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The effects of activity-travel context and individual attitudes on car-sharing decisions under travel time uncertainty: A hybrid choice modeling approach

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ABSTRACT

People's daily decision to use car-sharing rather than other transport modes for conducting a specific activity has been investigated recently in assessing the market potential of car-sharing systems. Most studies have estimated transport mode choice models with an extended choice set using attributes such as average travel time and costs. However, car-sharing systems have some distinctive features: users have to reserve a car in advance and pay time-based costs for using the car. Therefore, the effects of activity-travel context and travel time uncertainty require further consideration in models that predict car-sharing demand. Moreover, the relationships between individual latent attitudes and the intention to use car-sharing have not yet been investigated in much detail. In contributing to the research on car-sharing, the present study is designed to examine the effects of activity-travel context and individual latent attitudes on short-term car-sharing decisions under travel time uncertainty. The effects of all these factors were simultaneously estimated using a hybrid choice modeling framework. The data used in this study was collected in the Netherlands, 2015 using a stated choice experiment. Hypothetical choice situations were designed to collect respondents' intention to use a shared-car for their travel to work. A total of 791 respondents completed the experiment. The estimation results suggest that time constraints, lack of spontaneity and a larger variation in travel times have significant negative effects on people's intention to use a shared-car. Furthermore, this intention is significantly associated with latent attitudes about pro-environmental preferences, the symbolic value of cars, and privacy-seeking.

1. Introduction

Car-sharing has received increasing attention as an innovative mobility option to alleviate environmental problems that are caused by the increasing number of private cars. Car-sharing systems provide people the benefits of private cars without the costs and responsibilities of car-ownership. In order to use a shared-car, people need to join a car-sharing organization that owns and maintains the shared-cars and operates the system. After joining a car-sharing organization, people can use a shared-car by checking the availability of shared-cars, booking a car, and collecting and returning the car at the designated point-of-departure (POD). It is permitted to book a car for short-term use (one hour or less), and the costs depend on the distance traveled and the duration of car use.

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Travel behavior researchers have developed models to predict the market potential of car-sharing systems. From the perspective of a mid-term mobility decision (e.g., the car-ownership decision), the market potential relates to people's intention to join a car-sharing organization to acquire this mobility option for future travel demand. Discrete choice models have been estimated to explore factors affecting people's decision to join a car-sharing organization, such as pricing schemes and accessibility to PODs (Zhou and Kockelman, 2011; Kato et al., 2012), characteristics of other mid-term options (Le Vine et al., 2011, 2014), people's environmental consciousness (Efthymiou et al., 2013), subjective satisfaction with their current travel pattern (Efthymiou and Antoniou, 2016), the uncertainty that originates from the possible non-availability of shared-cars (Kim et al., 2017), and conformity with car-sharing decisions of the social network (Kim et al., 2016).

From the short-term mobility decision perspective, the market potential of car-sharing systems is determined by people's daily decisions to use a shared-car for conducting a specific activity. Once a member, people may consider a shared-car as their transport mode for a specific trip. In this context, some studies developed a transport mode choice model with an extended choice set that includes the shared-car. These studies employed stated preference methods to estimate the model, considering the lack of popularity of car-sharing systems in the current market. For instance, Ciari and Axhausen (2012) constructed a stated choice experiment of transport mode choice based on 3 alternatives (private car, public transport, and car-sharing). They considered travel time and cost, parking cost, and access time of each transport mode as the experimental attributes. Cantalano et al. (2008) and Eiró and Marínez (2014) considered similar attributes. In addition, both studies considered additional urban mobility options, such as carpooling, taxi, cycle, and walk. Le Vine et al. (2014) suggested a stated choice instrument allowing the examination of both the mid-term and short-term decisions. Respondents were asked to simultaneously compose a portfolio of mobility options and select which mobility option they will use to conduct different activities. The fixed costs of each mobility option (e.g., purchase costs and membership fees) were assumed influencing the mid-term decision, while travel time and cost of a specific trip were considered for the short-term decision.

Despite interesting results, these studies ignored some distinguishing features of car-sharing, which likely affect choice probabilities. First, availability checking and booking a car are required actions before departure. These actions may introduce a loss of spontaneity in using a shared-car. Thus, users may need to wait before a car becomes available. Such inevitable probability of delay in departure time may play a crucial role in deciding to use a shared-car when people are pressured by a lack of time, or simply due to the extra effort and possibly hassles. Second, the usage costs depend on the duration of car use, including driving and parking. Thus, not only travel time but also activity duration while using the car are directly associated with the costs. Therefore, the effects of such distinguishing features may depend on the activity-travel context at the moment of making a decision.

Furthermore, in light of paying time-based costs, uncertain travel time and its impact on short-term car-sharing decisions need to be taken into account. High travel time variability may lead to reserve or use a shared-car for a longer time period, resulting in higher costs. The effects of travel time uncertainty on transport mode, route choice and scheduling processes (e.g., Liao et al., 2014; Rasouli and Timmermans, 2014a,b,c) have been studied at length in transportation research. However, the effect of travel time uncertainty in the context of the car-sharing decision has not yet been examined.

In addition to uncertainty, latent attitudes deserve further consideration in better understanding short-term car-sharing decisions. Latent attitudes may reflect different values, social norms and lifestyles. However, these latent factors cannot be directly deduced from revealed choices. In order to identify these unobservable factors and incorporate them into discrete choice analyses, hybrid choice models (HCMs) have been developed (Ben-Akiva et al., 2002). HCMs allow simultaneously identifying the latent attitudes based on a set of observable attitudinal indicators and estimating their effects on discrete choice behavior. Temme et al. (2008) and Paulssen et al. (2014) considered personal attitudes toward flexibility, convenience, comfort and safety of transportation modes in investigating commuter's transport mode choice behavior. According to their results, people who have flexible- and safety-seeking attitudes tend to prefer private cars to public transport, while convenience and comfort are negatively associated with the utility of using private cars for the work commute. Kim et al. (2012) and Atasoy et al. (2013) employed pro-environmental attitudes as a latent variable in a transport mode choice model. Their estimation results suggest that pro-environmental attitudes are positively associated with the use of public transport. In addition, they considered people's pro-car attitudes and dislike of driving a car. However, to date, the effects of latent attitudes on car-sharing have been ignored.

The objective of the present study, therefore, is to incorporate activity-travel context and latent attitudes in a HCM to investigate the effects of these factors on people's willingness to use a shared-car for conducting a specific activity. In particular, the study is designed to investigate transport mode choice behavior under travel time uncertainty. The data used for estimating the model is based on a stated choice experiment, which included activity-travel context as an experimental attribute. A hypothetical choice situation is defined in terms of a series of travel times experienced for each transport mode in order to examine the effects of travel time uncertainty. The data also include responses to a set of attitudinal questions to identify latent attitudes. To the best of our knowledge, this study is the first study on short-term car-sharing decisions that takes all these factors into account. This study on day-to-day use of car-sharing is complementary to our earlier work that adopted a long term perspective (Kim et al., 2016, 2017). The data for the different perspectives were collected as part of the same survey but are based on different experimental. In addition, the modeling differs.

The paper is organized as follows. The following section discusses the data collection including the measurement of latent attitudes and the design of the stated choice experiment. The third section provides the suggested HCM framework, and the fourth section presents the estimation results. The last section concludes the paper.

2. Data collection

The data used in this study were collected using a 2-phase online survey instrument. Phase 1 included questions about