



Satisfaction and uncertainty in car-sharing decisions: An integration of hybrid choice and random regret-based models



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ABSTRACT

Car-sharing systems have attracted increasingly attention as one of several sustainable transportation systems. After joining a car-sharing organization, people can use a shared-car. Because sharing a car involves other members, there is some inherent uncertainty that originates from the possible non-availability of the shared-car. This uncertainty may trigger people to apply decision-making mechanisms other than the maximization of expected utility. In addition, variable satisfaction with current mobility options may affect individuals' decisions differently. Such uncertainty and satisfaction associated with car-sharing decisions have been largely ignored in previous studies. The present study is designed to examine the effects of latent satisfaction with current mobility options and uncertainty underlying car-sharing decisions. A random-regret minimization-based hybrid choice model is proposed to simultaneously estimate these effects. The model allows investigating car-sharing decisions in both risky and riskless choice contexts. The parameters are estimated based on stated choice data using a Bayesian D-efficient optimal design. The results show that satisfaction significantly affects the car-sharing decision, and that car availability has a significant effect on the likelihood of joining a car-sharing organization.

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1. Introduction

Increasingly, the number of private cars exacerbates environmental problems such as emissions, decreasing exhaustible resources, and taking scarce land for road and parking spaces. The severity of these damaging effects is even more problematic when it is realized that private cars are parked for most of the time. Public transport could be a good alternative, though it has several shortcomings in terms of door-to-door accessibility, flexibility, personalization and carrying goods. In this context, car-sharing systems have recently attracted increasingly attention (Shaheen and Cohen, 2013). These systems provide people the benefits of private cars without the costs and responsibilities of car-ownership. The shared-cars and their operating systems are owned and maintained by car-sharing organizations. In order to use a shared-car, people need to join a car-sharing organization paying a deposit and/or monthly membership fee. Once a member, they can use a shared-car by checking the availability of shared-cars, booking a car, collecting and returning the car at the designated point-of-departure (POD)

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and paying the time-based and distance-based costs. [Shaheen et al. \(2012\)](#) and [Shaheen and Cohen \(2013\)](#), summarizing existing knowledge, argued that car-sharing systems induce people to sell their own-cars and avoid purchasing a car. Therefore, knowledge of underlying decision-making processes in joining a car-sharing system may help designing more attractive systems, thereby reducing the number of private cars.

Car-sharing decisions can be viewed as both a mid-term and short-term mobility decision. From the perspective of a mid-term mobility decision (e.g., car-ownership decision, purchase of a seasonal ticket of public transport, etc.), the decision is whether or not joining a car-sharing organization to acquire this mobility option for future travel demand. When making this decision, future demand is uncertain because it depends on various expected and unexpected needs for particular activities and the possibility of coordinating car use in multi-person households. From the perspective of a short-term mobility decision, the car-sharing decision is which travel mode to choose for conducting a specific daily activity, conditional on the mid-term car-sharing decision. After joining a car-sharing organization, people may consider a shared-car as a travel mode for a specific trip, comparing other transportation modes such as public transport, bicycle, etc. Hence, individual decision-making processes may differ between the mid-term decision and the short-term decision. The short-term decision is relatively easy to model as it does not fundamentally differ from any transport mode choice model, except for the larger choice set and slightly different attributes for the shared car. Modeling the mid-term decision problem is more challenging because few, if any, examples can be found in the literature, the decision has to be conceptualized in an original way, and the complexity of the decision implies that standard stated choice experiments seem ill-suited to sufficiently capture the decision problem. The present study focuses on the mid-term car-sharing decision.

The objective of this study is to investigate the underlying drivers of joining a car-sharing organization and their effects on individual decision-making process. In particular, this study is designed to examine people's intention to join a car-sharing organization against purchasing a car and using their current mobility options. It is assumed that this intention depends on individual satisfaction levels with the current mobility options, which reflects perceived qualities of using a car and public transport in terms of congestion level, convenience, comfort, and safety. As previous studies investigating membership of car-sharing organizations have mainly been concerned with the costs of purchasing and maintaining a private car and the convenience of using public transport, these aspects have been largely ignored in studies investigating the market potential of car-sharing systems. The following section reviews the relevant studies and discusses their limitations.

Another common and critical limitation of previous studies is that uncertainties underlying car-sharing decisions have been ignored. Since a car is shared by a number of members, there is some inherent uncertainty in the availability of a car at the exact moment it is desired. A member cannot use a shared-car if all shared-cars at accessible PODs are being used or have already been reserved by other members. The possible non-availability of a shared-car at precise points in time and space is likely to have negative effects on people's willingness-to-join a car-sharing organization. For instance, a qualitative study by [Shaheen et al. \(2016\)](#) suggests that the elderly tend to be reluctant to replace their personal vehicles with car-sharing systems because of uncertain vehicle availability in an emergency situation. In this context, [Cari et al. \(2015\)](#) pointed out that the exclusion of the effects of the availability in estimating car-sharing demand may be one of the reasons why previous studies tend to provide optimistic predictions of car-sharing potential. In order to investigate the effects of the inherent uncertainty on the mid-term car-sharing decision, the present study developed a stated choice experiment by including the probability of the availability of shared-cars as an attribute. To the best of our knowledge, the present study is the first to consider the attributes of the alternative mobility options, including the satisfactions, and the uncertainty in a mid-term car-sharing decision model.

In order to simultaneously estimate these effects, we suggest an elaborated hybrid choice model framework. A hybrid choice model (HCM) generally integrates latent variables and discrete choice models into a structure that is estimated simultaneously ([Ben-Akiva et al., 2002](#)). A random regret-based model is developed to account for the risky choice context in the mid-term car-sharing decision, and is incorporated into the HCM framework as the discrete choice model part. In the framework, underlying satisfactions are identified through a latent variable model and included in a modified utility/regret function of the random regret-based model, implying that satisfaction can compensate anticipated regret.

This paper is organized as follows. As aforementioned, the following section provides a review of the state-of-the-art of studies on the mid-term car-sharing decision, and discusses their limitations. The third section presents the data collection including the design of the stated choice experiment. The fourth section provides the concepts and assumptions in terms of regret in risky choice contexts for car-sharing decisions. The fifth section presents the suggested model structure. In the sixth section, the estimation results with respect to the parameters and several policy measures are discussed. The last section concludes the paper.

2. Literature review

2.1. Mid-term car-sharing decision models

We start with a brief overview of findings from previous studies investigating membership of car-sharing organizations. Members tend to be largely motivated by financial savings because they need only periodically and/or occasionally a (an additional) private car ([Katzev, 2003](#); [Chatterjee et al., 2013](#)). On average, the members in North American organizations tend to use a shared-car 3 times per month ([Katzev, 2003](#); [Costain et al., 2012](#)). A second motive is the greater convenience

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