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Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Predicting new forms of activity/mobility patterns enabled by shared-mobility services through a needs-based stated-response method: Case study of grocery shopping



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ARTICLE INFO

Available online 29 January 2014

Keywords:

Stated-adaptation
Activity/travel patterns
Needs-based analysis
One-way carsharing

ABSTRACT

One-way carsharing systems are increasingly-prevalent in urban areas, though little is known about their impacts on activity-travel behavior, particularly their effects on usage of motorized and non-motorized travel. Such systems require privileged access to publicly-controlled street space, and in order to prepare suitably for negotiations regarding the price and terms of such access, transport planners require techniques to analyze their usage and impacts.

In contrast to previous methods, this study employs activity/mobility behavior as the quantity under study rather than aggregate travel distance. A stated-response method is presented to predict the impacts of one-way carsharing. The survey instrument is based on needs-based theory, in which multiple activity episodes undertaken in service of a broader personal objective are analyzed as a pattern of linked behavior. Food shopping was the activity type employed in the empirical analysis.

Substantive findings relating to the impacts of one-way carsharing are discussed, as well as limitations imposed by the survey protocol and limited sample size ($n=72$). It was found that non-car-owning respondents within our sample would use one-way carsharing to allow them to shop for food less frequently, would visit fewer distinct food shops, and would spend less time traveling for food shopping purposes. Instrument effects specific to this method are also discussed.

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1. Introduction

Shared-mobility systems are transitioning from a promising idea worthy of experimentation into a serious option for rationalizing urban mobility.

The most widespread form at present is ‘round-trip’ carsharing, in which a customer takes a shared-car (generally for a period of hours), performs a round-trip tour with it, and then returns it to its original location, thus ending the usage episode. The customer pays by the hour and reserves the car beforehand, as one would book a hotel room in advance.

A rapidly-emerging variant is ‘one-way’ or ‘point-to-point’ carsharing. In this operational concept, the customer takes a car from one point to another, and only pays by the minute while driving it, as with a taxicab. Usage is generally spontaneous rather than pre-booked; rudimentary reservation systems exist but provide no guarantee of access to a car at the requested place and time (Car2go, 2013a). Other forms of shared-mobility include

liftsharing (provision of car passenger travel in another person’s private car), bikesharing (short-term rental of bicycles, typically point-to-point), and peer-to-peer carsharing (provision of one’s personal car for other drivers to rent), as well as traditional car rental (more-detailed definitions of these services can be found at VTPI [2013]).

The first appearance of one-way carsharing appears to have been in Amsterdam in the early 1970s (Bendixson and Richards, 1976), and at the time of writing such services operate in at least two dozen cities in North America and Europe (Car2go, 2013b, DriveNow, 2013; Autolib, 2013; Citroen, 2013; Renault, 2013). In many cases the contemporary operators are automotive manufacturers (BMW, Mercedes, Citroen, etc.), which is in contrast to traditional round-trip carsharing which emerged primarily in the form of start-up companies. As of mid-2013 there are over 100,000 members of one-way carsharing services in North America alone (Shaheen and Cohen, 2013).

The literature shows that shared-mobility services affect both how and how much people travel. More evidence is available regarding the impacts of round-trip carsharing on mobility patterns (cf. Martin and Shaheen, 2010; Sioui et al., 2012, with earlier studies discussed in Harms and Truffer [1998]), though the limited

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results available at present regarding one-way carsharing (cf. Le Vine, 2011; Firnkorn, 2012) strongly suggest its impacts are substantial and quite different from round-trip carsharing. On the basis of a large-sample survey of carsharing members, Martin and Shaheen (2010) show that the majority of customers of round-trip systems drive somewhat more than they would if carsharing did not exist, whilst a minority report that they drive less. They further show that the magnitude of the average effect is greater amongst those that drive less, such that on balance round-trip carsharing leads to less vehicle-kilometers of car travel. Comparable results have also been found in Britain (Harmer and Cairns, 2012; Steer Davies Gleave, 2013) using similar methods.

Even though in many cases the public sector does not directly deliver shared-mobility services, transport planners play a mediating role in these markets. While there are limited examples of shared-mobility services operating in politically-unfavorable environments (cf. Robert, 2000), these services in general depend on privileged access to street space, which can only be granted by the public sector. Thus transport planners are gatekeepers of the shared-mobility marketplace, in the position to allow the private-sector shared-mobility services to reach their customers or to preclude them from doing so.

In order to support decision-making that balances between protecting the public interest and providing an acceptable environment for the private-sector operators to invest, it is imperative for transport planners to understand the implications of shared-mobility services. There are indications that the shared-mobility marketplace may be at a point of inflection, as major commercial operations based on both the 'round-trip' and 'one-way' operating concepts are beginning to report profitability (Zipcar, 2012; Reiter and Tschampa, 2013). It is also important to note that the shared-mobility paradigm is blurring a number of functional relationships within the automotive sector. Car rental firms, for instance, have been major customers of carmakers for many years, but they are now both beginning to compete for the same market in urban mobility services (Firnkorn and Muller, 2012).

