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Analysis of the Electric Vehicles Adoption over the United States

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Abstract

Increasing the use of electric vehicles (EVs) has been suggested as a possible method to decrease fuel consumption and greenhouse gas (GHG) emissions in an effort to mitigate the causes of climate change. In this study, the relationship between the market share of electric vehicles and the presence of government incentives, and other influential socio-economic factors were examined. The methodology of this study is based on a cross-sectional/time-series (panel) analysis. The developed model is an aggregated binomial logit share model that estimates the modal split between EV and conventional vehicles for different U.S. states from 2003 to 2011. The results demonstrated that electricity prices were negatively associated with EV use while urban roads and government incentives were positively correlated with states' electric vehicle market share. Sensitivity analysis suggested that of these factors, electricity price affects electric vehicle adoption rate the most. Moreover, the time trend model analysis found that the electric vehicle adoption has been increasing over time, which is consistent with theories about diffusion of new technology.

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1. Introduction

In order to increase the sustainability of transportation systems, it will be necessary to reduce GHG emissions, air pollution and dependence on fossil fuels. The solutions to these problems depend largely on the policies that can reduce U.S. gasoline consumption. Such solutions include driving less, purchasing more fuel-efficient vehicles and using alternative fuel vehicles (e.g. Bagherian et al., 2016; Asgari et al., 2014; Asgari and Jin, 2015; Soltani-Sobh et al., 2015; Talebpour et al., 2015; Soltani-Sobh et al., 2016a).

Electric vehicles (EVs) are one possible innovation to help address energy dependency and environmental concerns. EV adoption is heavily dependent on certain external factors such as stringent emissions regulations, rising

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gasoline prices and financial incentives (Eppstein et al., 2011; Nie et al., 2016). Similar to any new technology, there are barriers to adoption, including lack of knowledge, low consumer risk tolerance and high initial production cost (Jaffe and Stavins, 1994; Stoneman et al., 1994; Argote and Epple, 1990).

Social issues are challenging factors that should be considered in the commercial success of EVs. Ozaki and Sevastyanova (2011) determined that consumer acceptance is crucial to the continued success of sustainable transportation. Diamond (2009) summarized some common barriers to the adoption of any new technology as lack of knowledge by potential adopters, high initial costs and low tolerance risk. Hidrue et al. (2011) identified a high level of education, income and environmentalism as consumer characteristics with positive effects on EV adoption. Fuel price has been introduced as an influential predictor of alternative fuel vehicle adoption (Soltani-Sobh et al., 2016; Eppstein et al., 2011). The combination of fuel price and electricity prices makes up the majority of EV operating expenses, and these two factors are positively correlated with the likelihood of EV adoption (Zubaryeva et al., 2012). In some studies, the availability of charging infrastructures was identified as an important criterion in consumer acceptance of alternative fuel vehicles (e.g. Ghamami et al., 2014; Yeh, 2007; Struben and Sterman, 2008; Egbue and Long, 2012).

In order to overcome barriers, different states have established a number of consumer incentives for adopting EVs. Literature reviews on the effect of incentives on adoption of alternative fuel vehicles present conflicting results. Sierzchula et al. (2014) found financial incentives to be significantly and positively correlated to a country's EV market share, whereas Zhang et al. (2014) showed insignificant correlation between financial incentives and an individual's willingness to buy EVs. Thus, analyzing other factors affecting electric vehicles share is imperative.

The purpose of this study is to examine and analyze the significance and strength of state incentives and other significant socioeconomic factors in promoting EV adoption. A cross-sectional time-series analysis was conducted on the number of EV statistics over time. Data from individual states was used to test the relationship between EV adoption and variety of variables. The available EV data are an aggregated number of EVs for different states over time. The developed model is an aggregated binomial logit share model that estimates the modal split between EV and conventional vehicles for different states in the U.S. over time.

2. Methodology

The methodology for this study is based on development of the modal split model between electric vehicles and other fuel type vehicles (mainly conventional vehicles). The annual share of electric vehicles as aggregate data is considered as the dependent variable with a value between 0 and 1.

2.1. Macroscopic Logit Model for Cross-Sectional Model

There have been extensive bodies of research on the application of various mathematical, statistical and econometric models in science and engineering (e.g. Pour-Rouholamin and Zhou, 2016a; Pour-Rouholamin and Zhou, 2016b; Jin et al., 2014; Vaziri et al., 2014; Esfahanian et al., 2015; Ahmadi and Merkley, 2009; Hassan-Esfahani et al., 2015; Jalayer and Zhou, 2016; Ghasemi et al., 2016; Baratian-Ghorghi and Zhou, 2015; Zhou et al., 2016). Due to the availability of aggregate dataset, in this study the macroscopic logit market share model was developed to demonstrate the mode choice decisions. The market share model reduces to a utility function, which is a function of a number of independent vehicle type characteristics, and socioeconomic and policy variables that vary by state. The share variation of EVs over states (in addition to their variation over time) help separate and examine the different determinant factors of adoption that vary across states but are correlated in time. On a state level, consumers' preferences for different vehicle type choices are affected by a number of predictor variables. Monetary variables include: risk tolerance for new technologies (labeled as income variable which is considered as effective consumer discount rate for future energy cost), gasoline price (gas price variable), electricity price (Eprice variable) and annual miles travelled (VMT variable, which is related to annual fuel consumption). Non-monetary factors include government incentives (incentive variable) and rates of urban roads (urban variable). As such, the final specification of the utility function for EV in state i at time t can be defined as:

$$U_{Eit} = F(Income_{it}, Gasprice_{it}, Eprice_{it}, VMT_{it}, Incentive_{it}, Urban_{it}) \quad (1)$$

We define P_{Eit} as the share of EVs, and P_{0it} as the share of conventional fuel type vehicles. EV is in state i at

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