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Policy measures to promote electric mobility – A global perspective

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ABSTRACT

Research that addresses policy measures to increase the adoption of electric vehicles (EVs) has discussed government regulations such as California's Zero Emission Vehicle (ZEV) or penalties on petroleum-based fuels. Relatively few articles have addressed policy measures designed to increase the adoption of EVs by incentives to influence car buyers' voluntary behavior. This article examines the effects of such policy measures. Two of these attributes are monetary measures, two others are traffic regulations, and the other three are related to investments in charging infrastructure. Consumer preferences were assessed using a choice-based conjoint analysis on an individual basis by applying the hierarchical Bayes method. In addition, the Kano method was used to elicit consumer satisfaction. This not only enabled the identification of preferences but also why preferences were based on either features that were "must-haves" or on attributes that were not expected but were highly attractive and, thus, led to high satisfaction. The results of surveys conducted in 20 countries in 5 continents showed that the installation of a charging network on freeways is an absolute necessity. This was completely independent from the average mileage driven per day. High cash grants were appreciated as attractive; however, combinations of lower grants with charging facilities resulted in similar preference shares in market simulations for each country. The results may serve as initial guidance for policymakers and practitioners in improving their incentive programs for electric mobility.

1. Introduction

Literature addressing electric mobility has primarily considered two aspects: technical issues like the optimal range of electric vehicles (EVs; Franke and Krems, 2013; Lin, 2014) or charging infrastructure (Flath et al., 2014), and marketing questions like acceptance of EVs and predictions for EV sales (Bunce et al., 2014; Carley et al., 2013; Egbue and Long, 2012; Gnann et al., 2015; Kieckhäfer et al., 2014; Lieven et al., 2011; Plötz et al., 2014; Skippon, 2014). Other research studies have addressed policy measures designed to reduce greenhouse gas (GHG) emission and promote the acceptance of EVs. Policymakers are interested in the promotion of alternative fuel vehicles to reduce the GHG emission. There exist several kinds of policy measures in this regard. Governments could implement repressive regulations such as California's Zero Emission Vehicle (ZEV) program that requires auto manufacturers to produce a certain percentage of zero emission vehicles (Green et al., 2014). Moreover, penalties could be placed on petroleum-based fuels, or taxes could be imposed on implementing a price floor to prevent the decline of petroleum price beyond a certain level (National Research Council, 2013). This could

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discourage consumers to buy cars with internal combustion engines (ICE). A compound measure comprising a repressive portion and an incentive portion are so-called feebates, which are a combination of fees for high pollution cars and rebates for low pollution cars (Greene et al., 2005; Mueller and de Haan, 2009; de Haan et al., 2009).

Another policy approach is to establish eco-friendly rules like the Corporate Fuel Economy (CAFE) standard that led to a 50% reduction of fuel consumption per passenger car mile (Greene et al., 2005). Instead of regulation, governments could motivate the industry to make increased R&D efforts. Åhman (2006) discussed policy regarding legislation and support for the automobile industry's R&D capabilities in Japan. Such subsidies for R&D in the field of climate policy have been shown to be effective (Abrego and Perroni, 2002; Popp, 2006). However, these subsidies do not provide sufficient incentive to encourage consumers to adopt new technologies. Thus, R&D subsidies have to be accompanied by additional incentives (Popp, 2006).

Consequently, policy should address car drivers' purchase decision by incentives to convince them to voluntary switch to less polluting vehicles. One of the most prominent incentives in the automobile sector was the 2009 Car Allowance Rebate System (CARS), popularly referred to as "Cash for Clunkers," that offered up to $4500 to buyers of new cars when they scrapped their old vehicles. Similar programs have been implemented in other countries. All these incentives have been successful from the consumers' viewpoint. In the United States, subsidies were paid for approximately 700,000 vehicles amounting to a total sum of approximately $3 billion (Lenski et al., 2010). However, the evaluation of the overall economic effects revealed mixed results. Due to free-rider effects, approximately 45% of the incentives went to buyers who would have bought a new car anyway (Li et al., 2013). CARS had a positive effect on the reduction of GHG, albeit at a very high economic cost (Lenski et al., 2010). In recent years, a vast number of programs were offered for EV purchases worldwide with impressive results, such as in California and Norway. Thus, monetary incentives have shown positive effects.

Apart from monetary incentives such as tax credits or direct subsidies, there exist other measures that could boost EV sales, or at least, could clear some obstacles out of the way that prevent potential EV buyers from a purchase. These include the improvement of the charging infrastructure (Lin and Greene, 2011), road-tax exemptions, and traffic regulations such as the free use of bus lanes or downtown parking areas. Some of these incentives have been analyzed in literature (for direct subsidies see Helveston et al., 2015; for income tax credits see National Research Council, 2013; for charging infrastructure see Lin and Greene, 2011). However, these single measures have been analyzed in isolation and were not evaluated in comparison with each other in terms of the acceptance of potential EV buyers. It is still unknown which of these measures has the largest impact on increasing EV demand. Furthermore, the role of absolute must-haves is unclear. It is frequently argued that most car drivers cover daily distances of less than 40 miles and consequently do not deserve public charging facilities. However, the request of one or two longer vacation trips per year could make a charging network a *sine qua non* for an EV purchase. Consequently, governments could face the risk of pursuing a single-sided goal with an only-monetary policy since this could be insufficient to convince vehicle drivers to change over to EVs. The present article attempts to fill this research gap by focusing on those policy measures that convince consumers to voluntarily switch to electric mobility.

Furthermore, a global perspective regarding policy measures is missing. Sierzchula et al. (2014) have published an article that analyzes financial incentives and other factors related to EV adoption in 30 countries. However, these analyses were based on secondary data from national automotive institutions, government agencies, manufacturers, and automotive Web sites. In contrast, this article assessed primary data in 20 countries. The results stem from a more comprehensive study and the remaining findings concerning the general acceptance of EVs will be reported separately. The results could serve as guidelines for policymakers and practitioners. By utilizing a web appendix (www.researchfiles.com/Web Appendix.pdf) with a variety of figures and tables for each country, optimizing strategies can be simulated.

In the remainder of this article, the policy measures that are examined in this study are described as well as the research methods to assess consumers' preferences. Thereafter, the results of a large-scale survey in 20 countries with approximately 8000 participants are presented. The article is brought to a close with a discussion and conclusion.

2. Policy measures and research method

2.1. Policy measures

Due to the limitations present in any field research (Rao, 2014), only few of all existing policy measures could be included in the analyses. A workshop with drivers of conventional and electric vehicles was organized by members of a Swiss association of EV owners in which several proposals were discussed and seven policy measures were selected according to worldwide importance and sufficient coverage of several aspects such as monetary issues, traffic regulations, and charging infrastructure (Table 1).

With regard to the three categories of measures (monetary, traffic regulation, charging infrastructure), cash-related grant programs (monetary measures) in particular are often time limited or capped at a specific number of eligible recipients (Tyrrell and Dernbach, 2010–2011). For example, the UK government has limited its grant of up to 5000 GBP to a maximum of 50,000 cars or until the end of 2017, whichever comes first (UK Department of Transport, 2015). The nature of such grants requires them to be offered for each EV and without any increasing efficiency over time. This forces policymakers to quantitatively limit their offers (Tyrrell and Dernbach, 2010–2011). In contrast, the second category (traffic regulations) is the one that is less expensive when it is granted. Through merely altering traffic regulations and bus/fast lanes or parking spaces that