas may reinforce the existing mode choices of travelers. Transit services that can flex with demand have been explored as one option to address the demand variability problem (*e.g.*, Errico et al., 2013). Flexible transit is one of many emerging hybrid transportation service options. Ajelo, Split, and Bridj emerged in 2012–2014 as private transportation services that offer user-generated routes—for a higher fare than existing public transit—in cities such as Helsinki, Washing-

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ton, D.C., Boston and Kansas City. Transportation network companies (TNCs) such as Uber and Lyft (and formerly Sidecar) offer a competing form of taxi service for many travelers; while preliminary research has shown they may complement transit service in underserved areas, long-term impacts are not yet clear (Shared Use Mobility Center, 2016). Other mobile applications for hailing taxicabs are also available, and the regulatory definitions and policies to distinguish traditional ride-sharing, taxi/livery services, and public transportation are evolving (Yousef, 2014). To craft sound policy and provide sustainable, efficient travel alternatives, research is needed to define and understand the trade-offs users make when considering emerging modes and existing alternatives.

This paper examines the potential demand for a type of flexible transit service in which passengers may experience some walk time, wait time, or transfer time depending on demand for the service and the origin-destination pairs of all customers making requests (Frei and Mahmassani, 2015). In flexible systems, each additional traveler adds route deviations and hence increases the length of the vehicle itinerary and the travel time of other users (insertion cost). In contrast to paratransit service, which must provide door-to-door service, other dial-a-ride services—including the flexible transit mode described in this paper—may serve rail stations or other high demand locations, effectively converting many-to-many type services to many-to-few or even many-to-one services.

To understand the trade-offs travelers may be willing to make in regards to traveling via a flexible mode, we designed and implemented a stated-preference mode choice survey and estimated choice models. Residents of the city of Chicago were sampled. The survey instrument employed a d_p-efficient design and the Google Maps API to capture precise origins and destinations to create realistic choice scenarios. Respondents answered questions regarding their current work commute, activities onboard, and reliability of their chosen travel modes. The stated-preference experiments offered respondents a choice between traditional transit, car, and the hypothetical flexible transit mode. Wait time, access time, travel time, service frequency, cost and number of transfers varied systematically across the three modes in each choice scenario.

The hypothetical service studied could provide mobility where a traditional fixed route transit service is not justified, but where the trip distribution patterns are predictable enough to warrant more structure than existing demand-responsive services. Understanding the attribute trade-offs can help guide service design and policy as these technology-enabled services and their offerings continue to evolve. For example, the existence of reliable, guaranteed service on a time-table may become less important as real-time information regarding a vehicle's location becomes readily available. Recent research has suggested that shared-use mobility can complement transit for first- and last-mile service (Shared Use Mobility Center, 2016); providers need to understand how users value that connection in order to develop appropriate services and/or partnerships. Additionally, it is important to determine the types of travelers that are likely to benefit from and make use of a flexible, demand-adaptive transit service.

The remainder of this paper is structured as follows: the next section provides background on existing flexible transit systems and summarizes relevant literature related to service attributes influencing the choice of flexible or demand-responsive transit. Section 3 describes the stated-preference survey developed to measure trade-offs among transit service attributes and determine potential flexible transit users. Section 4 presents a summary of the data obtained from the survey of Chicago residents. Section 5 describes the formulation and results of the multinomial logit and panel mixed-logit mode choice models. The concluding section summarizes the choice model results, discusses policy implications and offers recommendations for future study.

2. Background and literature

The attributes that influence the demand for travel modes, and how their valuation may evolve over time, have been studied in urban and suburban contexts worldwide. This section describes relevant studies that measure customers' valuation of service quality attributes. This section also discusses emerging transportation service options including flexible, demand-adaptive transit systems as well as shared mobility services and Mobility-as-a-Service platforms.

2.1. Findings of related surveys

Which customers are willing to use a particular service and *what trade-offs* they will make (cost, walk distance, wait time, reliability, etc.) ultimately dictate service design. Answers to these questions with regard to flexible service will inform the potential cost to the service provider in terms of both resources (*e.g.* vehicles, staff) and facilities (*e.g.* park-and-ride) in the long-term.

Molin and Maat (2014) ask questions regarding such trade-offs to understand the willingness to pay for bicycle parking when bicycle is an access/egress mode to rail stations in the Netherlands. Respondents participated in a stated-choice experiment, choosing among:

1. Paid, surveilled indoor bike facilities with varying walk time and prices;
2. Free, open air bike racks, at varying walk distances from the station and surveillance levels (none, camera, and personnel);
3. Switch to another mode; or
4. Travel to another train station.