Energy Policy 105 (2017) 524–533

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership

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ARTICLE INFO

Keywords:
Electric vehicle adoption
Fiscal incentives
Public policy
Total cost of ownership
Electric vehicle sales

ABSTRACT

An important barrier to electric vehicle (EV) sales is their high purchase price compared to internal combustion engine (ICE) vehicles. We conducted total cost of ownership (TCO) calculations to study how costs and sales of EVs relate to each other and to examine the role of fiscal incentives in reducing TCO and increasing EV sales. We composed EV-ICE vehicle pairs that allowed cross-segment and cross-country comparison in eight European countries. Actual car prices were used to calculate the incentives for each model in each country. We found a negative TCO-sales relationship that differs across car segments. Compared to their ICE vehicle pair, big EVs have lower TCO, higher sales, and seem to be less price responsive than small EVs. Three country groups can be distinguished according to the level of fiscal incentives and their impact on TCO and EV sales. In Norway, incentives led to the lowest TCO for the EVs. In the Netherlands, France, and UK the TCO of EVs is close to the TCO of the ICE pairs. In the other countries the TCO of EVs exceeds that of the ICE vehicles. We found that exemptions from flat taxes favour big EVs, while lump-sum subsidies favour small EVs.

1. Introduction

The transport sector is one of the main contributors to anthropogenic climate change worldwide, accounting for 23% of global energy-related greenhouse gas (GHG) emissions (IEA, 2015b). The number is similar in the European Union (EU). Transport has the second biggest share, after energy industries, accounting for almost a quarter of total emissions. The modal decomposition of transport GHG emissions shows that road transport had the primary role in GHG emissions with a share of 73% in 2014 (EC, 2016a).

In contrast to other sectors in the EU, GHG emissions constantly grew in the transport sector from 1990 to 2007. Although transport emissions have been declining since 2007, they still have not reached the 1990 level. The share and growth patterns of transport emissions justify and prompt policy actions. Electromobility can be an effective solution in tackling negative externalities associated with internal combustion engine (ICE) car usage. There is a strong worldwide political will to foster the market introduction of electric vehicles (EVs). The most recent advancement happened during the COP21 Paris Climate Conference in December 2015, where the collaborative initiative “Paris Declaration on Electro-Mobility and Climate Change and Call to Action” was accepted (IEA, 2015b). It aims to promote electromobility to achieve a more sustainable transport sector compatible with a lower than 2 degree global warming pathway. To achieve this goal, electric vehicles have to represent 35% of global vehicle sales by 2030, according to the action plan.

Besides global GHG emissions, ICE vehicles also cause noise and local air pollution, creating adverse health effects especially in urban environments (OECD, 2014). Car-related petrol and diesel demand can cause dependence on foreign energy sources, compromising energy security. In light of these problems, national and local governments adopt a wide range of measures to encourage electric vehicle[2] use. Fiscal incentives are important measures as they influence directly the vehicle purchase decision of individuals or companies. They can be total or partial tax exemptions, or direct subsidies. The aim of this study is to assess and evaluate how different fiscal incentives may have stimulated the market penetration of EVs in eight European countries: France, Germany, Hungary, Italy, Netherlands, Norway, Poland, and the United Kingdom. We focus on year 2014 and our analysis covers roughly 66% of all EV sales in the EU28 and European Free Trade Association (EFTA) countries in 2014. One of the biggest barriers to market breakthrough of EVs is that, in the absence of incentives, they are currently not cost-competitive. We conducted total cost of ownership (TCO) calculations to determine how costs and sales of EVs relate

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[1] The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

[2] We consider as EVs battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV).

http://dx.doi.org/10.1016/j.enpol.2017.02.054
Received 17 October 2016; Received in revised form 22 February 2017; Accepted 28 February 2017
Available online 18 March 2017

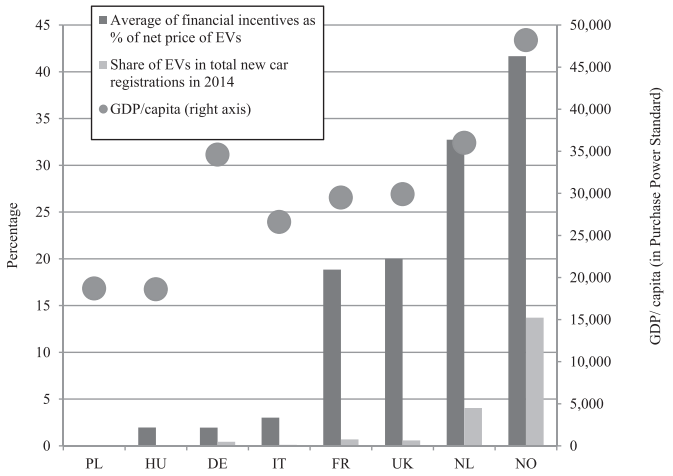

Fig. 1. GDP, fiscal incentives and share of EVs in 2014. Average incentives were calculated for the eight vehicle pairs in the eight countries analysed (see also sections 3.2 and 4.2). EV share data from Thiel et al. (2015) and EAFO (2017), GDP data from Eurostat (2017).

to each other, and to examine the role of fiscal measures in reducing TCO and thereby increasing sales of EVs.

