A qualitative comparative analysis on factors affecting the deployment of electric vehicles

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Abstract

To address environmental regulations on greenhouse gas emissions and depletion of fossil fuels, many countries around the world are actively promoting electric vehicles. The penetration rate of electric vehicles, however, is different in each country. What are the causal conditions of EVs adoption? To answer the question, the fuzzy-set qualitative comparative analysis methodology, fsQCA, is employed to compare the factors affecting the deployment of electric vehicles and to draw policy implications for promoting the deployment of electric vehicles. In conclusion, some effective policies, such as tax exemption, purchase subsidies, are summarized. And it can be seen that there is no single effective policy tool or the circumstances of the countries for electric vehicle supply. Therefore, in order to promote the diffusion of electric vehicles, it is necessary to promote an effective policy mix considering the circumstances of the countries concerned.

Keywords: electric vehicles; fsQCA; EV deployment

1. Introduction

To address environmental regulations on greenhouse gas emissions and depletion of fossil fuels, many countries around the world are actively promoting electric vehicles. Norway, which is the largest seller of electricity vehicles in

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Europe, plans to sell only electric cars and hydrogen cars from 2025 [1]. Japan plans to increase the penetration rate of electric vehicles and plug-in hybrid vehicles to 15–20 % of total new car sales by 2020 [2]. Germany announced the "National Electromobility Development Plan" for technology development and infrastructure construction with the goal of supplying 1 million electric vehicles by 2020 [3]. In this way, major countries have competitively promoted the adoption and deployment of electric vehicles, but the penetration rate of electric vehicles is different in each country. For example, the rate of sales of electric cars in Norway is 28.8 %, Sweden 3.2 %, Netherlands 2.3 %, Switzerland 1.7 %, US 0.8 %, India 0 % [4]. If so, what are the factors that make such a difference in the deployment of electric vehicles? What are the causal conditions of EVs adoption? To answer the question, the fuzzy-set qualitative comparative analysis methodology, fsQCA, is employed to compare the factors affecting the deployment of electric vehicles and to draw policy implications for promoting the deployment of electric vehicles.

2. Factors influencing EV adoption

According to the previous researches, factors affecting the deployment of electric vehicles were categorized into three dimensions; technology factors, policy factors, environmental factors.

2.1. Technology factors

Technology factors are closely related to characteristics of the EV, such as driving distance, charging time, EV purchase prices. Limited driving range, long charging time and EV's high purchase prices are the obstacles to EV adoption and diffusion [5–9]. According to Brownstone et al. [7], the high purchase price of an EV is a significant obstacle to widespread EV diffusion. Lieven et al. [10] and Hackbarth and Madlener [11] pointed out that the limited driving range of EVs is one of the main barriers in the purchasing decision. Moreover, Electric vehicles take longer to charge than internal combustion engine vehicles (ICEV). According to Saxton [12] EVs require 30 min at a fast charging station, whereas most ICEVs can refuel in roughly 4 min [12]. In addition, other technology factors, such as battery life, trunk space, top speed, are regarded as one of the technical barriers for limiting consumer adoption [13, 14].

2.2. Policy factors

The electric vehicle market is still at an early stage of development compared to the existing ICEV market [15]. Therefore, the government's active policy support is a major factor for the initial market creation and full-scale diffusion of EVs. Thus, many countries that promote electric vehicles are providing policy support such as purchase subsidies, public expenditure, tax reduction, tax exemption, EV deployment target, free charging, and parking permissions. In the United States, both the federal government and state governments have taken direct subsidies, tax credits or tax exemptions to stimulate consumers to purchase EVs [16]. In China, the government encourages purchasing public vehicles at the primary stage and then supports exploiting the private EV market in some pilot cities [16]. According to Wenbo et al. [17], the main policies such as subsidies, preferential tax, free parking, and driving privileges have positive effects on the consumers' adoption of EVs [18–21]. Sierzchula et al. [22] found financial incentives to be significant and positively correlated to EV market share and Whitehead et al. [23] found that a congestion tax exemption policy can substantially increase the share of energy efficient vehicles in Stockholm, these results are in line with Aasness and Odeck's [24] assertion that increase in the use of EVs is the result of multiple economic incentives.

2.3. Environmental factors

Environmental factors mean those that will affect EV adoption indirectly but are out of the direct control of EV manufacturers [25]. We can consider environmental factors as fuel prices, consumer characteristics, availability of charging stations etc. [25]. According to Coffman et al. [25] fuel prices are found to be the strongest predictors of HEV adoption and would similarly affect EV adoption depending on the relative price of electricity [5]. Consumer characteristics, such as income, education, gender, level of environmentalism, also affect the purchase of EVs [5].