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Investigating heterogeneity in social influence by social distance in car-sharing decisions under uncertainty: A regret-minimizing hybrid choice model framework based on sequential stated adaptation experiments ☆

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ABSTRACT

The present study is designed to investigate social influence in car-sharing decisions under uncertainty. Social influence indicates that individuals' decisions are influenced by the choices made by members of their social networks. An individual may experience different degrees of influence depending on social distance, i.e. the strength of the social relationship between individuals. Such heterogeneity in social influence has been largely ignored in the previous travel behavior research. The data used in this study stems from an egocentric social network survey, which measures the strength of the social relationships of each respondent. In addition, a sequential stated adaptation experiment was developed to capture more explicitly the effect of social network choices on the individual decision-making process. Social distance is regarded as a random latent variable. The estimated social distance and social network choices are incorporated into a social influence variable, which is treated as an explanatory variable in the car-sharing decision model. To simultaneously estimate latent social distance and the effects of social influence on the car-sharing decision, we expand the hybrid choice framework to incorporate the latent social distance model into discrete choice analysis. The estimation results show substantial social influence in car-sharing decisions. The magnitude of social influence varies according to the type of relationship, similarity of socio-demographics and the number of social interactions.

1. Introduction

Car-sharing systems provide people the benefits of a private car without the costs and responsibilities of car-ownership. The shared-cars are owned and maintained by car-sharing organizations. Car-sharing systems tend to induce people to sell their own cars and avoid purchasing one, thereby reducing carbon dioxide emissions (Shaheen et al., 2012; Shaheen and

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Cohen, 2013). Therefore, knowledge of decision-making processes leading individuals to join a car-sharing system may help designing more attractive systems, thereby alleviating environmental problems caused by private cars.

Recently, travel behavior researchers have become interested in the effects of social influence on travel choice behavior (Arentze and Timmermans, 2008; Axhausen, 2008; Maness et al., 2015; Goetzke et al., 2015). Since humans are social beings, people are members of social networks and interact with other members of their network. Through interaction, people exchange and share information with social network members and update their expectations of the outcomes of their choices. As a result of interaction, individuals' decisions may be influenced by the choices made by members of their social network. Therefore, beyond the individualistic perspective that regards individual behavior as an independent choice without respect to the influence of social relationships, interaction between individuals and its effect on decision-making processes deserve further consideration.

Conformity behavior, which implies the phenomenon that individuals tend to mimic the behavior of others, may influence choice processes. People may act upon or change their decisions to match attitudes, beliefs and behaviors the norms of their social network or sub-network (Cialdini and Goldstein, 2004). In addition, uncertain and incomplete information about alternatives may induce people to be more inclined to mimic the behavior of others. Conformity behavior as an effect of social influence has been investigated in various qualitative and quantitative studies about travel-mode choice (Dugundji and Walker, 2005; Dugundji and Gulyás, 2008; Walker et al., 2011; Pike, 2014), the adoption of telework (Wilton et al., 2011; Scott et al., 2012), the intention to purchase electric vehicles (Axsen and Kurani, 2012; Rasouli and Timmermans, 2013, 2016; Kim et al., 2014), attitudes and decisions about bicycling (Gordon and Handy, 2012; Sherwin et al., 2014), and travel behavior in an uncertain situation (Ryley and Zanni, 2013). Understanding the role of social influence in activity-travel decisions may provide insight into the dynamics of particular choice behavior and corresponding market shares. The present study focuses on conformity behavior in car-sharing decisions.

A generalized framework to incorporate social influence in discrete choice analysis is to construct a social influence variable as a function of an individual's social network and include it as an explanatory variable in the utility function of the choice alternatives. Maness et al. (2015) gives a review of discrete choice models of social influence in travel behavior research. There are several approaches to construct a social influence variable. For instance, following Brock and Durlauf (2001), Dugundji and Walker (2005), Dugundji and Gulyás (2008) and Walker et al. (2011) employed the field variable to represent social influence in travel mode choice behavior, defined as the average mode share of each alternative in the reference groups. The reference groups were classified by social and spatial strata based on socio-demographic similarities, residential districts, and postcodes. This approach addresses implicitly rather than explicitly social network effects.

On the other hand, Scott et al. (2012) and Pike (2014) collected information about the explicit social network of respondents using an egocentric network approach. In this approach, respondents are the egos, and they are asked to elicit their social network members (i.e. alters) based on a specific criterion (i.e. name generators). Scott et al. (2012) investigated the effects of social influence in a workplace on the choice to telework. They classified types of colleagues according to their current work types. The number of colleagues in each work type was dealt with as social influence variables in the model of the intention to adopt telework. Pike (2014) investigated social influence in travel mode choice behavior of university students. The sampled students were asked to list up to 5 persons in their social networks and to report the usual commute mode for each of the alters. The percentage of alters using each travel mode was included as a social influence variable in the travel mode choice model.

Another approach is to deal with the social influence variable as a latent variable, which can be identified through relevant indicators. Kamargianni et al. (2014) assumed that social interaction influences the formation of latent attitudes and the decision-making process. They asked respondents to indicate their parents' walking habits and used the answers as attitudinal indicators to identify parents' preference for walking. In addition, it was postulated that the parents' preferences affect individuals' preferences for walking which is associated with travel mode choice behavior. To simultaneously estimate the latent variables and their effects on the choice behavior, they employed a hybrid choice model (HCM) framework.

The alters' behaviors collected in these studies are all based on ego's subjective perception or anticipation. On the other hand, Rasouli and Timmermans (2013) suggested an experimental approach to investigate social influence in the purchase of electric vehicle. The social influence variables were defined by the market shares of electric cars for various social network types such as family, friend, colleague, and peers social networks. The market share of each type was systematically varied across different choice situations in a stated choice experiment. Thus, a respondent indicated his/her intention to buy an electric vehicle for different choice situations varying not only attribute levels of electric vehicles but also market shares by social network type. From the perspective of generalizability theory, this approach has some potential advantages.

Although the previous studies have provided useful approaches to investigate social influence in travel choice behavior, heterogeneity in social influences due to different social relationships has been largely ignored. An individual may receive different amounts of influence from different group members depending on their social relationships. Intuitively, for instance, it is obvious that our behavior and preferences tend to be more influenced by our best friends than other friends. The strength of the relationship between individuals can be referred as social distance, described as "the degree of closeness or acceptance that an individual feels towards another individual in a social network" (Bonguna et al., 2004). The social distance is associated with subjective feelings of other members (affective distance), membership status in a group (normative distance), and frequency of contacts (interactive distance) (Karakayali, 2009). In addition, the differences in social position and status, and personalities are also important measures describing the social distance between individuals (Reagans,