

# ***GOVERNMENT INCENTIVES FOR EV ADOPTION: A CLASSIFICATION OF EXISTING INCENTIVES AND ASSESSMENT OF THEIR EFFECTIVENESS***

Sarah Fluchs, RWTH Aachen University, +49 (0) 241 80 – 93934, sarah.fluchs@rwth-aachen.de

## **Overview**

Electric mobility is a key element in the strategy of tackling climate change. With dwindling oil reserves and urban development, clean and sustainable mobility becomes increasingly significant in today's society. The transport sector with its conventional propulsion systems of petrol and diesel engines is currently accountable for 19 % of greenhouse gas emissions and 60.3 % of oil consumption in Europe (European Commission, 2013; International Energy Agency, 2007). Electric mobility allows the promotion of environmental and air protection due to its low pollutant and noise emissions (Romm, 2006; Samaras and Meisterling, 2008; Silva et al., 2009; Stephan and Sullivan, 2008). The aim of the European Commission is to reduce greenhouse gas emissions by 20 % until 2020 and by 80 % until 2050 (European Commission, 2011). Thus, electric mobility is one of the crucial measures to achieve global and regional directives set by the EU.

However, since in most countries the change is not taking place very fast, governments intervene in the market. To achieve a higher market penetration of EVs, governments can strengthen supply and demand and thus accelerate the diffusion of electric vehicles (EVs) in the early stage by means of technology promotion and purchasing incentives. As a result, the promotion and usage of EVs plays a major role in the worldwide challenge of preserving the environment and enabling a sustainable use of resources.

In this paper, a detailed overview of the examinations of existing incentives in the most important global automotive markets, namely China, Germany, Japan, the Netherlands, Norway and the United States, is provided. Subsequently, incentives are clustered and analyzed regarding their effectiveness. It is investigated how these incentives as well as socioeconomic and sociodemographic factors studied in recent research affect the promotion of EVs. The paper is structured as follows: Section 2 provides a detailed overview of existing incentives in the most important global automotive markets. Section 3 gives a short summary of the methods used in empirical studies. Based on this, Section 4 investigates how these financial and non-financial incentives as well as socioeconomic and sociodemographic factors studied in recent research affect the promotion of EVs. Finally, Section 5 concludes this paper by summarizing important findings and by providing some ideas for future research in this field.

## **Methods**

Basic methods described in the paper are a selection of methods applied in empirical research both in the generation as well as the analysis of data. Among the most popular methods examined are the generalized method of moments (GMM) and the multinomial logit model (MNL). Conjoint analyses, use-maximizing approaches, OLS regressions, systematic comparisons or questionnaires to collect high amounts of data are used as analysis methods as well.

In addition, surveys are often carried out to analyze sociodemographic data, while the sales figures, fuel prices and market shares are obtained as a time series of statistical institutes. Those time series can be advantageous in relation to seasonal fluctuations, which can be explained or eliminated by smoothing process. Panels can be collected mainly through repeated surveys. Furthermore, simulations are used to analyze the effectiveness of incentive mechanisms. A solution area is usually created, each with a best and worst case scenario as limitations. The results can be used as guidelines for the extension or suspension of existing support measures.

## **Results**

The profound analysis of these methods represents one major finding of the study. Starting from the microeconomic theory of market balance, different possibilities of government interventions with the aim of giving impulses for sustainable development are typified. Currently applied incentives are summarized and classified in financial incentives (such as direct rebates or tax reduction) and non-financial incentives (such as parking facilities or special rules for road traffic). A detailed overview of the diverse characteristics of incentive mechanisms (current and previous) in the most important global automotive markets is provided in form of a comprehensive table.

Furthermore, the paper contains an investigation on how these incentives as well as socioeconomic and sociodemographic factors studied in recent research affect the market penetration of EVs. The result is a visualized qualitative overview of the causal relationships (positive or negative) found between certain measures, sociodemographic and economic data and the sales of EVs.

As a result, the paper gives an assessment of the comprehensiveness of existing literature and suggestions for directions of future research. On the one hand, financial incentives have an advantageous effect on the sales figures. The purchase price of EVs is often identified as one of the greatest barriers for potential customers and producers are not yet able to reduce the manufacturing costs significantly. Consequently, financial incentives are essential for the spread of electric mobility in the near future. An expansion of the charging infrastructure as a non-financial incentive is the basic requirement for many customers as well. But apart from that, it is difficult to make general statements about non-financial incentives, as they only convince certain buyers or are regionally bound.

Nevertheless, reduced driving behavior is just as much a part of sustainable mobility. This aim is not fulfilled by the financial support for electric or hybrid vehicles, but for example by a higher environmental awareness of consumers, which can be reached through increased information policy measures with regard to electric mobility, the usage of electric vehicles, current government incentives, etc. In addition, ecoconscious customers are willing to pay more for an electric vehicle than other potential customers implying that the general development of more sustainable consumption patterns might benefit electric mobility to some extent. Further socioeconomic and sociodemographic factors have an influence on the willingness to buy EVs, e.g., in surveys a higher income and a better educational level had a positive effect on the market shares of EVs.

## Conclusions

The paper concludes with an assessment of the comprehensiveness of existing literature and suggestions for directions of future research. There are many types of empirical literature with different main questions regarding vehicle type, period of time, location, methods and studied variables. As a result, the conclusions of these papers vary as well. Further research should aim to increase the level of detail of vehicle types, since mostly only hybrid electric vehicles (HEVs) were tested. Overall, there is little empirical evidence on battery electric vehicles (BEVs) and even less specifically on plug-in hybrid electric vehicles (PHEVs), which is why profound research is needed in these types of vehicles and markets.

Furthermore, a disregarded factor so far is the resale value on used car markets, which can be reduced by the degraded charging performance of the battery. These markets have their own dynamic and because of the lack of experience with respect to EVs, this can have a significant impact (Beresteanu, 2011).

In addition to these technical and market-specific questions, buyer-specific questions remain unanswered, for example, whether an EV is used as a second car, and if so, with which justification and with which incentives this potential buyer group can be acquired (Langbroek, 2016).

Overall, the partly contradictory results indicate that further research is needed in the area of incentive mechanisms and their impact on the sales of electric vehicles. Only a few regions and periods of time have been studied so far and the transposition or scaling is not necessarily possible.

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