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Analysis of public acceptance of electric vehicles: An empirical study in Shanghai

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ABSTRACT

Developing Electric Vehicles (EVs) has a significant meaning in protecting the environment. However, the low public acceptance of EVs hinders the promotion of EVs in China. Factor analysis method and structural equation model are used in this essay to explore the potential factors that affect consumers' acceptance of EVs in Shanghai based on the questionnaire survey. The results show that only 18.1% of the respondents are willing to purchase EVs to replace conventional vehicles. Technical level, marketing, perceived risks and environmental awareness have significant impacts on EV acceptance. Finally, the promotion solutions are put forward accordingly.

1. Introduction

In recent years, China's consumption of oil in the transport sector is > 50% of the total oil consumption, which is expected to reach over 60% in 2020. Besides, with the increase of car ownership, China's carbon emissions in 2014 have exceeded those of the United States and the European Union, indicating that the environmental problem is becoming increasingly prominent (Anon, 2015.). Under the pressures of energy security and environmental pollution, China should change the existing energy consumption structure to reduce fuel consumption and emissions. The adoption of EVs can reduce China's dependence on foreign oil and effectively reduce the environmental pollution problems.

Compared with the traditional gas-powered vehicle, EVs have much higher purchase cost, lower charging infrastructure availability and longer charging time, which make consumers unwilling to purchase EVs (Carley et al., 2013a). In order to promote EV's adoption, Chinese central government and local governments have introduced plenty of fiscal and non-fiscal policies. The fiscal policies include purchase subsidies, purchase tax exemption, charging infrastructure construction subsidies and electricity price subsidies. The non-fiscal policies mainly include road tolls exemptions and free public charging in designated charging places (Li et al., 2016). Stimulated by such policies, the ownership of EVs approached 500,000 by the end of 2015. However, the market share of EVs is still relatively small. Furthermore, EV sold badly in the private domain where Chinese government prefers to seeing a great success of EV. In the private domain, which is the most important is consumers' preference to EV. Therefore, it is necessary to

deeply study on key factors influencing consumers' acceptance of EVs.

In this paper, we analyze the key influencing factors of EV public acceptance based on a questionnaire survey of EV potential consumers in Shanghai which has the largest ownership of EVs in China. This paper is divided into 5 sections, the first being this introduction. The second section presents the factors affecting consumers' acceptance of EVs through literature review and expert interviews. The third section provides the research model and methodology. The fourth section provides the research results based on the questionnaire survey data and data analysis methods. The fifth section presents the research conclusions.

2. Literature review

According to recent researches, consumers' acceptance of EVs is influenced by many factors, which can be divided into four categories: EV technical performance, external environmental factors, consumers' demographics and personalities, and consumers' perceived values to EVs.

- (1). The technical performance of EVs is the most important factor. Based on the research of hybrid vehicle owners, Ozaki and Sevastyanova (2011) concluded that the factors related to the vehicle performance such as high ride quality, low noise, automatic transmission and easy operation will affect consumers' acceptance of EVs. (Jensen et al., 2013) made a survey of 369 Danish battery electric vehicle owners and found that the EV models, driving range and security will affect consumers' willingness to buy EVs.

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Egbue and Long (2012) found that the immature battery technology and the high battery price are the main obstacles to the large-scale promotion of EVs.

- (2). Besides product technical attributes, consumers' preferences to alternative vehicles also hinge on their demographics and personalities. Ziegler, 2012 investigated 598 potential car consumers in Germany and the results showed that young consumers with environmental awareness are more willing to buy EVs. Carley et al. (2013a, 2013b) investigated the American drivers of their willingness to purchase plug-in hybrid electric vehicles, and found that consumers who are interested in EVs are well educated, and hybrid electric vehicle owners are eco-conscious and concerned about dependence on imported oil. The research of Hidrue et al. (2011) showed that consumers' educational level, income and environmental protection awareness are positively correlated with the purchase intention of EVs. Tian (2012) concluded that consumers who have the intention to purchase EVs are tech-conscious and environment-friendly. Plötz et al. (2014) made a survey of German EV consumers and found that the most likely group of EV buyers are middle-aged men with technical professions living in rural or suburban multi-person households.
- (3). In the early stage of EV's industrialization and commercialization, government plays a crucial role to make EV's diffusion self-sustaining. Lane and Potter (2007) found that the environmental regulations, oil price policy, purchase subsidies and the charging infrastructure construction will affect the market penetration of cleaner vehicles. The studies of Eppstein et al. (2011), Beresteanu and Li, 2011, and Gallagher and Muehlegger, 2011 all indicated that the government financial subsidies play an important role in the large-scale EV promotion.

