



Behavioral mechanism design for transportation services: Laboratory experiments and preference elicitation cost

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ABSTRACT

We herein use the results of laboratory experiments to study the effects of preference-elicitation mechanisms on the efficiency of auctions. Transportation and reservation service providers need to know the potential user demand. However, the preference-elicitation method can impact the elicitation results. In this study, we experimentally analyze the effects of preference-elicitation mechanisms on users' eliciting behaviors and on the efficiency of auction results. In addition, we show that our preference-elicitation mechanism can reduce users' bidding cost and improve the efficiency of auction results. Finally, we examine users' behaviors in laboratory experiments to estimate their preference-elicitation costs.

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1. Introduction

All transportation systems involve supply constraints per unit time, and there can be traffic congestion and crowded trains. Therefore, having a mechanism for appropriately allocating a limited supply capacity to users is essential for the transportation services. Auction mechanisms are currently receiving increasing attention as one such method. In auction and reservation systems (e.g., tradable permit systems for transportation services), it is important for service providers to be able to predict the potential user demand. Many previous studies have focused on auction-based schemes for transportation systems and services, including tradable credit schemes (Viegas, 2001; Yang and Wang, 2011; Wu et al., 2012; Nie and Yin, 2013) and permit systems (Verhoef et al., 1997; Akamatsu, 2007; Wada and Akamatsu, 2013; Hara and Hato, 2018a). In an empirical study on a transportation service auction, Hara and Hato (2018b) demonstrated the significance of the bidding behavior of users under uncertainty and the effects of the cognitive cost for users on the auction results. However, no studies have been reported on evaluating the cognitive cost of users' bidding behavior and empirically establishing a relation between the efficiency of auctions and the elicitation methods.

First, we describe the concept and research question of this study. From the viewpoint of traditional mechanism design, there are mainly 4 elements in Fig. 1. First element is transport or activity demand of users. In general, it is the valuations or bidding values of transport system for users. And second element is efficient allocation for social good. The objective of mechanism designer is allocating the resources efficiently by using users' valuations. The third element is constraint conditions of transportation system. To decide the allocation, the mechanism designers need to satisfy the constraint conditions such as capacity limit and some conditions. The fourth element is the incentive for strategy-proofness. If the payments for users are irresponsible, users can tell a lie and they can get larger utilities than telling truth. Therefore, the payments for users need the incentive design. These elements are the significant elements for traditional mechanism design. However,

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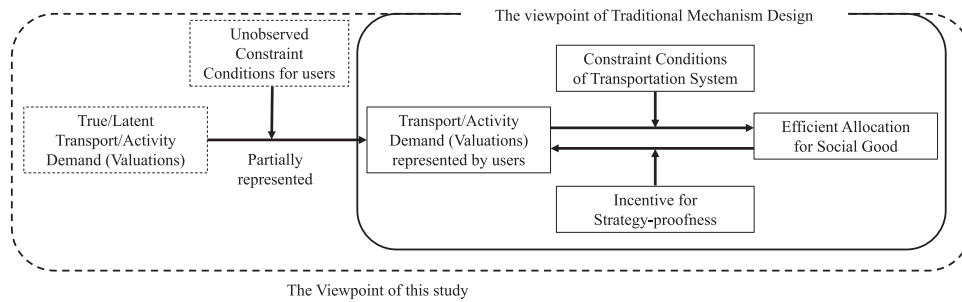


Fig. 1. The relationship between the concept of our study and traditional mechanism design framework.

as Hara and Hato (2018b) demonstrated, users rarely represent their all information. From the result, the viewpoint of this study extends the traditional mechanism design framework. It means the true and latent transport demand is different from that represented by users. And we assume that the latter is the part of the former because it is observed partially. The reason why the former is partially represented by users is that users have the unobserved constraint conditions such as transaction cost, cognitive burden, cognitive bias, misunderstanding and so on. They are collectively called preference elicitation cost in this study.

With respect to the cognitive cost of preference elicitation in an auction, we must think of the following three problems:

1. Does a preference-elicitation cost for bidding values or representing the willingness to pay (WTP) really exist?
2. If they do exist, to what extent can the preference elicitation cost be evaluated?
3. Is it possible to design preference-elicitation mechanisms that can reduce such a preference-elicitation cost?

This study aims to answer these three questions through empirical analysis using laboratory experiments. These research questions are significant in transportation services because the theory of the mechanism design itself cannot be applied in the deployment and implementation of transportation services. It is essential for real-world services and policies in areas like transportation services to raise the level of mechanism design to that of “behavioral mechanism design.” Needless to say, “behavioral mechanism design” is a broad concept beyond the scope of this paper. However, this is the first step for combining traditional mechanism design, desirable preference elicitation, and empirical behavior analysis.

In this study, we used the results of laboratory experiments to analyze the effects of preference-elicitation mechanisms on the efficiency of auctions. The service providers of transportation services and reservation systems need the accurate assessments of potential user demand. However, the user interface and preference-elicitation method can have an impact on the results elicited from the users.

The contributions of this study can be summarized in the following six points.

- We designed and executed laboratory experiments to analyze the differences in elicitation mechanisms for transportation service auctions.
- We introduced a survey system based on the Bayesian truth serum (BTS) (Prelec, 2004) which encourages subjects to improve their response accuracy.
- Based on the experiments, we empirically showed that valuations and the number of representations vary depending on the preference-elicitation mechanism.
- Differences in the number of representations resulted in a thin market, that is, a market with a few transactions. As a consequence, the differences in the number of representations can reduce the efficiency of the auction results.
- We showed that we can significantly improve the efficiency of an auction by increasing the number of preference representations using a preference-prediction mechanism.
- We empirically estimated the preference-elicitation cost for users on the basis of the experimental results. As the estimated elicitation cost is very large, a naïve preference-elicitation mechanism has a negative effect on the auction efficiency, and the results demonstrate the importance of the preference-prediction mechanism.

2. Literature review

2.1. Transportation system auction

There are two types of transportation auctions. The first one is an auction for general users, such as for tradable permits and credit. There have been many studies on this type of auction, such as those by Akamatsu (2007), Yang and Wang (2011), Wu et al. (2012), Nie and Yin (2013), and Wada and Akamatsu (2013). Those studies examined tradable permit systems for road networks. In addition, Hara and Hato (2018a) studied a tradable permit system for mobility sharing services. Such studies had two primary objectives. The first objective was to efficiently allocate transportation systems. The other was to understand the real preferences of users using a bidding and market mechanism. In these studies, The incentive-compatible

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