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The impact of business models on electric vehicle adoption: A latent transition analysis approach

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ABSTRACT

It is often argued that successful market penetration of electric vehicles may not only rely on the characteristics of the technology but also on business models. However, empirical evidence for this is largely lacking. This study intends to fill this gap by assessing the impact of business models, in particular battery and vehicle leasing, on Electric Vehicle (EV) adoption. By conducting a stated choice experiment, we examine to what extent car drivers switch their choices between conventional and electric vehicles after business models become available. The results based on the discrete choice model suggest that leasing does not increase EV adoption at the aggregate level. However, a latent transition analysis shows that different groups with internally homogeneous preferences react differently to leasing options at the disaggregate level. The results indicate that 13% of the car drivers changed their preferences, albeit in different ways. Transition probabilities are particularly related to attitudes towards leasing and knowledge of EV. The results show that leasing is useful in facilitating EV adoption for certain groups, which can be identified by their individual characteristics. In addition to these substantial insights, this paper makes a contribution to the literature by demonstrating the potential of latent transition analysis in uncovering heterogeneity in behavioral changes induced by policy or strategy interventions, especially when changes can occur in opposite directions.

1. Introduction

Substituting fossil-fueled cars by electric vehicles is considered to be a potential solution for many problems caused by road transport, including excessive CO_2 emission, environmental pollution and oil dependency. However, its market penetration has not been quite smooth except for only a few countries (e.g. Norway). Many researchers blame this on several deficiencies of EV in contrast to gasoline vehicles, such as expensive price and high uncertainties regarding battery upgrade and life expectancy. In order to reduce these barriers, most attention has been paid to improve the quality and reduce production cost through intensive Research & Development of EV (mainly battery) technology (Williander and Stålstad, 2013). However, an option often ignored in the literature is the implementation of different business models for commercialization of EV.

A business model has three key components: (i) value proposition: the product or service provided by the company; (ii) value

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network: the way in which the involved stakeholders are organized; and (iii) revenue model: the way in which the company to charge customers (Bohnsack et al., 2014; Kley et al., 2011). An example of business model is leasing. Consumers who lease a car do not have to pay the full purchase price upfront, which may help overcome the higher purchase costs of EV. Instead, they pay a fixed monthly leasing rate and have exclusive access to the car for around 3–4 years. At the end of this period, they can pay a surcharge to acquire full ownership if they wish so. Another business model which is innovative and specific for EV is battery leasing, for which consumers purchase the car body and lease the battery only. Both types of leasing alleviate financial burden brought about by the high purchase price of EV. They also reduce uncertainties and shift some risks away from customers by providing some guarantee for battery and the residue value of the car.

It remains unclear whether these new business models are sufficient to compensate the shortcomings of technologies and make a substantial difference in facilitating EV adoption. If it is found to be a useful way for promoting EVs, car manufacturers should allocate some attention to business model innovation besides focusing on technical developments only; furthermore, since it would also help to achieve sustainability targets, the government could intervene to stimulate business model innovation besides implementing other incentives and policies (Birkin et al., 2007). Therefore, knowledge about the extent to which consumers change their preferences and behavior under different business models can provide insights into its potential in boosting EV sales, which is crucial for both government policy and car manufacturer decision-making.

An issue in assessing the impact of business models is that they may have different effects for different groups of consumers, which may cancel each other out at the aggregate level: for example, when new business models become available for all car types, some car drivers may switch from conventional vehicle (CV) to EV due to the lowered financial burden; while those who initially prefer EV may change to CV because the introduction of private leasing offers attractive monthly payments. If these two flows are around the same size in the population, the aggregate impact of business models becomes insignificant. Hence, we may risk ignoring these heterogeneous changes if we only examine aggregate changes. Therefore, uncovering these heterogeneous changes for different groups and identifying the groups that are most susceptible to business models is important, because this allows developing tailored policy or strategy making for different target groups.

Latent transition analysis (Collins and Lanza, 2010) offers an elegant solution to study these heterogeneous changes. As a typical latent class model, it assumes that the population consists of several unknown groups that have internally homogeneous preferences, which differ from those of other groups. In a new context, for example after a particular policy is implemented, preferences and choices of individuals may change and this behavioral change is represented by transitions of individuals between different groups. Therefore, instead of exploring direct changes between taste parameters in different contexts, latent transition models capture preference change by identifying changes in class membership. This model is powerful in describing behavioral change since it (1) easily incorporates opposite behavioral change by representing different directions in transition flows between groups, and (2) captures the relation between behavioral change patterns and initial preferences by the probability of transition between different classes. Despite the above mentioned advantages, latent transition analysis has only found limited application in transportation studies. Kroesen (2014, 2015) applied the method for investigating travel behavior evolution over time analyzing panel data. To the best of our knowledge, no prior research applied latent transition analysis to study the impact of policies or strategies in combination with stated preference data collections.

Considering the aforementioned research gaps, the aim of this paper is twofold. First, we contribute to the literature on EV adoption by examining the potential of business models (in particular leasing options) in facilitating EV adoption and substitution for internal combustion engine (ICE) vehicles. In particular, we first examine the aggregate impact of business models on EV preferences; second, we identify homogenous groups based on EV preferences and then reveal how different groups are differently affected by business models; third, we identify how individual specific variables (including socio-economic variables and attitudes) influence class membership and transition probabilities. The second aim of this paper is to contribute to the choice modeling literature by showing how latent transition analysis is able to uncover the different impacts of a business strategy or policy on the preference and behavior of different groups. This allows identifying the groups which are most susceptible to a particular strategy/policy. To the best of our knowledge, this study is the first to study induced behavioral change by using latent transition analysis to analyze data obtained from a stated choice experiment.

This remainder of this paper is organized as follows: Section 2 presents the conceptual framework and specification of the models; Section 3 introduces the data collection and survey design; Section 4 discusses the estimation results of the models, and in the last section conclusions are drawn and implications discussed.

2. Modeling framework

There have been numerous studies, which aim to investigate the behavioral change induced by policies or strategies. Many of those collected data using stated choice experiments and adopt the framework of discrete choice models to ex-ante evaluate policies that either alter the characteristics of a certain alternative or change the preferences of individuals. In the former case, the policy can be represented as a change in one or more attributes in a stated choice experiment and the size of the policy impact can be deduced from the corresponding parameter (Hackbarth and Madlener, 2013; Hoen and Koetse, 2014). If the policy influences decision-making by affecting the preferences of individuals such as information or awareness campaigns, an option is to conceptualize it as a context variable, while the original choice tasks are coupled with different values of the context variable (Kim et al., 2014). The context variable enters the utility functions by interacting with attributes and the parameters of these interaction terms represent the preference change induced by policy. Another slightly different approach is to set up a stated choice experiment with multiple waves: for each choice task, respondents first give an answer under the status quo or a base context and then decide whether they will adapt