In addition, charging infrastructure determines EV's convenience and affects consumers' willingness to purchase EVs in result. Sierzchula et al. (2014) studied the EV adoption in 30 countries in 2012 and concluded that the charging infrastructure construction is a key factor affecting the EV adoption.

The relative advantage of EV's usage cost depends on fuel price and electricity price which encourages consumers to buy EVs. (Plötz et al., 2012) analyzed the impacts of the purchase cost and usage cost on the EV adoption based on the total life cycle cost. The research of Choi and Inha (2010) concluded that the main factors affecting consumers' acceptance of EVs are the purchase price, the usage cost and the maintenance cost. The studies of Zubaryeva et al. (2012) and Dijk et al. (2013) also confirmed the influence of oil price and electricity price on the EV purchase intention.

- (4). Finally, the car is not only a means of transportation, but also a symbol of identity. Kurani (Heffner et al., 2007) found that the symbolic meanings of hybrid electric vehicles will affect the purchase willingness of the 25 households in the United States. The respondents hold the opinion that driving a hybrid electric vehicle will express their personalities such as maturity, intelligence and distinction. Raham-Rowe et al. (2012) (surveyed 40 UK households of their driving experience of EVs and found that some drivers felt good because of the EV environmental benefits, while some drivers felt embarrassed because of the poor performance and appearance of EVs.

Although there have been many researches about this subject, most of them only incorporate one or several influencing factors without building up a comprehensive model. And the results seem unilateral and distorted according to other researches. For example, through the investigation of the Swedish car owners, Jansson, 2011 found that the consumers' willingness to purchase EVs was affected by consumers' subjective norms and attitudes, the innovative personality and perceived EV performance. The research of Schuitema et al., 2013 also

showed that the factors affecting consumers' acceptance of EVs are not only the product performance, but also consumers' perceptions of EV driving pleasure and symbolic meaning.

This research gap may be related to the methods used. Consumers' willingness to buy EVs is commonly regarded as a discrete choice problem using the multinomial logit model, nested logit model and mixed logit model. Bolduc et al., 2008 and Sikes et al., 2010 applied the multinomial logit model to study the influencing factors of consumers' acceptance of EVs, while Potoglou and Kanaroglou, 2007 applied the nested logit model to study the EV public acceptance. However, in the discrete choice problem, there exists rational inattention where some respondents give up processing information about the unknown values of the available options to maximize the expected value of the chosen option due to its high cost (Mckay and Matejka, 2011).

In order to found a comprehensive research model for studying the EV public acceptance, this paper applies the structural equation models which allows for the simultaneous analysis of whole system of regression equations. Furthermore, Structural Equation Modeling is able to deal with latent (non-observable) variables which are not directly but of utmost importance for the research (The Structural Equation Model, 2007). Besides, this model can make it easy to study the relationship between each latent variable and the manifest variables (Grewal et al., 2004).

3. Research model and research method

Based on the classification from above literature review, the research model of EV public acceptance is shown in Fig. 1. Here we assume that these four kinds of factors all have significant impacts on consumers' acceptance of EVs. These assumptions are verified in the following sections.

The questionnaire was designed based on the research model, which consisted of four parts. Part I covers 43 questions about the factors affecting the consumers' acceptance of EVs, except those factors related to consumers. All the factors are measured by multiple items on a 5-point "Likert" scale that ranges from 1 = Strongly Disagree to 5 = Strongly Agree. Part II gathers some basic information about travel behavior including private car ownership, average daily travel distance and the expectations to EVs such as driving range, maximum speed and price. Part III measures consumer's acceptance of EVs. Part IV is related to the demographic variables, including sex, age and educational level, etc.

The survey was done in the 4S stores and EV test drive centers of Shanghai whose respondents all have a good understanding about EVs and are the potential EV consumers. Finally, 458 valid questionnaires were collected. To analyze consumers' acceptance of EVs with the collected data, Spss21.0 and Amos21.0 software were applied as the statistical data analysis tools to establish a structural equation model. The main statistical analysis methods were as follows:

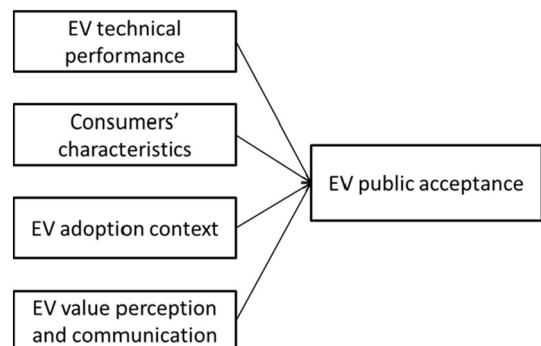


Fig. 1. Research model of EV public acceptance.

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