This paper's contribution is the use of patterns of activity/mobility behavior as the unit of analysis to assess the impacts of one-way carsharing systems. A novel stated-response method grounded in the emerging 'needs-based' theory of activity participation is proposed (Arentze and Timmermans, 2006; Abou-Zeid and Ben-Akiva, 2012). Previous studies of the impacts of shared-mobility services generally use aggregate travel distance (e.g. kilometers per year by various modes of transport) as the quantity under study (Communauto, 2006; Martin and Shaheen, 2010; Firnkorn, 2012). Patterns of activity/mobility are more complex to work with, but this paper shows that the advantage of this type of data structure is that it can support richer and more insightful findings.

The rest of this paper is structured as follows: Section 2 presents methodological background and Section 3 presents the details of the survey instrument and administration. Results are in Section 4. Section 5 summarizes the findings, highlights the main conclusions, and discusses future research needs.

2. Background

The stated-response survey design employed in this study draws on needs-based theory of activity participation, which is predicated on the notion that the activities people do are driven by [unobservable] underlying human needs. (which in principle include discretionary desires as well as 'needs'.) Thus mobility is viewed as a derived demand, arising from activity participation, whilst activity participation itself is conceptualized as a second level of derived demand arising from [unobservable] needs/

desires. The first two of these elements (mobility and activity behavior) are, in principle, observable; this is in contrast with needs, which are latent. Questionnaires may however be used to probe certain dimensions of the links between perceived needs/desires and executed activity/travel behavior (Nijland et al., 2010).

Previous applications of needs-based theory have employed various forms of simulated activity/travel data (Marki et al., 2012), revealed-behavior data (Abou-Zeid and Ben-Akiva, 2012; Marki et al., 2012; Nijland et al., 2012; Pattibhiraman et al., 2012), and stated-response data structures (Nijland et al., 2011; Khademi et al., 2012). In many of these studies activity types that are observed to have rhythmic patterns of execution have been used to parameterize utility functions which depend on, among other variables, elapsed time. Bhat (1996) analyzed the correlates of inter-episode participation in recurring activity types, and provides an overview of earlier attempts at representing multi-day rhythms in activity participation patterns.

Needs-based theory directly addresses several relatively under-appreciated aspects of activity participation. First, it is sensitive in principle to the interdependencies between activity episodes, either of the same class of behavior (standard categories include work, leisure, social obligations, shopping, etc.) or others. An example of linkages across different classes of behavior would be work-activity episodes leading to increased need/desire for leisure-activity episodes. Second, activity participation is explicitly analyzed to depend on the episode-specific attributes of earlier activities, beyond simply being conditional on the elapsed time since the previous episode of the same class. For instance, in the framework proposed by Arentze and Timmermans (2006) activity participation is sensitive to the degree to which previous episodes satisfied the underlying need as well as the elapsed time since the relevant earlier activities took place.

The empirical study reported here investigated food shopping behavior. It is recognized that food shopping is a somewhat coarse treatment of a human 'need', where nourishment for biological metabolism could be seen as the more fundamental relevant 'need'. Acquisition of the raw materials required for nourishment could conceivably be met by any of a number of means, such as others (a spouse, parent, child, etc.) shopping for the food that a person eats, eating prepared food at a restaurant or canteen, or even through nutrients provided intravenously. Further, 'food' as a category encompasses a large set of heterogeneous items. It is also important to note that food shopping is but one aspect of the complete supply chain leading to nourishment and is temporally separated from the metabolic processes; one purchases groceries at some arbitrary point that will be prepared and consumed at later points in time. Despite the complexities of the link between food shopping and nourishment, however, this study provides empirical evidence that the heuristic of treating food shopping as a 'need' which is met through flexible patterns of activity execution is tractable. It is noted that the needs-based stated-response technique proposed in Nijland et al. (2012) distinguishes only between 'daily' and 'clothes' classes of shopping activities, whereas Pattibhiraman et al. (2012) do not disaggregate the shopping class of activities at all. It therefore remains an item for the future research agenda to determine whether subtler needs-definition is feasible in the stated-response context of hypothetical behavior.

This study develops a structured stated-choice/adaptation instrument (Lee-Gosselin 1995). In each replication of the experiment, respondents choose whether to use a one-way carsharing service, and if they do they then indicate how they would adapt their pre-existing behavior in a structured way (along a small number of dimensions) to make use of it.

The revealed behavior that respondents report is in the form of a stylized pattern, as they indicate their 'regular' food shopping behavior rather than specific recent instances of food shopping. This

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