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Expanding scope of hybrid choice models allowing for mixture of social influences and latent attitudes: Application to intended purchase of electric cars

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ABSTRACT

Recently, policy makers' expectations about the role of electric cars in reducing emissions have risen substantially. In parallel, academic research on purchase intentions has dramatically increased. Originally, most studies have focused on utility attributes and price. More recently, several hybrid choice models have been estimated to include the impact of attitudes on choice probabilities. In addition, a few studies have caught the attention to social influence. In contributing to this line of research, this paper reports the results of an expanded hybrid choice, which simultaneously estimated all these different effects in a single integrated model of purchase intention. Results indicate that the model performs well. Costs considerations contribute most to the utility of electric cars. Social influence is less important, but there is also evidence that people tend to take it into consideration when there are positive public opinions about electric cars and the market share becomes almost half of friends of their social network. The intention to purchase an electric car is also influenced by attitudes about environmental concerns and technology acceptance.

1. Introduction

In order to reduce negative environmental impacts of private car use, many countries have invested in the development and promotion of alternative fuel vehicles. The electric car (EC) is one of such vehicles, which run on electric energy instead of gasoline or diesel fuel. Compared to gasoline and diesel vehicles, the EC is relatively new and its technology has matured recently. Because its current market share is still low, it is difficult to assess market potential based on current purchase data. Beyond the traditional factors that relate to car features and costs, the innovative nature of electric cars and its positioning in the environment debate suggest that the effects of attitudes and social influence may be relevant to include in studies of purchase intentions of electric cars. This study aims to identify the impact and relative importance of these factors and

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explores their effects on purchase intentions using advanced discrete choice analysis based on the stated choice approach. To the best of our knowledge, it is the first study on electric cars that takes all these factors into account using an integrated modeling framework that expands the scope of hybrid choice models to include social influence.

One aspect that deserves further consideration in better understanding choice behavior concerns latent attitudes. Latent attitudes relate to general opinions that may influence the utility that people derive from their choices. Attitudes may reflect different values, social norms and lifestyles. Graham-Rowe et al. (2012) conducted a qualitative study among consumers driving ECs. They identified several latent attitudes that play a crucial role in purchasing ECs: vehicle confidence, environmental attitudes, etc. Daziano and Bolduc (2013) and Turcksin et al. (2013) reported similar results. However, these latent factors relate to subjective beliefs and tastes, which cannot be directly observed from revealed market choices or objectively derived from measurable technical specifications of electric cars. In order to identify these unobservable factors and incorporate them into discrete choice analyses, *hybrid choice models* have been developed. These models include latent (class) variables and choice models with flexible error structures, which are considered simultaneously in estimation (Ben-Akiva et al., 2002). Latent attitudes are treated as latent variables based on diverse indicators collected from attitudinal surveys. Several studies have employed the hybrid choice model to explore the effects of latent attitudes on travel choice behavior (e.g.,Walker and Ben-Akiva, 2002; Temme et al., 2008; Daly et al., 2012; Prato et al., 2012; Kim et al., 2012). In particular, to better understand and predict people's choice of alternative fuel vehicles, the effects of diverse latent attitudes have been investigated through hybrid choice models. These latent attitudes relate to environmental concerns (e.g., Daziano and Bolduc, 2013; Hess et al., 2013; Jensen et al., 2013; Soto et al., 2014), latent attitudes toward vehicle features (e.g., design, spaciousness, technology, etc.) and leasing a vehicle (e.g., Glerum et al., 2013; Mabit et al., 2014).Results of the application of the hybrid choice model provide evidence of the additional insight they can provide in decision-making processes and their explanatory power.

Another aspect that may be considered in studies on the intended purchase of electric cars concerns social influence. Since humans are social beings, people are members of social networks and interact with other members of their network. Through interaction with social network members, people acquire information about alternatives and update their expectations of the outcomes of their choices. Therefore, individuals' decisions may be influenced by the choices made by members of their social network. Several types of social influence may affect individual choice behavior. As a result of joint activity participation, group decisions, negotiation, etc., which involve exchanging and sharing information with social network members, people may become aware of new alternatives (e.g., Han et al., 2008, 2011; Ettema et al., 2011). In addition, conformity behavior may influence choice processes. Individual may be inclined to mimic the behavior of others. This is the focus of the present study. Mimicking behavior implies that choices of social network members directly affect an individual's utilities. Hence, "individuals belonging to the same group may tend to behave similarly" (Manski, 1999). This phenomenon has also been referred to as spill-over, conformity and peer effect, social multiplier, cascade, bandwagon effect, imitation, contagion, herd behavior, and so forth. The impact and intensity of this phenomenon depends on the specific choice behavior. When the characteristics of certain choice alternatives are not well-known, or directly experiencing or evaluating the choice options is not easy, people may tend to be more conscious of others' choice. Thus, it can be expected that the lack of knowledge about ECs make others' experiences a more critical factor when deciding to purchase EC. In addition, mimicking behavior may reflect the tendency to express a similar lifestyle and make similar choices as other members of one's social network.

There are several approaches to investigate and represent social influence on travel choice behavior. Some approaches have addressed the effect of social network in agent-based micro-simulation models (e.g., Arentze and Timmermans, 2008; Ettema et al., 2011; Hackney and Marchal, 2011; Han et al., 2011; Cho et al., 2013). These agent-based approaches have simulated the actions and interactions of individual agents considering the context of the social interactions. Another approach is based on econometric models. Discrete choice models which include social influences as explanatory variables in the utility function have been suggested. The present research is in line with this econometric approach. A few studies in travel behavior research have investigated conformity behavior using discrete choice analysis. Some studies have applied Brock and Durlauf (2001) seminal choice model, in which the probability of an individual's choice is proportional to the aggregate choice behavior of the relevant social network (Dugundji and Walker, 2005; Dugundji and Gulyás, 2008; Walker et al., 2011; Dugundji and Gulyás, 2013). Application domains include illegal bicycle parking (Fukuda and Morichi, 2007), telecommuting (Páez and Scott, 2007), location choice (Páez et al., 2008) and vehicle type choice behaviors (Kuwano et al., 2012).Others have used general multinomial or mixed logit models and expressed social influence in terms of explanatory variables, included in the specification of the utility function. The latter approach may offer more flexibility (Rasouli and Timmermans, 2013a,b). In the first set of studies social influence variables have been dealt with as the average share of the considered alternative in social and spatial strata, which can be called a reference group. According to this approach, if a social influence parameter is significant and positive, an agent tends to choose the alternative, which was chosen dominantly by his or her reference group of similar age, income level and/or district. Beyond classification of agents by social and spatial characteristics, Páez et al. (2008) suggested a distant-decay function in terms of social space. They assumed that an agent receives different amounts of influence from other agents depending on their social distance, that is, the strength of social ties. While these approaches are all based on revealed preferences data, Kuwano et al. (2012) and Rasouli and Timmermans (2013a,b) suggested including social influence in stated choice experiments. Kuwano et al. (2012) included in their stated choice experiment an attribute depicting the general market share of electric vehicles. Rasouli and Timmermans (2013a,b) suggested an experimental approach allowing one to investigate more specific and