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The impact of car specifications, prices and incentives for battery electric vehicles in Norway: Choices of heterogeneous consumers ☆

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ABSTRACT

Electric vehicles (EVs), specifically Battery EVs (BEVs), can offer significant energy and emission savings over internal combustion engine vehicles. Norway has a long history of research and government incentives for BEVs. The BEV market in Norway allows us to fully examine consumers' BEV choices influenced by car specifications, prices and government incentives (public bus lanes access, toll waiver and charging stations). The Random-Coefficient Discrete Choice Model (referred to as the BLP model) is applied to understand the choices of heterogeneous personal consumers and business buyers. Our study is instantiated on the entire EV sales data in Norway from 2011 to 2013, as well as a set of demographics at the municipality level. The results suggest significant positive effects of BEV technology improvement, space, toll waiver and charging station density on EV demand for both personal consumers and business buyers. However, the effects on business buyers may be generally less pronounced than on personal consumers. Interestingly, bus lanes access demonstrates a negative impact for personal consumers, possibly due to consumers' concern regarding bus lane congestion. In addition, preferences on the BEV price can vary statistically among consumers with different income levels. Compared to the BEV technology development, demographical features and municipal incentives may have generally less impacts on market shares within the BEV market.

1. Introduction

Electric vehicles (EV) convert roughly 60% of the electrical energy from the power grid to wheels, compared to 20% from gasoline to wheels for a regular gasoline car (Department of Energy, 2014). In addition, EVs have no singular required energy source as most internal combustion engines have, since electricity can be produced from a multitude of sources, allowing for a diversification of energy sources in transportation. Significant energy/emission savings and flexibility offered by EVs call for increasing EV adoption all over the world. However, EVs have limitations compared to their internal combustion engine counterparts. The barriers to their adoption are that, to name a few, EVs are more expensive, have limited ranges and have less infrastructure support.

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Norway is one of the countries that have the highest Battery Electric vehicles (BEV) market penetration per capita with a record 14.5% of new cars sold being BEVs during the first quarter of 2014. A recent report shows that in April 2014, Norway was the first country where one in every 100 cars was purely electric (Radio, 2014). In fact, BEV sales in Norway have soared since 2010 (see Fig. 1) when established automotive manufacturers made an aggressive entrance into the Norwegian BEV market and supply-side shortage was no longer a constraint. Emerging BEV technology, such as battery capacity and power, has improved over the years. Such improvements not only extend the usage life of BEVs, but also make them more affordable, comfortable and powerful. It has been found that although BEVs were mostly bought as a second car in a household, people tend to use EVs as primary cars, especially for short daily trips (Klöckner et al., 2013).

In addition to BEV technology advancement and sufficient supply, one of the primary reasons that Norway has the greatest BEV market share is attributed to a variety of incentives for BEV only (some are for plug-in hybrid EV as well), including registration tax exemption, free parking, bus lanes access, exemption of toll roads, establishment of dense charging stations in the city, etc. The effective dates of most of those incentives are earlier than the current climate policies: exemption from registration tax from the 1990s, value-added-tax (VAT) exemption started in 2001, access to bus lanes from 2003, free parking from 1999 and waiver of toll roads from 1997. In June 2012, the Climate Policy Settlement was signed in the Norwegian Parliament to set an environmental goal of reducing average CO_2 emissions from new passenger cars to 85 g/km by 2020. The agreement states that all the current financial benefits of BEVs will be continued to the end of 2017.

The incentives, such as bus lanes access, waiver of toll roads and expansion of charging stations networks, could be discontinued after 2017. With the enormous increase of BEV sales, both politicians and consumers are concerned about whether those incentives would still benefit BEV adoption, and therefore should continue or not. A recent report (Figenbaum, 2013) summarized previous surveys of BEV sales in Norway, and found that those incentives indeed impacted consumers' choices of car purchase. Some respondents stated that they would move back to non-electric vehicles if the incentives were reduced or removed. However, it is unclear what the quantitative impacts of the incentives are on both the BEV and non-EV markets.

BEV specifications, prices and incentives may collectively affect two types of consumer choices: the choice between purchasing a BEV and an internal combustion engine vehicle, and the choice of what brand/model of BEV to purchase given availability of various BEVs. The effects vary among consumers, largely dependent on their demographics, such as income levels. For instance, wealthier consumers are more likely to afford a BEV with a long range than low-income consumers, and these BEVs require fewer charging stations. Therefore, the incentive of building new charging stations may or may not have substantial impact on wealthy consumers' choices. In another example, a price drop in high-end BEVs may lead to more BEV sales, but the effect may be minimal if the road toll is no longer waived for BEV drivers. In order to support policy making and BEV marketing, it is central to quantitatively estimate the effects of BEV specifications, prices and incentives to different consumers.

Our study aims to capture the effects of car specifications, prices and incentives on the BEV choices of heterogeneous personal consumers and business buyers. We have the luxury to possess both BEV specifications, prices and individual BEV sales data in Norway from 2000 to 2013 (Grnn Bil, 2015), of which sales are fairly significant across nearly all municipalities from 2011 to 2013. The data sets allow us to establish econometric models to understand the BEV market, namely, given that a consumer decides to purchase a BEV, what drives the choice of BEV and what are the impacts of the factors. On the other hand, due to the unavailability of regular vehicle sales data, unfortunately we are unable to model consumers' choices between a BEV and a regular vehicle. This paper serves as the first step to support policy making for BEV adoption by revealing the factors effecting market shares within the BEV market. Once the regular car sales data are collected, the latter choice can be further addressed in a separate paper.

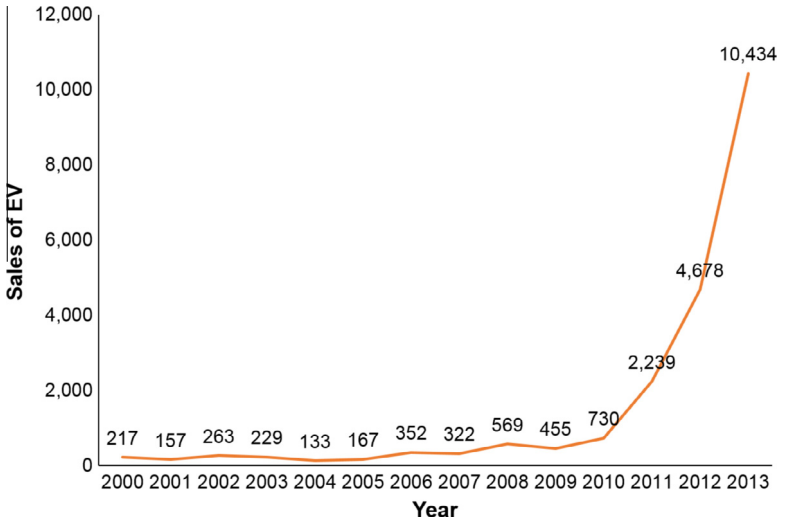

Fig. 1. 2000–2013 EV total sales in Norway.