An important aspect of our analysis is that we used real-life car prices. Previous cross-country comparisons of TCO either used vehicle prices from one country and generalized them to other countries (Mock and Yang, 2014; IEA, 2015a), or followed a bottom-up approach to calculate a hypothetical vehicle price from the costs of its components (Propfe et al., 2012; Wu et al., 2015). Some studies used real-world car prices but they were within-country comparisons (Windisch, 2013; Hagman et al., 2016).

Fiscal incentives, if sufficiently high to offset cost differences between EV and conventional cars, are the most important reason to buy an EV, according to a survey made among Norwegian BEV owners (Bjerkan et al., 2016). Fig. 1 shows the average national fiscal incentives provided for the vehicles included in our study, along with the share of EVs in total new car registrations in 2014, as well as the 2014 GDP/capita. The EV market shares vary greatly and do not seem to correlate strongly with GDP/capita levels, motivating the investigation of the differences in EV sales across countries and their relation to fiscal incentives and other costs associated with EV ownership. We performed pairwise comparisons of EVs to ICE vehicles, which are not subject to such incentives, to assess qualitatively the effects of fiscal incentives on market penetration of EVs.

The effect of fiscal incentives can depend on demand elasticities. Segmental price elasticities of vehicles have been investigated previously, see, for example, Berry et al. (1996); Coibion and Einav (2006); Eftec (2008). These works suggest that elasticity is lower in bigger-size car segments and higher in smaller-size, namely small-car demand is more price responsive than demand for big cars. There are two possible explanations: (i) substitution in small segments occurs as there are more models available; (ii) typical customers in the sports or luxury car segments have more income, thus they are less sensitive to price changes. We include small, medium, and big EVs in this study, a choice that allows us to assess segmental differences in the costs-sales relationship.

Other important non-fiscal factors can influence vehicles sales. Bounded rationality is an often mentioned problem with the purchase decision of EVs. As EVs have higher net price than ICE vehicles, consumers face big costs upon purchase, while benefits accrue during the ownership period. Consumers do not always have enough information about potential fuel, maintenance, etc. cost savings, which can result in suboptimal decisions. Another relevant cognitive factor is social norms, as suggested by, for example, Barth et al. (2016). They emphasised that social validation plays an important role in purchase decisions at the early stage of diffusion of new technologies. They argued that targeted education and experience programmes could effectively complement economic or technological interventions. Besides psychological considerations, range anxiety can also prevent customers from buying EVs. In a cross-country regression analysis, Sierzchula et al. (2014) found that the national market share of EVs is well explained by the number of charging stations. This is in line with the results of Lieven (2015). While bounded rationality, social norms, and range anxiety are important non-fiscal barriers to market penetration of EVs, in this study we follow a technical approach focusing only on EV costs.

We emphasize that our analysis is based solely on financial instruments used by national governments to promote electromobility. We do not consider additional city or national policies, for example availability of public charging points, use of bus lanes, parking in city centre, etc., that may be important factors in the decision to purchase an EV. Currently available data do not allow us to disentangle their effect and to evaluate and assess their impact. Future surveys may provide a means to eliminate the influence of these confounding factors.

2. Overview of EV-related policy context and incentives

2.1. Policy context

The level and design of incentives vary greatly in the different countries. The incentives are heavily influenced by wider policy considerations targeting, for example, climate change mitigation, air quality improvement, energy security, or industrial competitiveness. All analysed countries participate in the Emission Trading Scheme (ETS), with a 43% GHG reduction target by 2030 (versus 2005 levels) (EC, 2016b). The ETS covers approximately 45% of the EU's GHG emissions (EC, 2016c). GHG emission reduction targets for the non-ETS sectors, including road transport, are covered by the proposed effort sharing decision, which, amongst others, takes into account national GDP/capita levels for the definition of the GHG targets. The proposed reduction targets are high for Norway (40%), Germany (38%), France (37%), UK (37%), and the Netherlands (36%), medium for Italy (33%), and low for Hungary and Poland (7% each) (EC, 2016b).

The main motivation for Norway's commitment to EVs is to meet its climate goals, although originally the EV incentives, dating back to 1990, were also meant to establish a Norwegian EV industry (Figenbaum et al., 2015a). The aim of the Dutch government's CO_2-related vehicle taxation (since 2007) and EV incentive policy, which started in 2010, is to reduce CO_2 emissions, improve energy-efficiency, reduce dependency on fossil fuels, and reduce noise (Holland Trade and Invest, 2017).

EV incentives in the UK started in 2010: they were viewed as an opportunity to re-position the UK automotive sector to ultra-low emissions vehicle manufacturing and R & D. Additional motivations to introduce EV incentives are (i) to improve energy security; (ii) to meet the UK's carbon reduction targets; and (iii) to reduce local air and noise pollution (Office for Low Emission Vehicles, 2013).

France set up a plan for decarbonised vehicles in 2009. “For the government, the official ambitions of such a plan were energy independence, to cut CO_2 emissions to meet within EU criteria, and to ensure the competitiveness of the French automotive industry” (Hildermeier and Villareal, 2011). The French bonus-malus system was introduced in 2008.

The focus of Germany was on supply-side measures. From 2009, the government invested substantial amounts in R & D and market demonstration projects.[3] Regarding the wider policy context of German

[3] EV purchase subsidies started only in 2016.